



## Developing a Sustainable Drinking Water Management Model: Addressing Water Contamination in the Khlong Toei Slum in Bangkok, Thailand

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## **Abstract**

This project investigated water quality and its impact on residents of the Khlong Toei Slum in Bangkok, Thailand by testing water samples from fire hydrants and vending machines in three slum sectors. Results confirmed contaminated water in vending machines. Utilizing observations and slum resident surveys, the team explored slum residents' water usage and water quality perceptions. Interviews with slum leaders clarified their role in vending machine maintenance. To combat water contamination in the Khlong Toei Slum, the team developed a water vending machine maintenance program and recommended an educational campaign to improve the slum's current water quality. This project serves as a stepping-stone for future implementation of a drinking water management model for the Khlong Toei Slum.

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## Executive Summary

### Introduction

Water is a vital element in human survival. However, 769 million people globally lack access to water suitable for consumption (Water.org, 2015). Drinking contaminated water can lead to a multitude of negative health effects through the transmission of pathogens (Ford, 1999). According to the Water Environment Partnership in Asia (WEPA), increasing population, economics, and the expansion of agriculture and industry in Thailand are the major causes of deteriorating water quality in various water sources, such as groundwater and surface water (Water Environment Partnership in Asia, n.d.). The Khlong Toei Slum in Bangkok, Thailand, with residents consuming water from these sources of contaminated water, exemplifies the world's drinking water crisis.

Residents have lived in this slum for many years with low access to high quality water. While working to build Khlong Toei's Port in the 1960s, workers, now residents originally settled in the area. After the completion of the port, the Port Authority of Thailand (PAT) took back the surrounding land, causing workers and their families to become illegal squatters. The PAT signed land-sharing agreements in 1981 because they could not evict all the residents living in the area. These agreements allowed the residents to settle on specific areas of land near the port. Shortly after, the Metropolitan Waterworks Authority (MWA) began to install water lines throughout the slum for those who remained in the area. In an effort to obtain water suitable for consumption, residents have installed water vending machines throughout the slum. However, the Duang Prateep Foundation (DPF), a long-standing charity within the slum that promotes healthy living, recently discovered the presence of bacteria in water from filters in its kindergartens and became concerned about the water quality from the MWA and the water vending machines.

The goal of this project was to address the problem of contaminated water in the Khlong Toei Slum (Figure 1). Due to time limitations, the team narrowed the research field for this study to the following three sectors within the slum with the help of the Duang Prateep Foundation: Chum Chon Rim Khlong Phra Kra Nong (Sector 1), Chum Chon Wat Klong Toei Nai (Sector 2), and Chum Chon Mhoo Baan Pattana Jed Sib Rai (Sector 3). The project aimed to achieve the objectives of (1) establishing water testing locations, (2) determining the potential presence of pathogens in the water, (3) learning about the residents' water usage, (4) learning about the perceptions of the residents of the current water quality issue, and (5) recommending a drinking water management model to eliminate pathogenic contamination in the Khlong Toei Slum.

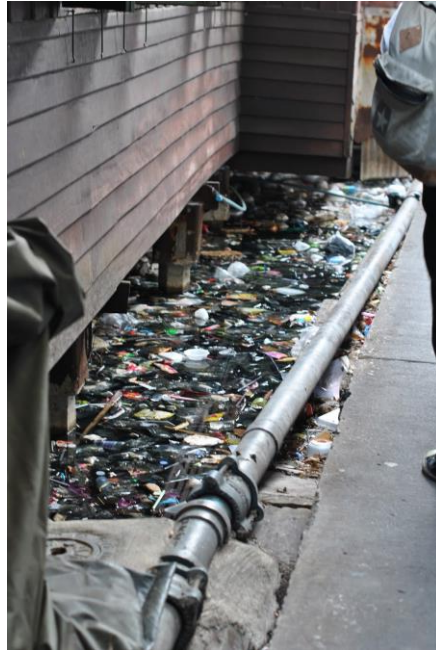


Figure 1: Contamination in the Khlong Toei Slum

## Methodology

To achieve the project goal and objectives, the team conducted background research and established the following methods: (1) observe daily life in the slum (2) map testing locations, (3) collect and test water from fire hydrants and water vending machines, (4) interview sector leaders, (5) survey residents, and (6) analyze the results. The team added a supplemental method to trial a hygiene educational program in a DPF school at the completion of the methods.

Observations addressed all of the project objectives. During walk through of the Khlong Toei Slum, the team noted and photographed the current conditions of the community and water networks, residents' water usage and locations of water vending machines and fire hydrants the team could collect water samples from.

Mapping water collection sites enabled the team to have records to inform the Duang Prateep Foundation about the water quality found at testing locations. The team mapped the fire hydrant and water vending machines sample locations in each of the three sectors. This method fulfilled the objective of establishing testing locations.

Water testing helped the team determine the potential presence of pathogens in the water. The water tests focused on indicating only pathogens since pathogens can cause the most detrimental health effects to humans compared to other contaminants. To test the quality of the water before and after water vending machine treatment, the team chose to collect water from fire hydrants and water vending machines, respectively. The team tested one fire hydrant and three water vending machines in each of the three sectors. Fire hydrants are connected to the main line provided by the Metropolitan Waterworks Authority and represent the water they supply to the slum. Guided by staff from the DPF to each of the testing sites, the team began water testing by first recording the geographical location of each site. The team labeled the collection containers, followed standard sterilizing, and collected water samples. Testing the water in the lab, the team followed standard testing procedures, as taught by Professor Sirirat of

Chulalongkorn's Microbiology Department, and performed the following three laboratory tests to determine pathogen contamination: presumptive, confirmed, and completed (Blodgett, 2010).

Results from the interviews with sector leaders and surveys with residents helped the team accomplish the objectives regarding the residents' water usage and perceptions on the water quality. The team interviewed the leaders of the three sectors to understand their role, obtain information on demographics and water management procedures, and determine the best location and time to conduct surveys in each specific sector. The team conducted thirty surveys within each of the three sectors of the Khlong Toei Slum studied.

To fulfill our last objective of recommending a sustainable drinking water management model, the team analyzed results from observations, water testing, interviews, and surveys.

After obtaining results from observations, the team discovered one of the biggest problems in the slum was the lack of hygiene practices. Unhygienic behaviors can contaminate safe-drinking water. Therefore, as a supplemental method, the team developed and conducted a trial hygiene education program for children aged 3-6. The program targeted children since they are the most susceptible to the harmful effects of consuming contaminated water and because they are, ultimately, the future of the Khlong Toei Slum.

## Results and Analysis

The team analyzed results from the data collected by the methods described above and determined the impact of the results in the project.

Observations such as the polluted water of the canal, and road defecation, lead the team to conclude that the Khlong Toei Slum residents face a substandard quality of life. In addition, finding dirt in the nozzle on the water vending machine and the overall appearance of vending machines suggest that **water vending machines do not receive regular upkeep.**

From the results obtained through water testing, the team found **water from the MWA, present in the fire hydrants, is free of pathogen contamination.** However, the team identified pathogenic contamination in one out of nine vending machines (11% of the tested machines). The tests conducted by the team, only identified the presence of pathogens, but other contaminants could exist. In conclusion, the team cannot deem the water from the fire hydrants drinkable, but rather, free from pathogenic contamination. However, the team has evidence that **the water from the vending machine, S<sub>2</sub>V<sub>1</sub>, which tested positive for pathogens, is undrinkable.**

After analyzing the interviews conducted, the team learned **residents do not require permission or approval to install a water vending machine, and maintenance of the machine is neither regulated nor enforced.** As a result, the team recommends a water vending machine maintenance program. Also, discussion with various stakeholders suggests that even though **sector leaders are not responsible for the water quality in the sector,** they could be a resource for the implementation of a management model. Sector leaders represent an authority in the sector and respond to community complaints, however, they cannot force residents to follow their orders, therefore, the presence of a higher authority will be needed for the implementation of a maintenance program.

The analysis of surveys led the team to understand the residents' water usage and perceptions of water quality. **42% of the residents drink water from in-home filters, and 23% from vending machines**, therefore the team planned to recommend a water management model that targets both sources to benefit the largest number of residents from the solution. Residents choose their drinking water sources because they believe those provide the best quality of water. Analyzing the ways in which residents perceive the drinking water sources they selected as trustworthy, suggests the need to raise awareness about the potential risks in drinking from these sources if residents do not properly maintain systems, in-home filters and water vending machines. Furthermore, the **presence of illness in 27% of the surveyed population** raises concern because residents are getting sick for an unknown reason. Although symptoms of the sick residents are consistent with those that arise from pathogen contaminated water, the team cannot conclude residents get sick because of the quality of water because the symptoms listed are associated with many illnesses not related to water quality such as food poisoning, the common cold, dengue fever, etc. Also, realizing that **52% of the residents do not think water can make people sick**, suggests that residents lack information regarding the negative health effects of consuming pathogenic contaminated water. Finally, only **9% of residents of the surveyed population that boil their water after consumption** indicate residents of the Khlong Toei Slum do not understand the benefits of boiling water.

After analyzing the results and conclusions, the team created three main deliverables: a water quality report, a community water evaluation, and a water management model. The water quality report developed by the team indicates whether or not pathogens are present in the samples of water collected and tested and if the samples passed or failed the three tests conducted. The team developed a community water evaluation to **represent the water usage and perceptions of the residents of the three sectors of the slum**. The water management model represents a way to address the current water quality situation in Khlong Toei. The model focuses on the importance of trial maintenance, and the implementation of a water vending machine maintenance model.

In addition, the results of the trial hygiene program, suggest the effectiveness of the educational campaign conducted in the Duang Prateep Foundation Kindergarten on March 3<sup>rd</sup>, 2015. Therefore, the team will recommend the conduction of the hygiene educational program in other schools around the slum.

## Recommendations and Conclusions

The project recommendations were informed by background research and the data we collected. They focus on improving the water quality in the Khlong Toei Slum by raising awareness of the current water quality issues, informing residents of point-of-use water treatment methods, implementing a water management model and a hygiene education campaign for schools, and, lastly, implementing future research projects in the Khlong Toei Slum.

The team recommended that the DPF initiate a campaign to raise awareness of the contaminated water issue throughout the slum. Raising awareness throughout the community addresses three parties. First, residents must be informed of the negative health effects of consuming contaminated water. Second, water vending machine owners and sector leaders should be educated on the water quality issue and presented with the team's water test results. Lastly, the Bangkok Metropolitan Administration should be



contacted to obtain their support in authorizing a water management system for the water vending machines. Together, the residents, water vending machine owners, sector leaders and the Bangkok Metropolitan Administration, represent an influential population in the Khlong Toei Slum. By making these parties aware of the current water conditions in the Khlong Toei Slum, the team believes there would be a stronger effort to improve the water quality.

Another recommendation of the team is to inform residents of point-of-use water treatment methods. Through surveys, the team discovered most of the residents use in-home filters for their water sources. Since the team was unable to test the water from this drinking source, the team recommends the DPF to distribute the pamphlet designed by the team. The pamphlet informs residents of the types of filters used to clean water, the cost of purchasing and maintaining these filters, and the benefits of boiling drinking water before consumption. These pamphlets may encourage residents to learn more about how to keep themselves and their families safe from pathogenic contamination.

The team's recommendation of a drinking water management model is primarily to implement a water vending machine and in-home filter maintenance program. The team believes that through the implementation of our recommended drinking water management model, the Khlong Toei Slum could see drastic improvements in their drinking water quality.

The team also recommends the DPF to implement a hygiene educational campaign in all schools of the slum to teach children about water contamination through unhygienic behaviors. Modeled after the program the team conducted, the campaign should focus on educating students about contaminants and how they affect people, transmission of pathogens and how to properly eliminate pathogens by washing your hands. Focusing on the education of younger generations may have the greatest impact because changing their habits can lead to a healthier lifestyle for the future.

The last recommendation of the team is for the DPF to continue future research projects to address the limitations of this project. Future research should include testing the water, based on Thai drinking standards, in all 27 sectors of the Khlong Toei Slum from the MWA water network, in-home filters, and water vending machines. This recommendation would establish the drinking water quality in the Khlong Toei Slum and identify all potential contaminants. Establishing this data would allow the DPF to implement a water management model that effectively eliminates all contaminants and distributes drinkable water for the residents of the Khlong Toei Slum.

In conclusion, the goal of this project was to address the issue of contaminated water in the Khlong Toei Slum and recommend a sustainable drinking water management model to improve the quality of life for the residents. Water testing identified water pathogen contamination in one water vending machine, suggesting the potential contamination of other untested vending machines. Surveys and interviews identified that residents consume water from two main sources, water vending machines and in-home filters. The survey and interview results offer a starting point to launch a larger social project. These recommendations will benefit not only residents in the Khlong Toei Slum, but could also benefit slums globally facing similar a water quality issue.



## 1 Introduction

Access to water fit for human consumption is an essential component for the health and livelihood of all people (Grey, Grey, & Sadoff, 2007). However, more than 3.4 million people worldwide die each year from substandard water quality. Studies by the Environmental Health Perspectives claim that contaminated water can negatively affect the health of communities by transmitting pathogens such as bacteria, protozoa, and viruses (Ford, 1999). Poor sanitation methods contaminate water through these harmful pathogens contained in untreated domestic sewage and solid hazardous wastes (Wiwanitkit & Suwansaksri, 2008). According to the Water Environment Partnership in Asia (WEPA), increasing population, economics, and the expansion of agriculture and industry in Thailand are the major causes of deteriorated water quality in various water sources, such as ground and surface water.

In 2013, the Thai Ministry of Interior installed water vending machines in four provinces of Bangkok to improve the quality of life for its inhabitants (Asian News Monitor, 2013). Following the initiative of the Thai Ministry of Interior, slum-dwellers of Khlong Toei installed water vending machines. Similarly, the Duang Prateep Foundation (DPF), the sponsor of this project, installed water filtration systems in schools throughout the Khlong Toei Slum to provide safe sources of drinking water for the children. However, the DPF recently verified through water testing, the presence of pathogen contamination in the water filtration systems of schools, and deemed the water undrinkable. This in turn, raised concerns of the DPF about the quality of water from the water vending machines installed around the slum. Some residents of this community depend on these sources for their drinking water but potential water contamination may negatively affect the people. To tackle the health issues that arise from the consumption of pathogenic contaminated water, this project investigated and compared the water quality from the main water line through fire hydrants and water vending machines to identify the presence of pathogen indicators in three sectors of the Khlong Toei Slum. The project recommends a sustainable water management model for the DPF with hopes that, if implemented, it could improve the community's drinking water.

Recommending a water management model for the Khlong Toei Slum required obtaining information regarding water quality, water usage of slum-dwellers, and residents' perception about water quality. Important research topics include pathogenic water contamination and the use of water sources throughout the slum. These topics represent gaps in prior research and established the foundation of this project. To help fill those gaps, the team tested water samples taken from three sectors in the slum to determine whether pathogenic contamination exists in the water. Furthermore, research helped the team understand where slum-dwellers collect drinking water, the reasons for choosing those sources of drinking water, and the different ways they use collected water from vending machines, in-home taps, and communal taps. Although in past years various teams have performed different projects in the Khlong Toei Slum, none have addressed the poor water quality in the community.

The goal of this project was to recommend a water management model to assist the DPF in improving the quality of life for residents in the Khlong Toei Slum. The objectives of the project were to establish water-testing locations, determine the potential presence of pathogens in the water, learn about the resident's water usage, learn about the perceptions of the residents on the current water issues, and recommend a water

management model to improve the current water system. The team's approach was to conduct observations, map water testing locations, collect and test water, interview sector leaders, survey slum-dwellers, and assess results. With the completion of the previously stated methods, the team held a formal presentation at the DPF headquarters to spark a dialogue between stakeholders and the residents regarding the quality of the drinking water. Also, the team conducted an educational campaign at school- teaching children aged 3-6 about the importance of safe hygiene practices. The culmination of these methods led to the production of a water quality report that presents the results of the water testing, a community water evaluation expressing the residents perception on the current drinking water quality and additionally, a recommendation for a water vending machine maintenance program, the encouragement of point-of-use water treatment methods, and an educational campaign for school children focused on proper hand washing.

This project explores Khlong Toei's land tenure history and its water network, water pathogen contamination, and water management models. First, the team introduced the land tenure issues that have challenged the community in obtaining drinking water. Second, the team traced the water from the Chao Phraya River to the Khlong Toei Slum to establish how water is distributed to the residents. Third, the team discusses pathogens regulated by the United States Environmental Protection Agency (U.S. EPA) that could potentially contaminate the water in the community. Lastly, the team introduces water management models that the DPF may implement to improve the current drinking water quality in the Khlong Toei Slum. This project serves as a cornerstone for future establishment of a water management rehabilitation program for the Khlong Toei Slum and could serve as a guideline for drinking water development in slums globally. This report details the project team's research area, methods of obtaining new data, analysis of data collection results, and finally, recommendations that could contribute to improvement of the current drinking water quality in the Khlong Toei Slum.

## 2 Background

### 2.1 Khlong Toei Slum

Bangkok, known as the thriving urban center of Thailand, is also home to thousands of impoverished residents living in makeshift shanties in the Khlong Toei Slum. Bordering central Bangkok, as seen in Figure 2-1, the Khlong Toei Slum resides on a network of partially paved roads and wooden boardwalks covering three-meter-deep beds of swampland (Elliott, 2003).



Figure 2- 1: The Khlong Toei Slum Bordering the City Life of Thailand (London & London, 2013)

The Khlong Toei Slum, known for its high-density population, falls within the United Nations' slum definition. A slum is a heavily congested and often poorly built temporary settlement, which is commonly defined by the lack of one or more of the following four amenities (Pokhariyal, 2005; UN-Habitat, 2008):

1. Housing infrastructure resistant to extreme climate conditions
2. Access to drinkable and affordable water in a sufficient amount
3. Access to sanitation facilities such as a private or public toilet shared with a reasonable number of people, and
4. Presence of medical and social facilities that serve the community's needs.

The Khlong Toei Slum may face a water quality issue that relates to the lack of the second and third amenities described above.

In Khlong Toei, residents receive limited recognition from public authorities. As a consequence, basic utilities such as water and electricity have lacked behind municipal standards (Angel & Boonyabancha, 1988). Lack of land tenure is one of the slum resident's most critical obstacles in obtaining drinkable water. Subsections of 2.1

introduce the Duang Prateep Foundation and discuss the history of three sectors of the Khlong Toei Slum and land tenure issues that affect utility implementation.

### 2.1.1 The Duang Prateep Foundation

The Duang Prateep Foundation (DPF), the sponsor of this project, is a non-governmental organization based in Bangkok, Thailand. Established in 1978 by Mrs. Prateep Ungsongtham Hata, the mission of this organization is to provide aid to the Khlong Toei Slum in three major areas. The first area is education to youth in impoverished communities. The second is to provide guidance in vocational studies and craftsmanship. Lastly, the Duang Prateep Foundation aspires to stimulate healthy living within communities (Hata, 2010). The Foundation, operating for about thirty-six years to date, is now working on over twenty projects to help change the lives of people living in the Khlong Toei Slum (Duang Prateep Foundation, 2014).

### 2.1.2 History of Sectors in the Khlong Toei Slum

Irrigated by canals since the 18th century, Bangkok became “known as the “Venice of the East” during much of the 19th century” (Bodry, 2012). Bordering the Chao Phraya River, Khlong Toei’s name originates from Bangkok’s canal history (Elliott, 2003). The word “*khlong*” is Thai for canal while “*toei*” is the name of the trees that ran along the side of the waterways (DiNino, 2006).

The Khlong Toei Slum community consists of 26 sectors in total. The Duang Prateep Foundation narrowed the team’s research down to three sectors: Chom Chun Rim Khlong Phra Kra Nong, (Sector 1), Chum Chon Wat Khlong Toei Nai (Sector 2), and Chum Chon Mhoo Baan Pattana Jed Sib Rai (Sector 3). The team chose these sectors, with the help of the DPF, based on their distribution throughout the Khlong Toei Slum. Figure 2-2 is a map of the Khlong Toei Slum that locates the three sectors the team studied. The purple, green, and pink blocks represent Sectors 1, 2 and 3, respectively.



Figure 2- 2: Sectors in the Khlong Toei Slum

The Port Authority of Thailand (PAT) owned the area of Sector 1, Chum Chon Rim Khlong Phra Kra Nong, until the Port handed the land over to the Tanning Leather



Organization for construction of a factory. Approximately 2,500 employees working for the organization rented the area. In 2007, a royal decree abolished the tanning business and gave the land to the Quartermaster Department Royal Thai Army (Tee, 2011), a governmental pillar associated with logistics (Army, 2015). According to the sector leader, Mr. Chaichayun Chaengcharoen, some of the former residents of this sector moved away after the tanning business ceased operation. The current population of 1,036 residents consists of newcomers and former workers that remained after the factory shut down (Refer to Appendix J-2 for the team’s interview with sector leader 1).

The establishment of sector 2, Chum Chon Wat Khlong Toei Nai, began in 1919. Residents looking for jobs near the port initially settled into this sector, which was owned by the PAT. According to the sector leader, Mr. Punya Silaluk, the old canal in this sector is the reason for the community being named Khlong Toei. The area used to be a marsh that became immensely overcrowded with residents until there was no longer any free space. At the time of establishment, there were no paved streets or buildings. Over time, residents built houses and market places, tightly packed together. In 1991, there was a great fire that wiped out the whole sector due to the dense concentration of building and shacks inside the slum. After the incident, the community reconstructed and has been making improvements since, forming Chum Chon Wat Khlong Toei Nai to what it is today (Securities, 2007). Currently, there are around 1,600 residents living in 425 households (Refer to Appendix J-4 for the team’s interview with sector leader 2).

In 1994, former residents of Chum Chon Lot 12 established sector 3, Chum Chon Mhoo Baan Jed Sib Rai. According to the sector leader, Mr. Thongkum Saekow, the Port Authority of Thailand and the National Housing Authority helped establish this sector after the port requested to reclaim the Lot 12 area. Initially, when the Port Authority of Thailand attempted to evict residents living in Lot 12, the residents protested eviction. As a result, the port decided to help establish a new sector for the residents of Lot 12, now known as Chum Chon Mhoo Baan Pattana Jed Sib Rai (Securities, 2007). Sector 3 is currently home to around 9,000 residents living in 1,183 households (Refer to Appendix J-6 for the team’s interview with sector leader 3). Table 2-1 shows a comparison of demographic data in each of the three sectors.

**Table 2- 1: Comparison of Demographic Data of the Three Khlong Toei Sectors**

Name	Area	Total Population	Families	Households	Community Committee
<b>Chum Chon Rim Khlong Phra Kha Nong</b>	0.054 square kilometers	1,036 people	370	230 houses	14 people
<b>Chum Chon Wat Khlong Toei Nai</b>	0.0192 square kilometers	1,600 people	400	300 houses	9 people
<b>Chum Chon Mhoo Baan Pattana Jed Sib Rai</b>	0.113 square kilometers	9,000 people	2,000	1,183 houses	25 people

The three sectors in the slum experienced different historical events, but all three experienced land tenure issues and the lack of proper utility implementation with the

government. The Khlong Toei Slum, covering a 12.3 square kilometer area, consists of over 100 thousand migrants (Duang Prateep Foundation, 2014). Most residents of the Khlong Toei Slum do not own rights to the land they live on and therefore face eviction everyday (Asian Coalition for Housing Rights, 2003).

### **2.1.3 Disputed Land Tenure Issues in Utility Implementation**

Slum-dwellers in the Khlong Toei Slum, including residents of the three sectors that are the focus of this project, generally “have secure housing tenure, but many do not have secure land tenure” (Asian Institute of Technology, 2008). Therefore, residents own houses but do not own the property where their homes reside. Lack of secure land tenure is an issue because under no land tenure contract, the Thai government is not responsible for providing basic utilities. Thus, many slum communities lack basic facilities such as water supply or waste removal.

Eviction is not a feasible option for the Thai government due to the large slum population. To aid in land tenure issues, the Thai government signed land-sharing agreements. In 1981, the Port Authority of Thailand signed a land sharing agreement with residents of the Khlong Toei Slum (Angel & Boonyabancha, 1988). In the land sharing agreements, the slum-dwellers living on government property had to condense their housing into a smaller section of the disputed area so that the government could use the rest of the land for city development (Pacione, 2005). According to a representative from the Duang Prateep Foundation, under the land-sharing agreement, the residents have permission to live on the land owned by the Port Authority. However, the Port Authority has the right to evict the residents at any moment. Since the residents legally live in the Khlong Toei District, the government had to supply the residents with water. In 1982, shortly after the signing of the land sharing agreement, the Metropolitan Waterworks Authority (MWA) established a water network throughout the slum.

## **2.2 Water in the Khlong Toei Slum**

Water is a vital aspect in sustaining life and in the Khlong Toei Slum water is used not only for drinking. Residents use water for cooking, cleaning dishes, showering, and for so much more. The supply of drinkable water is crucial. While the Khlong Toei Slum residents have access to water, there are doubts in the quality of the water distributed to the residents. This section discusses the transmission of water into the Khlong Toei Slum from the intake of raw water from the Chao Phraya River to the consumption of water by residents of the Khlong Toei Slum.

### **2.2.1 Water Utility Network Serviced to Khlong Toei**

The Khlong Toei district receives water through a distribution network by the Metropolitan Waterworks Authority. The MWA, a state enterprise under the Thai Ministry of Interior, is responsible for clean, disinfected water production, transmission, and distribution to people living in three provinces: Bangkok, Nonthaburi and Samut Prakan. The Bangkhen Water Treatment Plant (Bangkhen WTP) serves as the center for water filtration and transmission for the city. The MWA follows the World Health Organization (WHO) standards to control its water quality, ensuring that the water treated is drinkable (Metropolitan Waterworks Authority, 2010).

Figure 2-3 shows the path of water traveling from the Chao Phraya River to Khlong Toei. The water process encompasses six steps: raw water extraction,

clarification, filtration, water storage, transmission, and distribution. The water network starts in the Chao Phraya River where the Sam Lae Pumping Station takes raw water, meaning untreated, into the East Canal until it reaches the Bangkok WTP. The water pumping stations transport raw water through the influent channel to the clarification section. The clarified effluent channel then delivers the water to rapid sand/anthracite coal filters. Water storages, called reservoirs, collect filtered water. To meet the MWA drinking water standards, the water receives doses of post-lime and chlorine, disinfecting substances. Pumping stations transmit and distribute the treated water from the Bangkok WTP to the majority of MWA customers through water tunnels and conduits. Transmission Pumping Station No. 2, which is part of the East Pumping Stations, distributes water to many pumping stations including the Khlong Toei Distribution Pumping Station (Khlong Toei DPS). Once in Khlong Toei, water reaches the customers through the MWA branch offices of the district (Metropolitan Waterworks Authority, 2010).

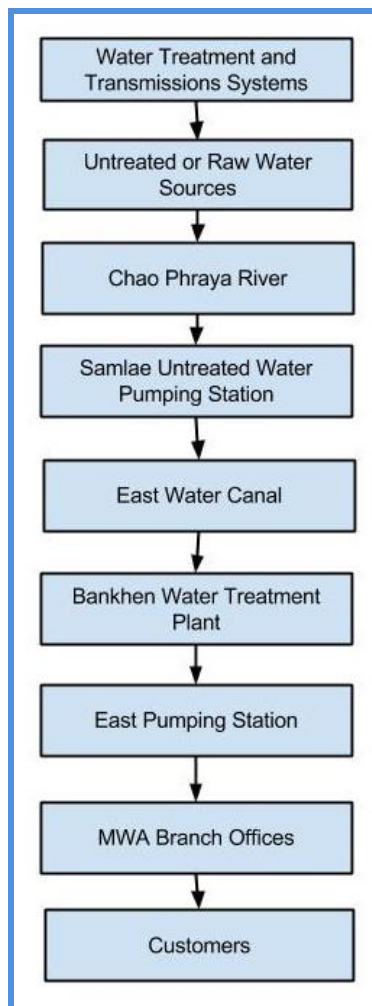


Figure 2- 3: Route of Water from Chao Phraya River to Bankhen Water Treatment Plant (Metropolitan Waterworks Authority, 2010)

Water enters the slum community through main pipelines that are located along the streets of the slum. From these pipelines, local residents connect smaller pipes to the

MWA meters, bringing water to their households. Before the water gets into their residences, it passes through a water meter owned by the MWA, which measures the amount of water each household consumes on a monthly basis. The MWA is responsible for the quality of the water before the meter, giving homeowners responsibility for the water that enters their houses. According to DPF, damaged underground pipelines and leakage lead to poor water quality. Following this assumption, lack of maintenance of in-home pipes may result in poor quality water, exposing slum-dwellers to contaminated water on a daily basis. Figure 2-4, presented below, serves as an example of a water meter connected to a main pipe in the Khlong Toei Slum.



Figure 2- 4: Water Meter in the Khlong Toei Slum

### 2.2.2 In-Home Filters

According to the results of the surveys the team conducted during this investigation, 42% of the surveyed residents use in-home filtration systems as their main source of drinking water. The in-home filters link to the residential pipelines that are attached to the MWA meters. According to sector leader 2, slum-dwellers buy in-home filters from different companies' salesmen that walk around the area offering promotions to buy filters on a monthly payment plan. Consequently, even though the price of filters is high (roughly ฿3,000) residents can afford the payment and accept the promotion.

Examples of filtration systems used in Khlong Toei and in Thailand include: 3 purifier filter, Air Filter 4 Filter, Sistema, and eSpring water treatment. Figure 2-5 displays the filters used in the Khlong Toei Slum, and the filters these systems are composed of.





Figure 2- 5: Filtration Systems in the Khlong Toei Slum and Thailand

The process of filtration aims to treat and ensure safe water for consumers and each filter treats for specific contaminants. Water filtration removes suspended impurities or recovers solids by passing through substances such as cloth, paper, porous porcelain or a layer of charcoal or sand (filtering, 2015). There are different types of filters for each type of contaminant. Filtration systems include a combination of filters to address more than one type of contamination. Table 2-2, shows specific filters, their functions and the recommended maintenance.

Table 2- 2: Specific Filters and Their Main Functions

Filters	Function	Maintenance (KP Thai Vending, 2014)
<b>Sediment Filter</b>	Sediment filters reduce sediments, solid materials that settle at the bottom of liquid, of a certain micron size from the water (LennTech, 2015).	Check every 1-2 months. If dirt found, replace filter.
<b>Polypropylene Filter</b>	Polypropylene Filter (PP) separates particles from liquid (Raihan Bin Abdul Rashid, 2012)	
<b>Granular Activated Carbon Filter</b>	Granular Activated Carbon filters make use of activated carbon to absorb different harmful chemicals. Activated carbon is carbon engineered to have more of an electro-positive charge to better attract chemicals and other impurities (Home Plus Water, 2015).	Replace every 6-8 months.
<b>Ion Exchange Resin Filter</b>	The ion exchange resin take the advantage of positive and negative charge inside the filter, cation and anion resins, to attract the contaminants such as inorganics components and heavy metal contents such as Lead, Cadmium, Copper, etc. (Pure, 2010)	Caution exchange resins need to replace every 7 years. Anion exchange resins need to replace every 4 years (W.S. Miller, 2009)
<b>Carbon Block Filter</b>	Although similar to the Granular Activated Carbon filter, Carbon Block filters are more effective because the filter consists of a powdered block that is	Replace annually, or every 8-12 months, or when water has an unpleasant odor.

	so dense that water travels through it slowly. The longer the water is in contact with carbon, the more impurities the carbon can catch (The Water Page, 2012)	
<b>Ultraviolet Filtration</b>	The properties of Ultraviolet light destroy pathogens by attacking the microorganism's DNA, thus limiting the ability of the pathogen to reproduce (APEC Water Systems, 2014)	Replace bulbs annually. Replace quartz sleeve when broken. The quartz sleeve should be cleaned several times per year (outside only) (Home Plus Water, 2014)
<b>Membrane Filtration</b>	Membrane filtration filters out debris and particles by a special porous membrane. Only certain particles, depending on the characteristic of the membrane, are small enough to pass through the pores of this special membrane, while the membrane holds back large particles. (Mountain Empire Community College, n.d.)	Replace every 1-2 years. When the flow of water is not normal, replace filter.
<b>Ultrafiltration</b>	Ultrafiltration has a high removal rate to filter out protozoa, bacteria, and viruses. It is not as useful in removing certain kinds of chemicals (Prevention, 2012)	

Filtration systems vary according to the contaminants present in the water. Most of the filtration systems trap particles to ensure clarity in the water, but not all systems kill microorganisms and bacteria (Natural Resources Defense Council, 2006).

### 2.2.3 Water Vending Machines

In 2013, the Thai Ministry of Interior installed water vending machines throughout Bangkok to improve the quality of life of the people (Asian News Monitor, 2013). According to the Duang Prateep Foundation, many households in the Khlong Toei Slum, mimicking the strategy of the Thai Ministry of Interior, installed water vending machines for public use to help overcome the risks of being exposed to contaminated drinking water. Homeowners purchase the water vending machines for roughly ฿30,000 and profit from community use of the water vending machine. Users bring their own containers and can fill them at the water vending machine. The price of the water from water vending machines is ฿1 per liter of water. The water vending machines intake water through the homeowner's pipes, which are connected to the MWA water network pipelines, and the water travels into the water vending machine through an interior filtration system to improve the quality of water.

During water collection in the Khlong Toei Slum, the team noted the presence of an abundance of water vending machine brands. Several water vending machine brands include Siam Water, Ozone Plus, D-Fresh and PG Water. Figure 2-6 displays these four vending machines.

The water filtration system of a water vending machine is composed of multiple stages: a four stage pre-filtration, reverse osmosis, and a two stage post-filtration system. The pre-filtration system consists of two screen filters, which are a sediment filter and a carbon filter. Reverse osmosis is the process in which water travels through a membrane filter (National Sanitation Foundation, 2015). The post-stage filtration system consists of a carbon block filter and a UV sterilizer. The water pumps through the vending machine and dispenses at a flow rate of 3-3.5 gallons per minute. Table 2-3 in the previous section shows the purpose and maintenance of each of the filters found in water vending

machines including sediment filters, carbon block filters, membrane filters and UV sterilizers.



Figure 2- 6: Water Vending Machines in the Khlong Toei Slum

If working properly, water vending machines should deliver filtered, purified water. Yet, according to Thailand’s Health Department, only 70% of drinking water from vending machines in Bangkok meet water quality standards (The Nation, 2011). In the case of the water vending machines in the Khlong Toei Slum, it is unknown whether the dispersed water is meeting Thai drinking standards determined by the Water Environment Partnership in Asia (WEPA). Water vending machines require filter replacement depending on each filter, which could range from every three to six months. In the case of water vending machines in the Khlong Toei Slum, the team does not know if the water vending machines receive maintenance regularly, or whether the machines are malfunctioning. Moreover, the Duang Prateep Foundation tested the water from filtration systems in schools and found bacterial contamination. Consequently, DPF believes the water from vending machines may be contaminated as well, leading to diarrhea and other water-related diseases.

### 2.3 Negative Impacts of Pathogenic Water Contamination

A water contaminant is defined as a physical, chemical, or biological factor that affects the quality of water (Goel, 2006), see Figure 2-7. A biological factor that commonly contaminates water is a water pathogen.



Figure 2- 7: Water Contamination in the Khlong Toei Slum

The Environmental Protection Agency (EPA) regulates four pathogens in drinking water: cryptosporidium, giardia lamblia, legionella, and enteroviruses. Although there are other contaminants which affect the quality of water and can lead to health effects for people, this project focused on pathogenic contaminated drinking water. The team chose to narrow the research to pathogen contamination due to the likelihood of their prevalence in the slum conditions. Additionally, pathogenic contaminants have the potential to cause a multitude of serious water-related diseases. When pathogens such as bacteria, protozoa, and viruses are present in drinking water, people consuming these contaminants may suffer ailments such as diarrhea, amoebiasis, typhoid, cholera, giardiasis, and dracunculiasis (Ford, 1999). Some of these diseases are fatal while other diseases cause severe side effects to people. This section explores the EPA regulated water pathogens of cryptosporidium, giardia lamblia, legionella, and enteroviruses, their health effects, sources of contamination, treatment, and preventative measures.

### 2.3.1 Cryptosporidium

Cryptosporidium, also known as Crypto, is a microscopic parasite that lives in the intestines of infected humans or animals. Crypto exists in food, soil, water, or surfaces that have been in contact with contaminated human or animal stool (Center for Disease Control Prevention, 2011). The most common methods of transmission are through drinking water and recreational water sources, such as swimming pools, which have been infected with the feces of contaminated humans or animals (Center for Disease Control Prevention, 2011).

Cryptosporidium causes most “gastrointestinal parasite infections”, and waterborne diseases, leading to “watery or mucous diarrhea with abdominal pain” for “immunocompetent individuals”. For immunocompromised individuals, crypto could lead to dehydration due to chronic diarrhea (Hunter & Nichols, 2002). Other symptoms are nausea, vomiting, fever, and weight loss (Center for Disease Control Prevention, 2011). Developing countries’ citizens and travelers may be at higher risk of crypto infection due to poor water treatment methods and food sanitation practices (Center for Disease Control Prevention, 2011).

In contrast with other parasites, crypto is resistant to chemical treatments due to its outer shell. Crypto stops being infectious through heat treatment such as boiling, therefore sterilized and pasteurized products do not pose threats to human health



(Snelling et al., 2006). It can also be removed from drinking water through several filtration methods. Practicing good hygiene reduces the risk of contracting Crypto infection. Therefore, people can prevent Crypto by minimizing contact with human and animal feces, as well as washing hands with soap for 20 seconds after using the restroom, preparing or eating food, and changing diapers (Center for Disease Control Prevention, 2011).

### 2.3.2 Giardia Lamblia

Giardia Lamblia is “a single-celled protozoan parasite in the genus *Giardia* that causes gastrointestinal disease” (Center for Food Security and Public Health, 2012). The genus *Giardia* develops in two stages: cysts and trophozoites (Centers for Disease Control and Prevention, 2012). According to the CDC, cysts thrive in water and are able to survive for several months in a cold environment (Centers for Disease Control and Prevention, 2012). The transmission of cysts occurs directly through consuming contaminated water, food, and surfaces as well as through contact with those infected (Centers for Disease Control and Prevention, 2012).

When consumed, the small intestine releases trophozoites from the ingested cyst. The trophozoites reproduce and eventually create more cysts. The life cycle of *Giardia* concludes with the newly formed cysts being released from the body through excretion. The process causes symptoms such as hives, diarrhea, stomach pain, nausea, vomiting, and dehydration (Centers for Disease Control and Prevention, 2012).

Direct treatments for water contaminated with *Giardia* include boiling and filtration systems (Pearson, 2007). To deter *Giardia*, homeowners may use filters with one or more of the following specifications: (1) Reverse osmosis, (2) Absolute pore size of 1 micron or smaller, (3) Tested and certified by NSF Standard 53 for cyst removal or, (4) Tested and certified by NSF Standard 53 for cyst reduction (Centers for Disease Control and Prevention [CDC], 2012). The CDC encourages healthy hygiene, such as washing hands and cleaning commonly used surfaces in both public and private areas to prevent giardia (Centers for Disease Control and Prevention, 2012).

### 2.3.3 Legionella

The bacteria *Legionella* is an aerobic bacteria that exists in the environment, most commonly in fresh, salt, and potable water (United States Environmental Protection Agency, 2000). *Legionella* in water poses health risks if the bacteria are present in aerosolized form and then inhaled (United States Environmental Protection Agency, 2000). Some systems that pose these risks include “faucets, showerheads, cooling towers, and nebulizers” (United States Environmental Protection Agency, 2000). Transmission to people often occurs through contact with the environment rather than through contact with other people (United States Environmental Protection Agency, 2000).

Nearly everyone is potentially susceptible to infection from *Legionella*. Through the inhalation of the bacteria, *Legionella* can result in Legionnaires disease, which is a type of pneumonia (United States Environmental Protection Agency, 2000). Symptoms of Legionnaires disease include cough, shortness of breath, high fever, muscle aches and headaches. Typically, the infected person will display symptoms two to fourteen days after being exposed to the bacteria (CDC, 2015). Individuals with weakened immune systems are more prone to become seriously ill when infected with *Legionella* such as

hospital patients and people taking immunosuppressive medications (United States Environmental Protection Agency, 2000).

Legionnaires disease requires antibiotic treatment with drugs that kill bacteria in the body. Successful treatment of Legionnaires disease is obtainable, however patients often require hospitalization (CDC, 2015). Proper maintenance of water systems, including drinking water systems, can prevent the proliferation of Legionella (CDC, 2015). It can also be prevented through filtration systems such as UV light sterilization or point of use treatment methods (United States Environmental Protection Agency, 2000).

#### **2.3.4 Enteroviruses**

Enteroviruses are one of the most common viruses found in humans (Centers for Disease Control and Prevention, 2013a). Researchers have identified 64 enterovirus serotypes, which infect humans (Palacios & Oberste, 2005). These viruses can combat the conditions of the gastrointestinal tract “as they thrive in an environment with a pH of 3-5” (Rajtar, Majek, Polanski, & Polz-Dacewicz, 2008). Transmission of enteroviruses occurs through contaminated water, surfaces/objects, and feces (Centers for Disease Control and Prevention, 2013a). They also flourish in both salt and freshwater environments (Rajtar et al., 2008). Untreated water sources such as drinking water, groundwater, rivers and seas can contain enteroviruses (Rajtar et al., 2008). Epidemics of enterovirus infections are typically waterborne, posing a high risk to human health in populations throughout the world.

These viruses lead to many human diseases and are responsible for approximately 10-15 million illnesses per year in the United States (Centers for Disease Control and Prevention, 2013a). Some strains of the virus are asymptomatic while others are symptomatic (Centers for Disease Control and Prevention, 2013a). Diseases include fever, muscle aches, respiratory illness, cardiovascular diseases, meningitis, herpangina, hand, foot, and mouth disease, paralysis, and encephalitis (Centers for Disease Control and Prevention, 2013a; United States Environmental Protection Agency, 2013).

Prevention of enteroviruses is possible, but these viruses are problematic to treat. Researchers have not developed a vaccine but healthy habits can stop them from spreading. The CDC encourages people to frequently wash their hands and not to physically contact others sick with the virus (Centers for Disease Control and Prevention, 2013b). Infected people often recover from their symptoms with little to no treatment while others require hospitalization. Strains of the virus cannot withstand types of water filters but can withstand some chemical treatments (Centers for Disease Control and Prevention, 2013b).

Table 2-3 lists the four pathogens discussed with a description of the pathogen, transmission methods, health effects, preventative measures and treatment.

**Table 2- 3: Water Pathogen Contamination**

Pathogen	Description	Transmission Methods	Health Effects	Preventative Measures	Treatment
<b>Cryptosporidium</b>	Microscopic parasite	Contaminated drinking and recreational water sources	Diarrhea Nausea Vomiting Fever	Frequent hand washing	Filtration POU Pasteurization
<b>Giardia Lamblia</b>	Protozoan parasite	Contaminated food, water, and surfaces	Diarrhea Stomach pain Vomiting Dehydration	Frequent hand washing  Cleaning commonly used surfaces	Filtration
<b>Legionella</b>	Aerobic bacteria	Contact with environment	Shortness of breath Muscle aches Cough	Maintenance of filtration	Filtration POU
<b>Enteroviruses</b>	Virus with 64 serotypes	Contaminated drinking water	Cardiovascular diseases Hand, foot, mouth disease Paralysis	Frequent hand washing	Chemical

## 2.4 Testing for Water Pathogen Indicators

Pathogen indicators are physical or chemical qualities that reflect water pathogen contamination when the presence is outside a specified limitation (United States Environmental Protection Agency, 2013). Pathogen indicators regulated by the EPA include turbidity, total coliforms, and fecal coliforms. This section will provide information regarding the description and linked health effects of the EPA regulated pathogen indicators.

### 2.4.1 Pathogen Indicators

Pathogen indicators range in their origins, health effects to humans, and the pathogens they indicate. The table below, Table 2-4, outlines these qualities for each of the EPA regulated water pathogen indicators.

**Table 2- 4: Pathogen Indicators**

Pathogen Indicators	Origin	Health Effects	Indicates for
<b>Turbidity</b>	Viruses or Bacteria attached to suspended particles	Does not affect health but interferes disinfection process	Bacteria, Viruses, and Parasites
<b>Total Coliforms</b>	Found in environment (soil, vegetation, animal waste, or surface water)	Ranges from no ill effects to cramps and diarrhea and other gastrointestinal distresses	Pathogenic bacteria
<b><i>E.coli.</i></b>	Human and animal waste	Diarrhea, cramps, nausea, headaches. More severe in infants and people with immunodeficiency	Fecal coliforms

### 2.4.2 Water Testing

The United States Food and Drug Administration (U.S. FDA) presents their Bacteriological Analytical Manual (BAM) to the public, detailing information about “preferred laboratory procedures for microbiological analyses.” (U.S. Food and Drug Administration, 2015). This manual provides instructions to determine pathogens present in a wide range of food and beauty products. In 2000, the manual was published on the U.S. FDA website, allowing world-wide access and unceasing edits (U.S. Food and Drug Administration, 2015). The ease of protocol and ever-developing “rapid methods” for test results allows replication on water testing (U.S. Food and Drug Administration, 2015).

The United States Public Health Service Drinking Water Standard developed the Most Probable Number (MPN) method in 1914 (Ashbolt, Grabow, & Snozzi, 2001). The method involves three rounds of tests called Presumptive, Completed, and Confirmed. Figure 2-8 displays prepared test tubes to conduct the presumptive test. Analysis of final results of the tests performed should take place within seventy-two hours of initial tests. Since the 1930’s, scientists have used this method to analyze food and water for non-fecal and fecal bacteria, or coliforms. Its use includes identifying all types of coliforms, including *E. coli* (Ashbolt et al., 2001). MPN is known to be useful in identifying lower concentrations of organisms, and allowing researchers to understand the growth units of bacteria present in the medium being tested. MPN is an effective method of testing for water pathogen indicators to assess water quality.



Figure 2- 8: Prepared Test Tubes for Presumptive Test

### 2.5 Water Management Methods

A water management method is a system or procedure that manages, handles, directs, or controls the use of water resources for safe drinking purposes (Management, n.d.). Efforts made globally by researchers and social scientists addressed the lack of access to quality water through the implementation of different water management methods. “Point-of-use (POU) water treatment technology has emerged as an approach that empowers people and communities without access to safe water to improve water quality by treating it in the home” (Sobsey, Stauber, Casanova, Brown, & Elliot, 2008). According to the Department of Environmental Sciences and Engineering of North California, the improvement of household drinking water at the point of use can lead to



“30-40% reductions in diarrheal disease cases” (Sobsey et al., 2008). The World Health Organization (WHO) describes different methods of drinking water treatment at the point of use in emergency situations or extreme conditions, such as those of slums. Some of the recommended methods are boiling water, water filtration, and improved hygiene practices (Kayaga & Reed, 2011).

Worldwide, people use boiling as a point-of-use treatment method (Sobsey et al., 2008). Boiling water removes pathogens when properly executed. The steps to effectively boil water entail: bringing the water to a boil for five to twenty minutes, allow the water to cool, store in a closed container, and finally refrigerate, if preferred (World Health Organization, 2012). Boiling water is a simple point-of-use water treatment method, which residents of the Khlong Toei Slum may achieve.

Filtration is the process of cleansing water through the passage of a porous medium which aims to provide clear, good-tasting, and contaminant free water (World Health Organization, 2012). There are different types of filters for different types of contaminants, therefore, understanding the type of contaminants present in the water is necessary in determining which filter to purchase. The presence of pathogens is common in environments similar to the Khlong Toei Slum; therefore filters that address pathogenic contamination are necessary. According to the CDC and EPA, reverse osmosis, ultrafiltration, and ultraviolet filtration are all recommended methods for effective and safe removal of pathogens such as crypto, giardia lamblia, and legionella from drinking water (Prevention, 2012; United States Environmental Protection Agency, 2000). Furthermore, filtration systems, including in-home filters and water vending machines, require regular maintenance to perform effectively. Lack of filter maintenance can result in a worsened quality of water by releasing bacteria back into the water. Each filter has different guidelines indicated in Table 2-2 that explain how regularly the cartridges need to be changed (Natural Resources Defense Council, 2006). Residents have implemented filtration in the Khlong Toei Slum through in-home filters and water vending machines, however, without proper maintenance; point-of-use water treatment methods could be ineffective or cause contamination.

The World Health Organization emphasizes that hygienic behaviors are equally important as the supply of clean water (Kayaga & Reed, 2011). The benefits of point-of-use water treatment systems can be lost due to contamination from poor hygiene (Kayaga & Reed, 2011). In relation to drinking water, hand washing is the most effective method to preventing recontamination of safe drinking water. Washing hands before dealing with drinking water is a simple precautionary measure that residents of the Khlong Toei Slum could immediately implement.

Restricted by poverty, unsanitary living conditions, and deteriorating water networks, residents of the Khlong Toei Slum lack access to quality drinking water. Point-of-use water treatment methods offer a, “safe survival level supply of drinking water from unsafe polluted water sources” (World Health Organization, 2012). In conclusion, point-of-use water management methods could serve as viable options for residents of the Khlong Toei Slum.

## **2.6 Summary of Background**

Lack of access to water fit for human consumption negatively affects the health and quality of life for those living in many slum communities. The Khlong Toei Slum, characterized by its high-density population, poverty, and land tenure issues, exemplifies

this situation. By researching the history of the slum, the water network that serves the district, water pathogens and their indicators, and water management methods, the team better understood the current water situation and created methods to obtain missing information.

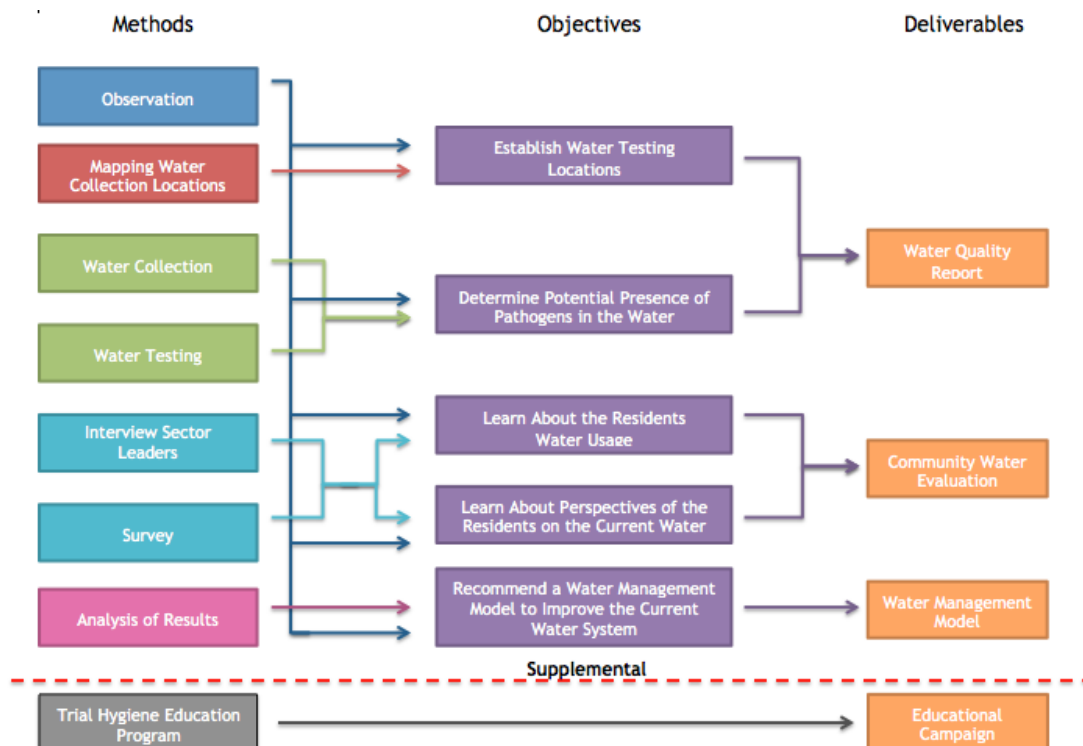
### 3 Methodology

This project addressed the socially important problem of contaminated water in the Khlong Toei Slum through the following objectives: (1) to establish water testing locations, (2) to determine if there are pathogens present in the water, (3) to learn about the residents’ water usage, (4) to learn about the perceptions of the residents on the current water issues, and (5) to recommend a drinking water management model to improve the current water system. Table 3-1 shows the three sectors that the Duang Prateep Foundation specified for the team to study and Figure 2-2 indicates the three sectors in a map of the Khlong Toei Slum.

**Table 3- 1: Sector Names of Khlong Toei Slum**

Sector Number	Sector Name
1	Chom Chun Rim Klong Pra Kra Nong
2	Chum Chon Wat Khlong Toei Nai
3	Chum Chon Mhoo Bann Pattana Jhet Sip Rai

The team designed a methodology, which included seven phases: observation, mapping water collection locations, water collection, water testing, interview sector leaders, survey residents, and analysis of results. At the completion of the methods, the team added a supplemental method of a trial hygiene education program in a DPF school. Figure 3-1 outlines the scope of the methodology for the project and displays the addition of the supplemental method with the red, dashed line. Appendix B includes a Gantt chart detailing the timeline of the project. This chapter discusses these methods in the context of the project objectives.



**Figure 3- 1: Methodology, Objectives and Deliverables**

### 3.1 Observation

Observations addressed all of the team’s objectives and filled knowledge gaps between the research presented in the background chapter and the reality of water quality and usage within the Khlong Toei Slum. Observing local gathering places identified possible locations where surveys may have a high response rate. This allowed the team to determine the most convenient place and time for the residents to take surveys. The team also used observations to determine the current conditions of the water networks, how the residents used water, the location from which residents obtained their water, evidence of poor sanitation, and the locations of water vending machines and hydrants to use for water sampling. The team made observations by taking several full-day visits to the three sectors targeted in Khlong Toei, taking notes, and taking photos of the water network including items such as water meters, broken pipes, and communal taps in the slum. The observer also wrote the time, day, and sector location they took notes to consider if any of these three factors change in comparison or affect daily habits of the community members. Table 3-2 shows the specific time, date, and sector locations the team made observations.

**Table 3- 2: Slum Visits, Dates and Locations**

Time and Date	Sector Location
Tuesday, January 13 3:00 pm	Sector 3
Wednesday, January 28, 2015 10:00 am	Sector 3
Thursday, January 29, 2015 2:00pm	Sector 1
Thursday, January 29, 2015 3:30 pm	Sector 2
Tuesday, February 3, 2015 1:30 pm	Sectors 1, 2, 3

### 3.2 Mapping Water Collection Locations

Mapping water collection sites enabled the team to record locations to inform the Duang Prateep Foundation about the water quality found at testing sites. The team mapped the fire hydrant and water vending machine sample locations in each of the three sectors. The team chose to collect the water before and after it went through the filtration systems in the water vending machines. The water collected from the fire hydrants is the water that runs through the main pipelines throughout the Khlong Toei Slum before going through the filtration systems in the vending machines. This same water runs into people’s homes. The water taken from the vending machines undergoes four steps of filtration, as described in Section 2.2.2.

Smartphones have the capability of locating the geographical location using a compass application. At each collection site, the team used the compass application to record the geographical coordinates and developed coded labels to classify the water samples taken from each location of the slum. With all inputted coordinates, Google Maps generated a map displaying all water testing sites. Creating detailed maps of the testing locations accomplished our first objective to establish water-testing locations.

### 3.3 Water Collection

Collecting water samples in the Khlong Toei Slum was important in testing the water to determine the potential presence of pathogens. If the team identified the pathogen indicators of turbidity, total coliforms, fecal coliforms, and E. coli present in the water, the team could better recommend a proper management system that can control the pathogens found. The team collected samples of 120 mL using twelve sterile collection

containers provided to us by Associate Professor Ph.D. Sirirat Rengpipat of the Department of Microbiology at Chulalongkorn University and collected the samples following the professor’s guidelines.

The team obtained twelve sterile collection containers, shown below in Figure 3-2, and used four of these containers in each of the three sectors. The team collected four samples from each sector; three from vending machines and one from fire hydrants. The team coded sector one, Chom Chun Rim Klong Pra Kra Nong, as S<sub>1</sub>. Fire hydrants were labeled F<sub>1</sub>, while water vending machines were labeled V<sub>1</sub>, V<sub>2</sub>, and V<sub>3</sub>. Our team repeated this coding procedure for sector two, Chom Chun Wat Klong Toei Nai, and sector three, Chom Chun Moo Baan Pat Thana Jet Sip Rai. Table 3-3 shows the exact codes used for each collection location.



Figure 3- 2: Sterile Collection Containers

Table 3- 3: Khlong Toei Slum Water Collection Codes

Sector Number	Management Method	Code
1	Water Vending Machine	S <sub>1</sub> V <sub>1</sub> , S <sub>1</sub> V <sub>2</sub> , S <sub>1</sub> V <sub>3</sub>
	Fire Hydrant	S <sub>1</sub> F <sub>1</sub>
2	Water Vending Machine	S <sub>2</sub> V <sub>1</sub> , S <sub>2</sub> V <sub>2</sub> , S <sub>2</sub> V <sub>3</sub>
	Fire Hydrant	S <sub>2</sub> F <sub>1</sub>
3	Water Vending Machine	S <sub>3</sub> V <sub>1</sub> , S <sub>3</sub> V <sub>2</sub> , S <sub>3</sub> V <sub>3</sub>
	Fire Hydrant	S <sub>3</sub> F <sub>1</sub>

### 3.4 Water Testing

The team focused on indicating the pathogens because of the bacteria’s detrimental health effects to humans. The four main indicators were turbidity, total coliforms, *Escherichia coli* (*E.coli.*), and *Enterococci* (fecal coliform) (United States Environmental Protection Agency, 2013). The team brought collected water samples to Chulalongkorn’s Microbiology Laboratory for testing. The collected water samples

underwent three laboratory tests to determine pathogen contamination: presumption, confirmed and completed testing as shown in Figure 3-3 (Blodgett, 2010). Appendix C provides a step-by-step laboratory procedure for the testing methods used.

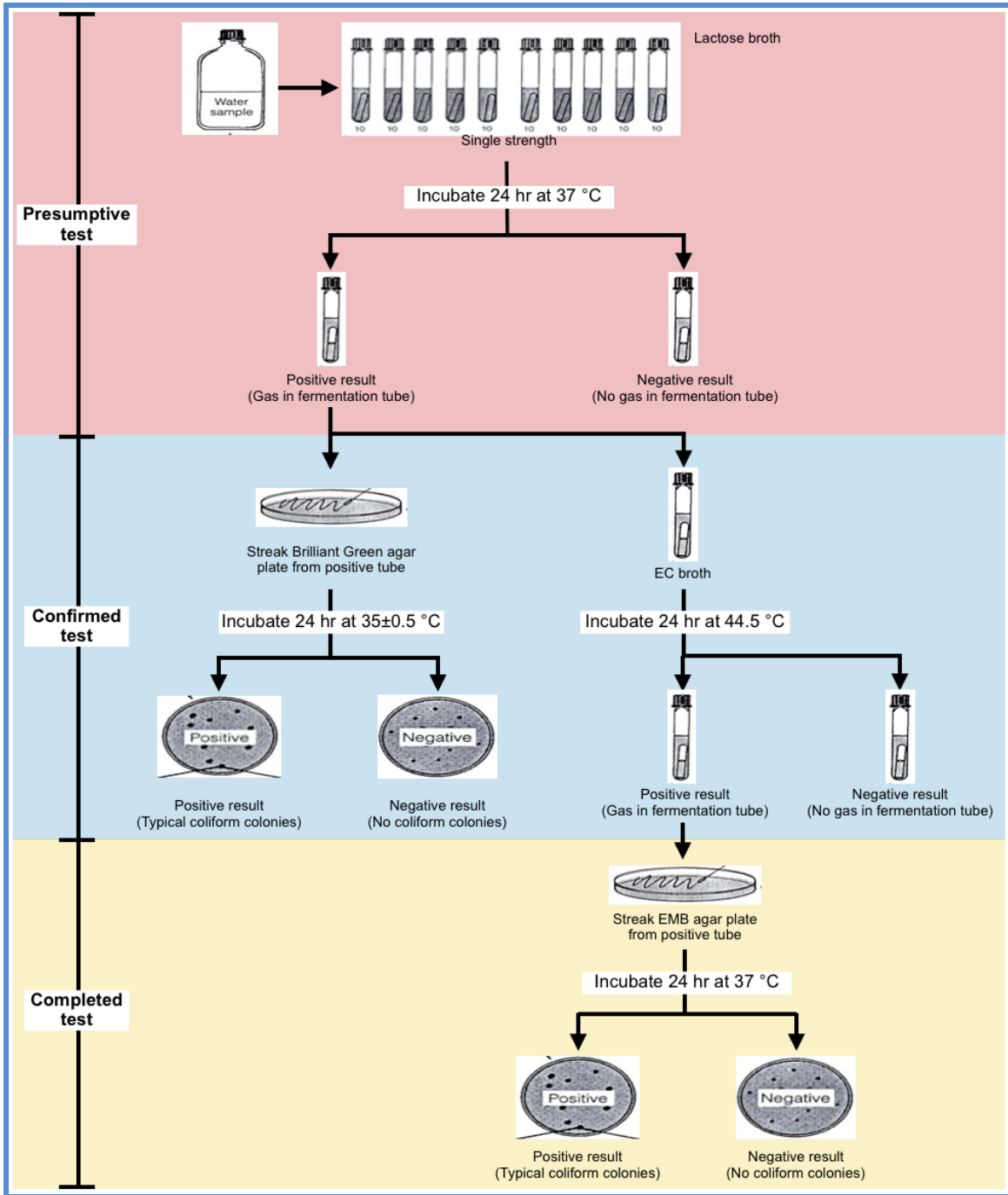


Figure 3- 3: Water Testing Procedure Outline

Laboratory staff, Chanakarn Pisitkul and Dulyapat Benyajirapatch, from the Microbiology Department, supervised the preparation and testing methods the BSAC students performed. Before the team set out to the Khlong Toei Slum to collect the water

samples, the BSAC team members went to the Microbiology Laboratory to prepare the lactose medium containing an inverted gas vials.

After the collection of four water samples from each designated sector, the BSAC team members preceded the presumptive stage, which initially tested for the possible presence of pathogens by dividing each sample into 10 tubes with the prepared medium, resulting in 120 tubes total. The team then incubated all tubes for 24 hours. After the incubation period, turbid tubes containing bubbles indicated the presence of coliform bacteria and implied a positive result. Figure 3-4 shows the capability of the bacteria for using lactose as a carbon source, releasing carbon dioxide gas through a fermentation reaction. The team suppressed the growth of organisms other than coliform bacteria with a surface-tension depressant and bile salt in the lactose medium. The team determined whether or not the water in the Khlong Toei Slum sectors is drinkable, based on MPN charts and acceptable values of pathogen indicators as discussed in Section 2.4.2. Nevertheless, positive presumptive tests may be the result of organisms of non-coliform origin that the presumption test does not recognize as indicators of fecal pollution; therefore the confirmation test was necessary.

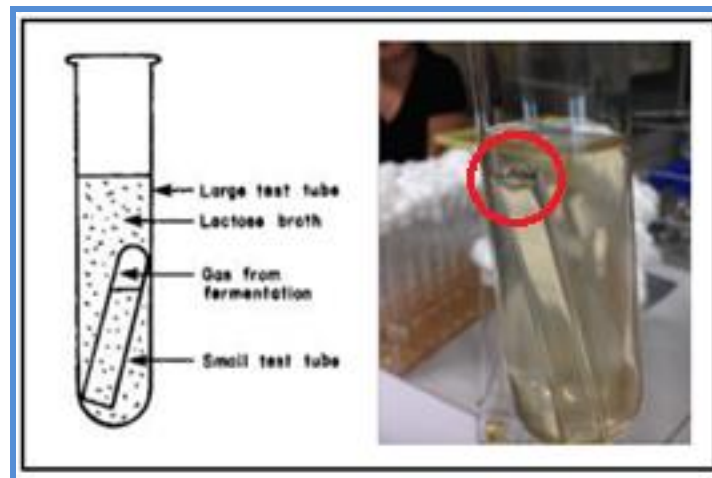


Figure 3- 4: Presence of Turbidity and Bubbles

To confirm the presence of coliform bacteria and *Escherichia coli*., indicators for fecal coliform in the positive test results, the team proceeded with the confirmed test stage by streaking each water sample on the surface of a brilliant green agar plate and incubating the tubes for 24 hours at 35.5°C. Positive results in this step refer to having yellow to yellow-green colonies surrounded by a bright yellow-green zone confirming the presence of coliform bacteria. BSAC team members transferred samples, which had positive results into tubes that contained EC broth medium as a confirmatory test for *E.coli*. The team then incubated the tubes for 24 hours at 44.5 °C, which was the optimum temperature for the growth of *E.coli*.

The completed test stage finally validated the presence of fecal *E.coli* by streaking positive samples from E.C. broth on an Eosin Methylene Blue (EMB) agar plate. If a metallic green sheen developed on the plate, like the one displayed in Figure 3-5, the growth belonged to *E.coli*. originating from sources such as feces. After obtaining and collecting results from the laboratory procedures, the team analyzed the gathered data to identify which species of pathogen indicators were present in the water.





Figure 3- 5: Metallic Green Sheen on EMB Surface

### 3.5 Interview of Sector Leaders

The team interviewed the sector leaders of the three areas to understand their role, to obtain information on demographics, history of the sector, and water management procedures. Knowing the population size allowed the team to determine the percentage of the population that our surveys sampled. Obtaining information about water management procedures led our team to understand whether there is or is not an approval or required maintenance process to owning water vending machines. Interviewing sector leaders aided our team in fulfilling our objectives of learning about water usage in the slum and recommending a water management model to improve the current water quality.

The team conducted sector leader interviews with the following protocol: a BSAC team member met with the sector leader in their respective sector and obtained verbal consent from the sector leader to conduct the interview and obtained permission to use their name. The BSAC team member asked interview questions, found in Appendix D, to the leader and took notes on the answers in Thai. With the leader's permission, the interviewer recorded the interview with the iPhone's Voice Memo App for future confirmation of the transcribed responses. The BSAC team member read the answers to the participant to ensure the information written was correct. After interviews were complete, the BSAC team member summarized the interview to the WPI team members and later transcribed interview responses in Thai using the recording. The BSAC team members translated the transcribed interview to English. The team performed content analysis on the notes from the interviews. Content analysis is a technique for making inferences by systematically and objectively identifying characteristics within the text. The team assigned different colors to the different types of responses (i.e., [Red] leadership roles, [Orange] demographics, [Blue] water management procedures, and [Green] local gathering places).

### 3.6 Survey

The team chose to design and administer surveys because this method enabled the collection of required data regarding the slum-dwellers' water collection practices and perceptions about the water quality issue. The quick question-and-answer nature of surveys allowed the team to receive a higher response rate. The team conducted the survey following a non-probability sampling method called convenience sampling, which relies on the availability of subjects (Berg, 2001). A Duang Prateep Foundation staff member and a sector leader from the slum guided the team throughout the three sectors. The path the team traveled to survey seemed random but the guide brought team



members on major roads rather than smaller alleyways. Due to the staff member's concern for the team's safety, the staff member identified residents that were willing to participate in the survey. This selection process restricted the team from having a completely random sample. Therefore the resulted sample size does not represent a significant sample of the total population from which the team can infer conclusions. Despite this limitation, the team was still able to obtain a variety of survey responses that led to valuable quantitative data and the team does not believe any intentional bias existed in the selection of the surveyed population. At the completion of this method, the team achieved its target survey population of thirty residents per sector, totaling ninety residents of the Khlong Toei Slum.

The BSAC team members conducted the surveys in Thai. Prior to each survey, the BSAC team members introduced the project by explaining that the survey assisted the team and the DPF in understanding how the residents are affected by the current water quality. The BSAC team member then obtained verbal consent from the resident to conduct the survey and assured confidentiality of their responses. The survey consisted of open-ended questions to avoid the possibility of persuading the responses of the slum-dwellers. As opposed to providing multiple responses for the residents to choose from, the surveys had predetermined responses (responses the team created based on observations) listed below the questions, with space for an 'other' answer. As the residents responded, the BSAC team members marked the answers. After the completion of the survey, the BSAC team member recited the recorded responses back to the survey participant to assure the information written down was correct. Refer to Appendix E for survey questions.

The team designed each survey question to collect specific information. There are three sections to the survey: one section questioning water usage and sanitation practices, the second section questioning the health of the residents and potential implications water can have on your health, and the third section identifying the demographics of the survey participant. The team split the survey into three sections as to not potentially raise unnecessary concern within the sectors regarding the water quality and health effects and also to classify the survey responses based on different demographics. The first section, covering water usage and sanitation practices, is important because the team must understand specific aspects of the slum-dwellers' daily lives in order to recommend a water management method that could improve the current water quality in the Khlong Toei Slum. Through these surveys, the team collected information regarding the residents' sources of drinking water, the reason they use those sources, and whether or not the residents treat their drinking water after collection. This section informed the team of the resident's water usage and their perceptions on the different water systems within the sectors. The second section of the survey, covering the potential health implications from consuming poor quality water, is valuable in understanding how the Khlong Toei slum residents perceive water quality and if they believe it can affect their health. This section of the survey investigated any illnesses the survey participant or family members may have faced in the past three months from the time of the survey conduction. The team designed demographic questions for the third section of the survey regarding gender, age, and time spent in the slum to understand the water perceptions, usage, and health of different groups of residents. The design of these surveys intended to obtain

information about the Khlong Toei Slum residents' water usage and perception of water quality.

To analyze the survey responses, the team created a Google Form mimicking the printed survey questions and recorded each response for digital record keeping. From this digital record, the team used SPSS Statistics v. 22.0 to run quantitative tests and then created visual graphs to exhibit the data. Using the demographic information from the survey leader interview, the team compared the number of people who chose a certain answer to the overall sample population. This gave the team useful values and percentages that were presented to emphasize health concerns and lack of sanitation practices, and support the team's recommendation in a water management model.

### **3.7 Analysis of Results**

To deliver a water quality report and community water evaluation, the team assessed results from observations, water testing, interviews, and surveys. The team combined data from water tests and observations to develop a water quality report. The water quality report serves as a technical evaluation of the water in the Khlong Toei Slum and includes when water samples were collected and tested, names of the sectors, and results from the water testing. In addition, the team used information obtained through interviews and surveys for a community water evaluation. The community water evaluation identified the residents' water usage and perceptions of the water quality using quotes, charts, and graphs.

With the results from the water quality report and the community water evaluation, the team recommended a sustainable water management model to improve the current water quality in the Khlong Toei Slum. To determine if a water management model recommendation is advisable, the team analyzed all results to determine feasible options for the community of the Khlong Toei Slum.

### **3.8 Trial Hygiene Education Program**

After obtaining results, the team perceived one of the biggest problems in the slum was the lack of hygiene practices heightened by the contaminated conditions of the environment. As a supplemental method, the team developed and conducted a pilot educational campaign for school children aged three to six in the DPF kindergarten school on March 3<sup>rd</sup>, 2015. In order to help change the daily habits in the slum, the team decided to educate a younger generation on healthier hygiene habits. The team designed the program to teach children about pathogens, transmission pathways, and proper hand washing techniques. Appendix F outlines the lesson plan, supplies needed, pictures from the event and the survey questions the team asked the students.

The program conducted in the school lasted approximately two hours and included three different activities. The team used the program in two classrooms and each team member was assigned a specific task to perform. In each classroom, there was one WPI team member and two BSAC team members because the students only spoke Thai. One WPI team member took pictures of the event. One classroom had 20 students and the other had 23 students. Teachers from each classroom and a DPF representative helped team members manage the students and kept students focused and calm throughout the program. The team helped students throughout each of the three activities when they needed help or had a question.

The BSAC students used a storyboard to explain to students that pathogens, or germs, negatively affect the health of people. Then, the students used crayons to decorate a coloring page of a germ. This initial activity introduced the students to the concept of germs and their harmful health impacts. This first part of the program took about a half hour to complete. The next phase of the program took the same amount of time to complete. The WPI students put “invisible” ink on their hands and shook hands with a few students. The BSAC team members encouraged the students to shake hands with each other. After about ten minutes, team members gathered the students into a circle and used a black light to show students the invisible ink on their hands. Team members explained that germs are easy to transmit from objects to people, people to people, and people to food and drinks. The final part of the program taught students how to properly wash their hands. The BSAC team members taught students each step of proper hand washing. The team brought students to the bathroom to teach them to wash their hands following the steps from the posters. Team members instructed students to wash their hands for twenty seconds which is the same amount of time it takes students to sing “Chang Chang Chang”, a popular Thai song for children. Teachers and team members encouraged students to sing while they washed their hands with the techniques taught.

The team assessed the educational program utilizing a questionnaire in the form of a game with the students. Before the first activity began, the team asked students a series of questions to determine their knowledge of germs, their transmission pathways, and prevention. To prevent students from being influenced by their peers, the team asked the students to put their heads down and raise their hand if they knew the answer. The same questions were asked after the team completed the three activities. The team performed an analysis of the effectiveness of the program.

### **3.9 Summary of Methodology**

A sustainable water management model must address all pathogens confirmed in the water as well as the water usage practices and perspectives of the community members in order to be successful. Figure 3-1 above shows the scope of the project and the strategy the team employed to produce our deliverables, which are a water quality report, community water evaluation, and a recommendation for a water management model. The team’s approach was conducting observations, mapping water testing locations, water sampling, conducting interviews and surveys, and analysis of collected data. The team used data collected through observations and water testing to produce a water quality report. Interviews conducted to slum-dwellers contained questions regarding their perspective of the water issue and water usage practices to give the team qualitative data. In contrast, surveys with slum-dwellers provided the team with quantitative data to represent trends of these perspectives and water usage practices. With the results of both the water quality report and the community water evaluation, the team aimed to recommend a water management model to improve the water quality within the Khlong Toei Slum.

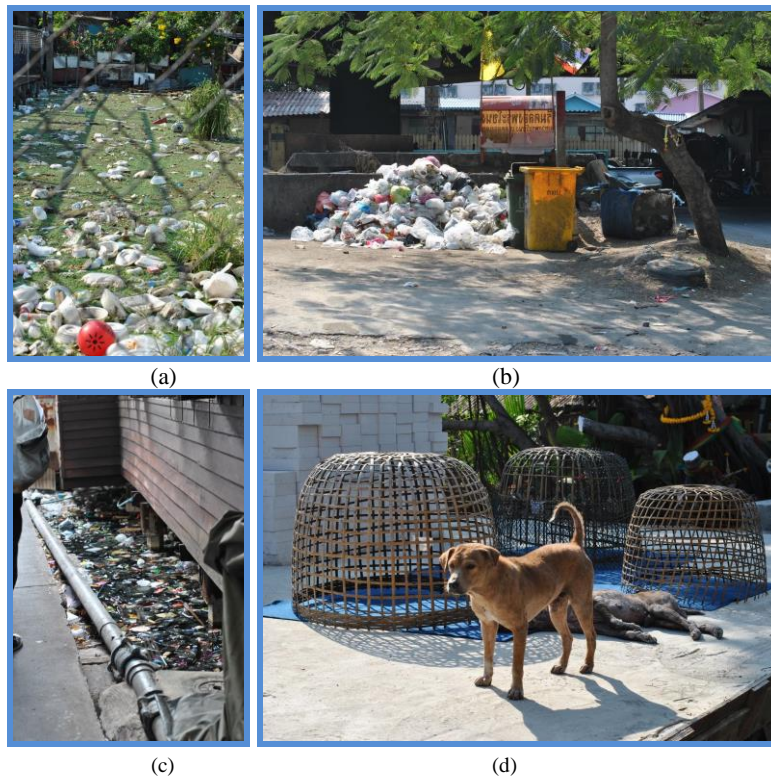
As a supplement to the original project methods and objectives, the team conducted a trial hygiene educational campaign with students at a DPF kindergarten. As noted in background research, presented in Section 2.5, unhygienic behaviors can contaminate safe-drinking water (World Health Organization, 2012). After analyzing the effectiveness of the campaign, the team used these results to recommend a lesson plan for future hygiene educational campaigns in schools throughout the Khlong Toei Slum.

## 4 Results and Analysis

This chapter discusses the results from the data collected by methods: observations, mapping water testing locations, water testing, interviews with sector leaders, surveys with residents of the Khlong Toei Slum, analysis of results and trial hygiene education program. For each of these results, the team determined the impact they have on the project.

### 4.1 Observations

Through observations, the team discovered that the living conditions of the Khlong Toei Slum are rather subordinate and unsanitary. The densely populated area is extremely polluted. Empty cans litter grass fields and trash make up tall piles in parking lot corners. (Figures 4-1 (a) and (b)). Stagnant water, polluted with trash, lines the streets and homes of the slum (Figure 4-1 (c)). Stray animals roam the streets and defecate in close vicinity to homes and playgrounds (Figure 4-1(d)). Polluted water, lack of a waste management system, road defecation, and stray animals are some of the observations that raised hygiene concerns. Appendix G provides all observations made by the team. The team grouped the observations from each sector because the team members observed similar conditions in all three sectors.



**Figure 4- 1: Conditions of the Khlong Toei Slum**

Furthermore, observations taken while collecting the water samples indicated the presence of a black residue on the gauze used to clean the water nozzle of vending machines. The team noted the presence of the residue in seven out of the nine water

vending machines tested. Figure 4-2 (a) shows the cleaning of the nozzle, and Figure 4-2 (b) shows the black residue the team found.



Figure 4- 2: Residue in the Nozzle of Water Vending Machine

### Implications

These observations lead the team to conclude that the Khlong Toei Slum **residents face a substandard quality of life**. In addition, finding the black residue in the nozzle on the machine, suggests to the team that **water vending machines do not receive regular upkeep**.

### 4.2 Map of Testing Locations

The team developed a map, shown below in Figure 4-3, using the geographical coordinates of the water testing locations in each of the three sectors. The red circles represent fire hydrants and the green squares represent water vending machines. The yellow star represents the Duang Prateep Foundation's Headquarters. Appendix H provides a chart with the geographical coordinates of the testing locations and the brands of each water vending machines. Appendix I displays close-up maps of each sector and their respective water testing locations.

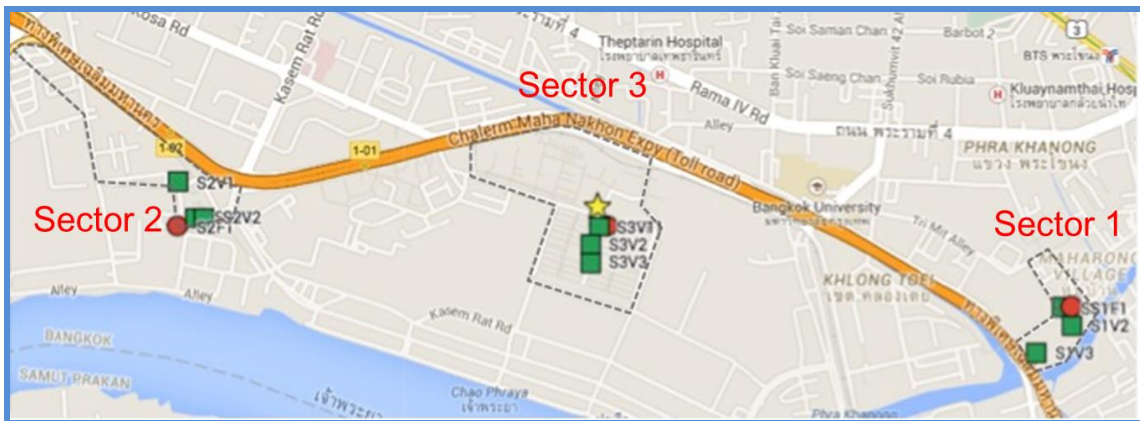


Figure 4- 3: Water Testing Locations in Three Sectors of the Khlong Toei Slum

### Implications

The Duang Prateep Foundation can use this map to **reference the tested machines**. The map also suggests which areas, within each sector, have been tested so future research can either focus on different areas or track changes in the areas which the team tested. The maps also show **the limitations of the water tests the team conducted**. A comparison between the amount of testing locations and the entire sector area raises



questions about the number of other sources that could present contamination in each sector.

### 4.3 Water Testing Results

#### Presumptive Test: 3 out of 12 samples presented positive results

The presumptive stage initially tested for possible presence of pathogens. As shown in Table 4-1 above, the team identified the presence of coliforms in drinking water in samples S<sub>1</sub>F, S<sub>2</sub>V<sub>1</sub>, and S<sub>3</sub>V<sub>2</sub>, by noting the presence of turbidity and gas bubbles, shown in Figure 4-4.

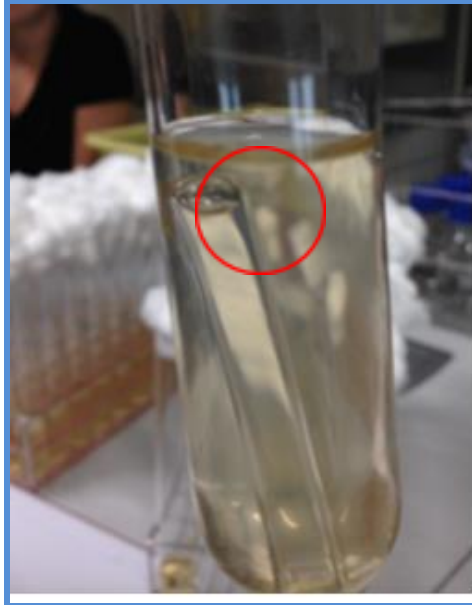


Figure 4- 4: Presence of Turbidity and Bubbles in Tube

Table 4- 1: Results of the Presumptive Test

		Tube No. 1		Tube No. 2		Tube No. 3		Tube No. 4		Tube No. 5		Tube No. 6		Tube No. 7		Tube No. 8		Tube No. 9		Tube No.10	
		T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B	T	B
S <sub>1</sub>	V <sub>1</sub>	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
	V <sub>2</sub>	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
	V <sub>3</sub>	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
	F	1	0	1	0	1	1	1	0	1	0	1	0	1	0	1	0	1	0	1	0
S <sub>2</sub>	V <sub>1</sub>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	V <sub>2</sub>	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
	V <sub>3</sub>	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
	F	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
S <sub>3</sub>	V <sub>1</sub>	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
	V <sub>2</sub>	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	1	1	0	1	0
	V <sub>3</sub>	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
	F	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0

S = Sector  
V = Water vending machine  
F = Fire hydrant

T = Turbidity  
B = Bubble

1 = Apparent  
0 = Not apparent



### MPN Comparison: 1 out of the 3 positive samples was determined not drinkable

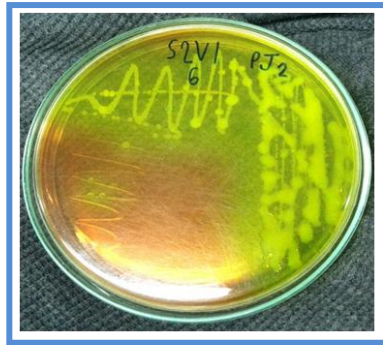
Table 4-2 shows the relation of the number of positive tubes and the MPN value. An MPN value above 2.2 indicates that the source of that sample provides undrinkable water. Sample S<sub>2</sub>V<sub>1</sub> contained 10 positive tubes (out of 10 samples) resulting in an MPN value of 23, exceeding the MPN drinking threshold of 2.2. Therefore, the team deemed water from S<sub>2</sub>V<sub>1</sub> as undrinkable. On the other hand, the presence of turbidity and gas bubbles was observed in only 1 tube from each of the S<sub>1</sub>F and S<sub>3</sub>V<sub>2</sub> samples, resulting in the corresponding MPN value of 1.1. Because the MPN value does not exceed 2.2, the water from all sources, except S<sub>2</sub>V<sub>1</sub>, are deemed free of pathogenic contamination. Positive presumptive tests may result from fecal or non-fecal coliforms. To determine the type of coliform, the team conducted the confirmed test.

Table 4- 2: Most Probable Number (MPN)

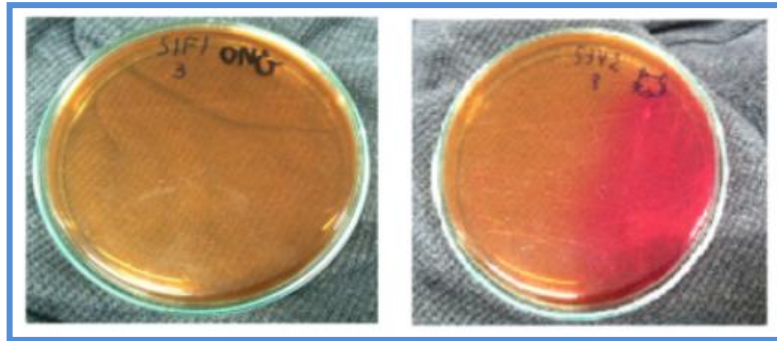
Positive Tubes	MPN/100ml	Positive Tubes	MPN/100ml
0	< 1.1	6	9.2
1	1.1	7	12
2	2.2	8	16
3	3.6	9	23
4	5.1	10	> 23
5	6.9		

### Confirmed Test: 1 out the 3 samples presented positive results for E.coli

The team conducted the confirmed test on one tube from samples S<sub>2</sub>V<sub>1</sub>, S<sub>1</sub>F, and S<sub>3</sub>V<sub>2</sub> to confirm the presence of coliform bacteria and *Escherichia coli*. Figure 4-5 (a) shows the positive result from sample S<sub>2</sub>V<sub>1</sub> for fecal coliforms. The growth of yellow colonies in the bright, green-yellow zone of the plate represents *E.coli*. On the other hand, the agar plate remained unchanged for S<sub>1</sub>F and S<sub>3</sub>V<sub>2</sub>, sample as shown in Figure 4-5 (b), indicating *E.coli* was not present.



(a)



(b)

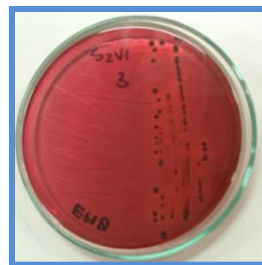
Figure 4- 5: Results of Confirmed Test

**Completed Test: Sample S<sub>2</sub>V<sub>1</sub> presented negative results for fecal *E. coli***

To confirm or deny the presence of fecal *E.coli*, the team conducted the completed test on sample S<sub>2</sub>V<sub>1</sub>. A sample contaminated with fecal *E. coli* would show a colony possessing a green metallic sheen and a dark center, indicating the vigorous lactose and/or sucrose fermentation of fecal coliforms, shown in Figure 4-6 (a) and (b). However, no metallic sheen was observed on the surface from sample S<sub>2</sub>V<sub>1</sub>, suggesting that fecal *E. coli* was not present in the sample.



(a)



(b)

Figure 4- 6: Results of Completed Test

## Implications

From the results obtained in the three water testing phases (presumptive, confirmed, and completed), the team concluded **water from the MWA, represented by the fire hydrants, is free of pathogenic contamination.** In addition, the team identified pathogenic contamination in one out of nine vending machines, (11% of the tested machines). Assuming the Khlong Toei slum has more machines located in each sector, the team believes more machines may be contaminated. The tests conducted by the team, only identified the presence of pathogens. Therefore, the potential presence of other contaminants such as heavy metals and chemicals could make the water undrinkable. In conclusion, the team cannot deem the water from the fire hydrants drinkable, but rather, free from pathogenic contamination. **However, the team can deem the water from the vending machine, S<sub>2</sub>V<sub>1</sub>, which tested positive for pathogens, undrinkable.**

## 4.4 Interview

After the team conducted interviews with each of the three sector leaders, the team coded the interviews to group the answers by categories. Refer to Appendix J for the interviews in Thai and English, and Appendix K for the coded interviews.

### Sector leaders deal with public works and are not responsible for the water quality in the slum.

The team found that sector leaders hold responsibility over residential problems such as utilities not working correctly, waste management, road potholes, and residential conflict. According to the leader of sector 2, “[the sector leaders] usually [manage] everything that is problematic to the residents. When a problem arises, we have to go and check on the issue. When the residents notify us [of a problem], we fix everything, such as water and electric utilities not working, well-being of the residents, or the condition of the road. Everything falls under our responsibility.” The leader of sector 1 clearly states he is not responsible for the water quality of the slum: “I’m not the one who is in charge of water”.

### Residents do not need leaders’ permission to buy water vending machines and sector leaders do not enforce maintenance.

According to all the sector leaders interviewed, residents of the slum currently have the freedom to purchase and install a water vending machine outside their home or business, without permission, as long as the water vending machine does not block the main road. The leader from sector 2 stated, “[The residents of the slum] can install [water vending machines] immediately without our permission...If there are any complaints, then we order the owner to maintain and clean the machines. But no, we do not conduct any maintenance [ourselves] if there are complaints or notifications from the residents”. The sector leader has a responsibility to settle conflicts between residents and thus would order the owner to clean the machine if a complaint about the quality of water from the machine arises. However, as stated by the leader of sector 1, “They don’t really care much [about maintaining their vending machines].” Although the sector leader can order the owner to clean their machine, the owner most likely will not follow the orders because of the high filter costs and because the sector leader cannot enforce maintenance.

### Sector 2 residents are middle class

The leader from sector 2 defined the sector population as “middle class” in comparison with other sectors of the slum. The sector leader emphasized “in-home filters are not as expensive as people think, and can be paid monthly”. Residents can buy cheap in-home filters from “salesmen that walk around the slum”. Therefore, sector 2 residents commonly own in-home filters.

### Implications

Seeing that residents do not require permission or approval to install a water vending machine and maintenance of the machine is neither regulated nor enforced, raises a suggestion for the team to **recommend a water vending machine maintenance program**. From the interview responses, the team can conclude that **even though sector leaders are not responsible for the water quality in the sector, they could be a resource for the implementation of a management model**. Sector leaders represent an authority in the sector and respond to community complaints, however, they cannot force residents to follow their orders, therefore, the **presence of a higher authority will be needed for the implementation of a maintenance program**.

### 4.5 Survey Responses

After conducting surveys, the team used IBM’s Statistical Package for Social Sciences (SPSS) Version 22.0 to analyze collected data. Appendix L shows results for every survey question. This section discusses the characteristics of the surveyed population, water usage, and perceptions of the water quality of the residents of Khlong Toei. The team conducted statistical analysis to determine associations, dependencies, and frequencies. The surveyed population consisted of 90 residents, 30 from each sector. Many questions in the survey allowed residents to select more than one answer; therefore the number of responses is sometimes higher than the population size.

### Demographics

The team identified four demographic characteristics of the surveyed population through survey questions, and compared them between the sectors: gender, age, years in the slum, and number of children. The surveyed population consisted of 71% females, as shown in Figure 4-7. These results reflect that females spend more time in the slum during the afternoon, the time the team conducted all surveys, while males are typically out working, leading to a higher number of females surveyed.

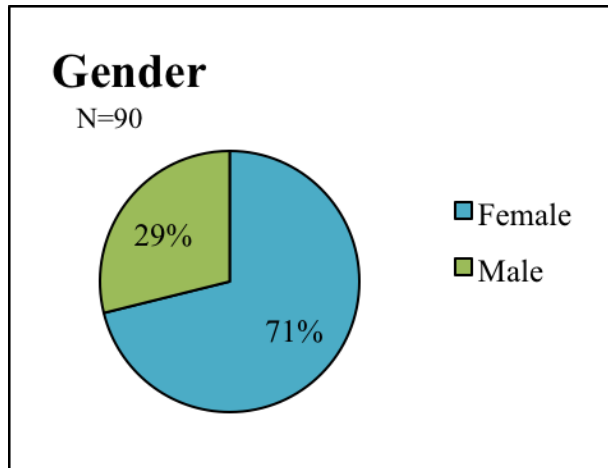


Figure 4- 7: Gender Distribution

Figure 4-8 shows a breakdown by gender and sector. The team used a Chi-Square Test to analyze the distribution of gender within each sector (Chi-Square = 6.29,  $p(2) = 0.037$ ). As the p-value was smaller than 0.05, the team can conclude the gender distribution is significantly different from one sector to another. This result is not surprising because during the conduction of the surveys, sector 2 had many workers rebuilding burnt houses. Contrary to the other sectors, a large population of the surveyed residents was male. However, the team does not expect any difference on the survey responses based on gender; therefore, the responses are combined.

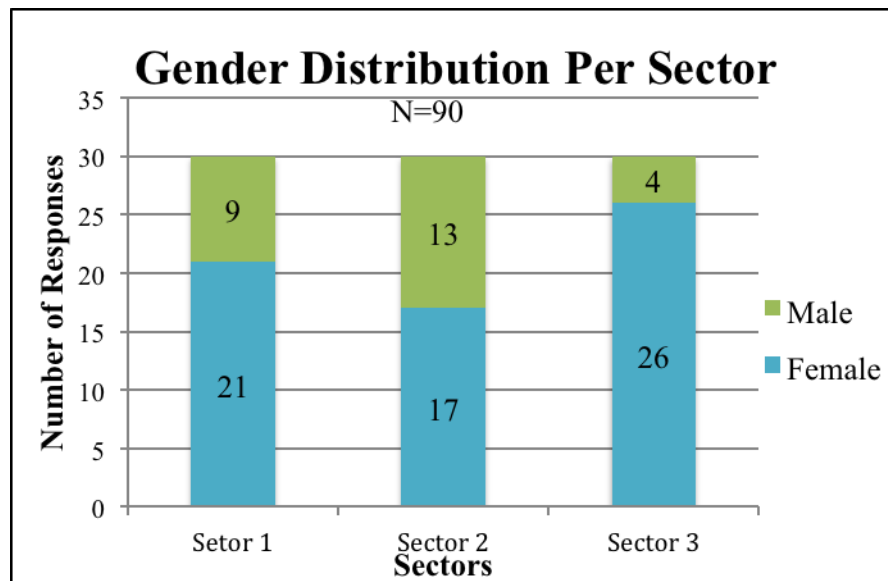


Figure 4- 8: Gender Distribution by Sector

Figures 4-9, 4-10, and 4-11, show the age, years in the slum, and the number of children distribution in the Khlong Toei Slum respectively.

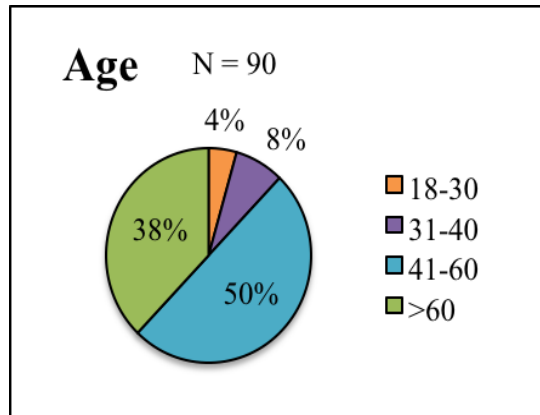


Figure 4- 9: Age of Residents

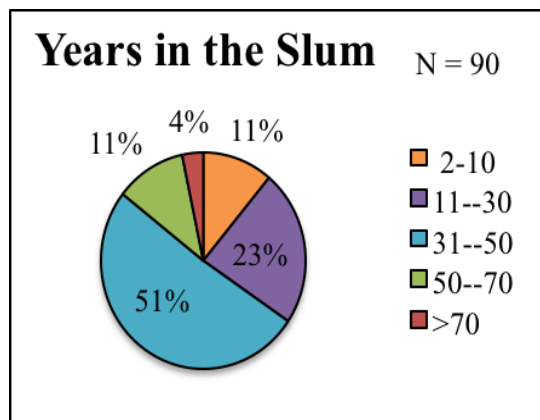


Figure 4- 10: Years Lived in Slum

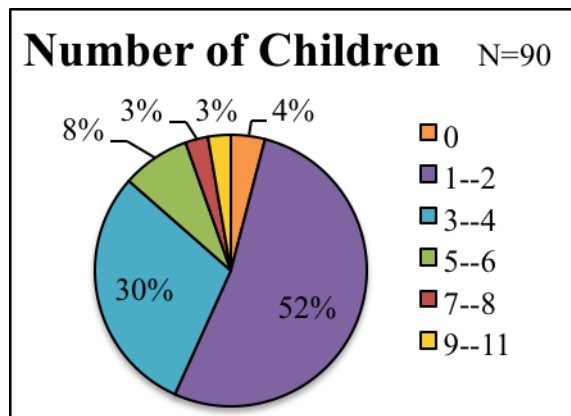


Figure 4- 11: Number of Children

**The most commonly used drinking source is an in-home filter.**

The team included a question in the survey asking the participant from which source they and/or their family use to obtain drinking water: “Where do you or your family members get water to drink?” The team found that forty-two percent of the one hundred and eleven responses indicated the use of in-home filters, while only twenty-three percent use water vending machines. In Figure 4-12, N represents the number of responses received for this question. The number of responses exceeds the number of



residents surveyed because the team allowed residents to choose more than one source of drinking water. The team conducted a Chi-Square test to determine if the source of drinking water varies significantly between sectors (Chi-Square = 16.38,  $p = 0.042$ ). Because the  $p$ -value is smaller than 0.05, the team can conclude the source of drinking water is significantly dependent on the sector of the slum. As seen in the graph, sector 2 contains the higher number of responses for in-home filters and the lowest responses for vending machines compared to the other two sectors.

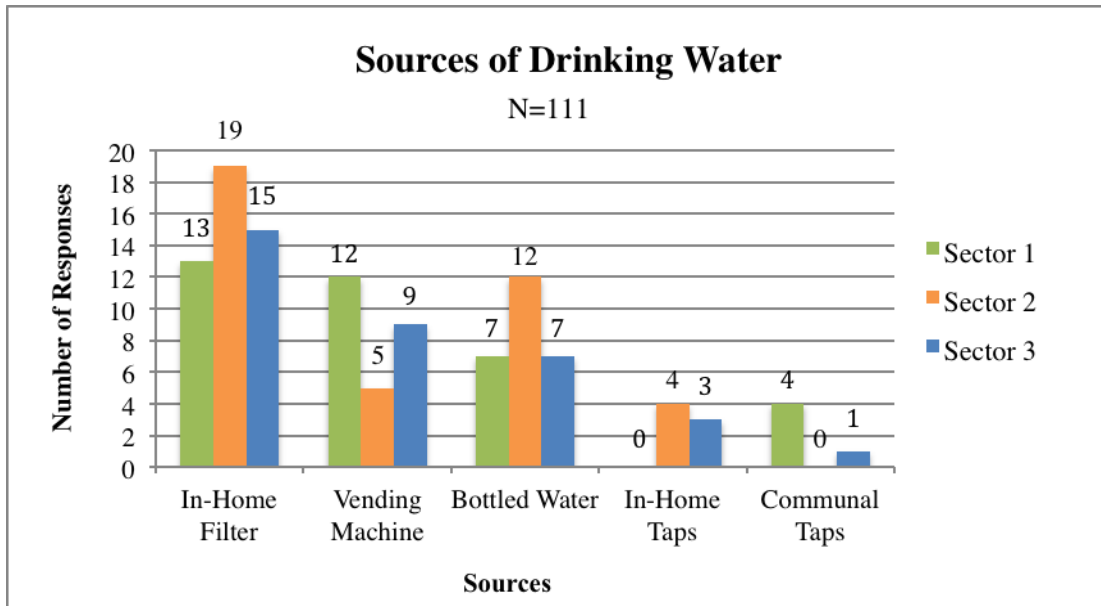


Figure 4- 12: Sources of Drinking Water

**Residents choose to drink from water vending machines and in-home filters because they think the quality of water from these sources is high.**

The team found that residents trust the quality of water from water vending machines and in-home filters. Appendix M provides the coded survey responses detailing the reasons slum dwellers choose vending machines and in-home filters as their drinking sources. Results from the survey suggest that the residents choose to use in-home filters because they believe in-home filters provide the best quality water: “I trust in the quality of water from in-home filters” and “It is great quality; there is no odor or bad taste”. On the other hand, a resident that drinks from water vending machines said: “water from vending machines is cleaner than tap water”, “the taste is also better than the taste of tap water.”

**27% of the surveyed residents have been sick in the past three months and have encountered symptoms consistent with drinking pathogen contaminated water.**

To determine the number of sick residents in the slum, the survey incorporated the question “Have you or your family members been sick in the past three months?” to determine the presence of health issues in the surveyed population. From the ninety residents surveyed, eighty-six responded to this question. Twenty-seven percent of the respondents answered yes, as seen in Figure 4-13. The team conducted a Chi-Square test to determine the existence of a dependence relationship between being sick and the sector

(Chi-Square = 3.417,  $p = 0.181$ ). As the  $p$ -value is larger than 0.05, the team can conclude there is no significant dependency between the two.

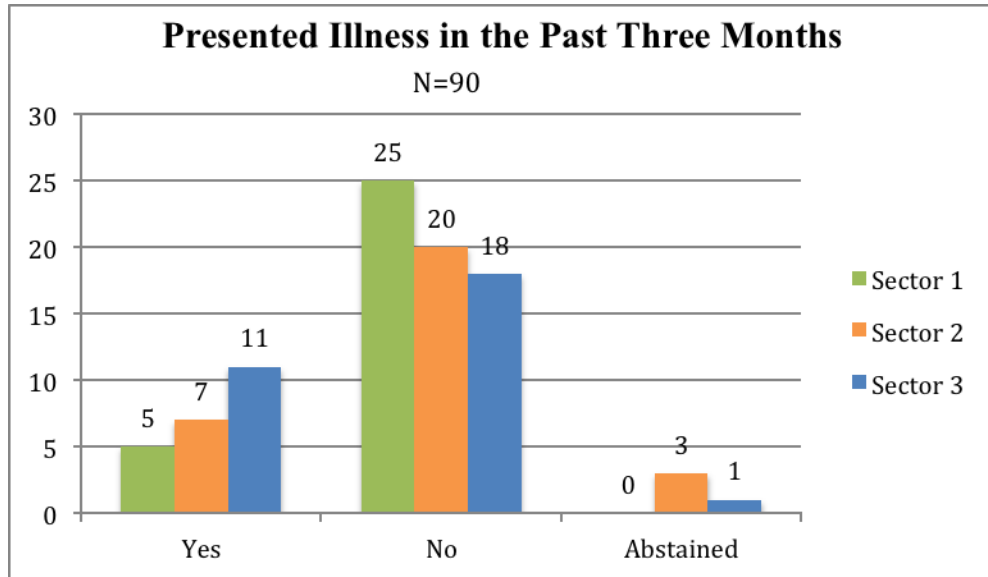


Figure 4- 13: Presented Illness in the Past Three Months

The team also asked the participants who answered yes to list the symptoms associated with their illnesses, “What health symptoms did you or your family members’ experience?” From the twenty-three positive responses, the participants indicated symptoms, such as high fever, diarrhea, and stomach cramps, that may originate from drinking poor quality water. Figure 4-14 shows the symptoms listed by participants vary in degree, but most of the residents experience a high fever. The team allowed the 23 participants to answer more than one symptom; hence the number of responses is 27. The team conducted a Chi-Square test between the drinking sources of residents and being sick to determine the existence of an association (Chi-Square = 7.137,  $p = 0.129$ ). As the  $p$ -value is larger than 0.05, the team can conclude there is no statistically significant association between being sick and the source of drinking water.

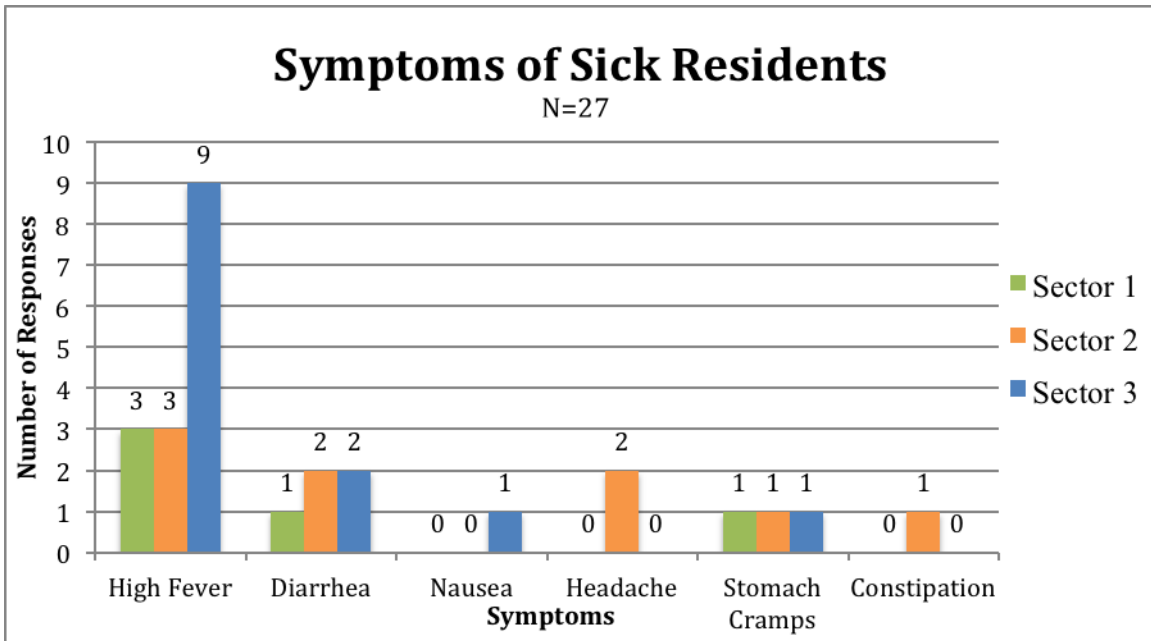


Figure 4- 14: Symptoms of Sick Residents

#### 52% of the population do not think water can affect their health

In order to determine the knowledge of residents in the slum about the possible effects of contaminated water on health, the team included the following question in the survey: “Do you personally think water can make people sick?” As seen in Figure 4-15, fifty-two percent of the residents don’t think water can make people sick.

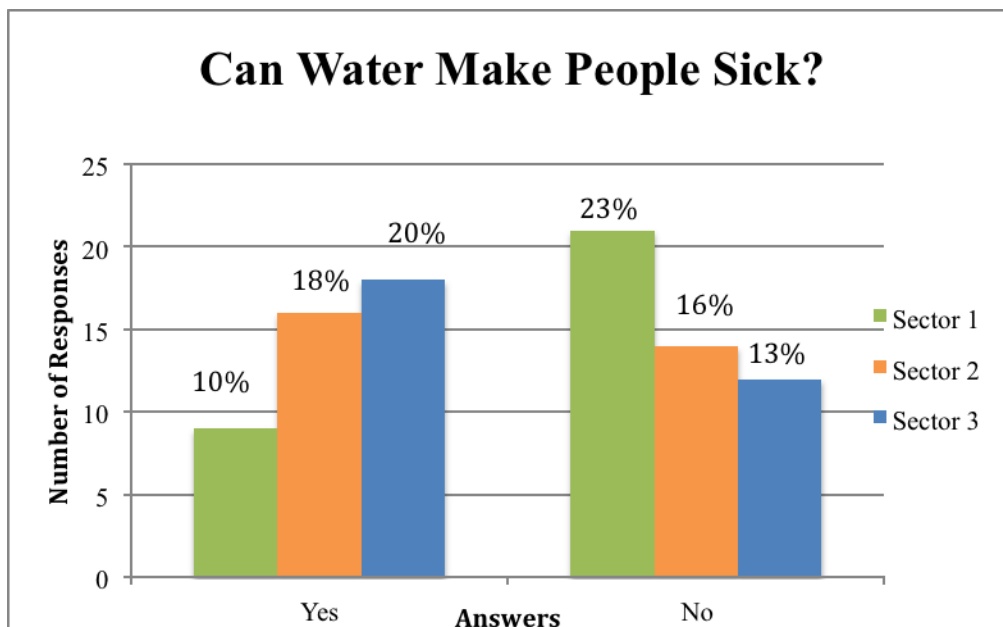


Figure 4- 15: Understanding the Impacts of Health Effects

#### 9% of the surveyed residents do not boil their water before drinking

To determine community members’ practices of handling drinking water after collection, the team asked the participants: “What do you or your family members do

after getting their water to drink?” In the analysis of these answers, the team removed from the total 90 responses, the 26 who responded saying they drank bottled water because bottled water does not pose risks to human health; hence the population size decreased to 64. Each respondent could refer to more than one practice; therefore the number of responses is 89. As shown below in Figure 4-16, only nine percent of the responses indicated boiling as an after collection practice, while most responses indicated drinking water directly after collection.

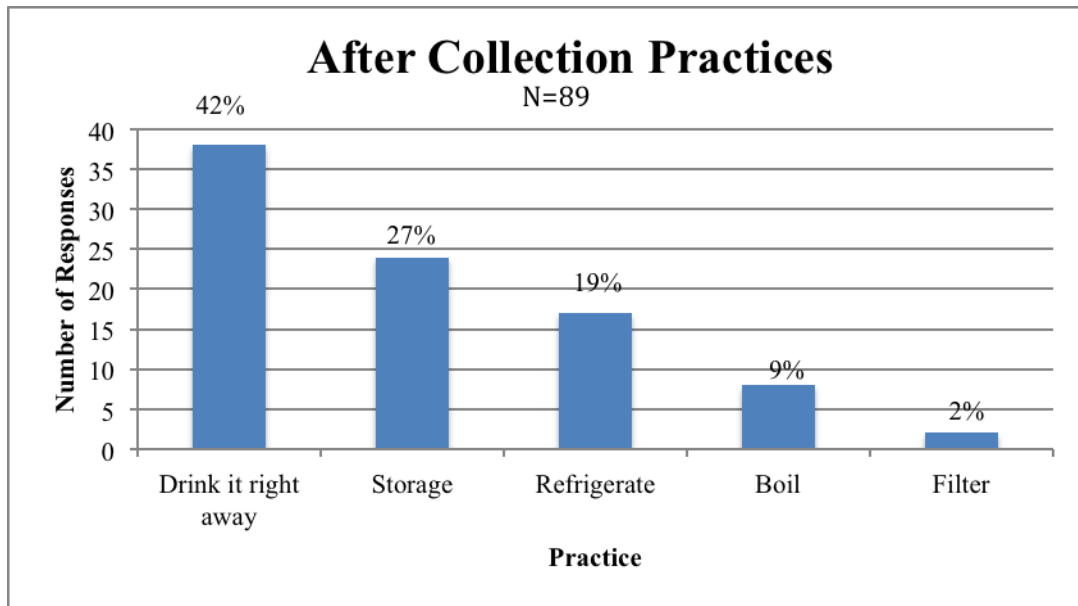


Figure 4- 16: After Collection Practices

### Implications

After finding that the most common source of drinking water is in-home filters, followed by vending machines, the team **planned to recommend a water management model that targets both water vending machines and in-home filters** so the largest number of residents benefits from the solution. Residents choose their drinking water sources because they believe those provide the best quality of water. Analyzing the ways in which residents perceive the drinking water sources they selected as trustworthy, suggests the **need to raise awareness about the potential risks in drinking from these sources if residents do not properly maintain systems, in-home filters and water vending machines**. Furthermore, the presence of illness in 27% of the surveyed population raises concern because residents are getting sick for an unknown reason. Although symptoms of the sick residents are consistent with those that arise from pathogen contaminated water, the **team cannot conclude residents get sick because of the quality of water because the symptoms listed are associated with many illnesses** not related to water quality such as food poisoning, the common cold, dengue fever, etc. The environment and unsanitary conditions of the slum also render these illnesses possible. In addition, realizing that 52% of the residents do not think water can make people sick, suggests that **residents lack information regarding the negative health effects of consuming pathogenic contaminated water**. Finally, Section 2.5 indicates that people worldwide use boiling as a point-of-use water treatment method to eliminate pathogenic

contamination. The low amount of residents of the surveyed population that boil their water after consumption indicate **residents of the Khlong Toei Slum do not understand the benefits of boiling water.**

#### 4.6 Analysis of Results

The team assessed the results from the data collection methods in order to draw all-encompassing conclusions and develop the deliverables of the project.

First, according to the sector 2 leader, residents can afford the price of in-home filters, and therefore rely on this source for drinking water, explaining the high number of responses indicating the use of in-home filters in sector 2. Furthermore, the team identified the presence of pathogens in a water vending machine located in sector 2, which could have led residents of sector 2 to stop using vending machines months or years ago and therefore, could explain the low responses indicating the use of vending machines for drinking. The team can conclude **the difference between the uses of vending machines and in-home filters of sector 2 compared to the other sectors could exist due to the contamination of the machine in the sector and the economic level of the residents.**

Second, the team observed the presence of an unknown, black residue in 7 out of 9 tested vending machines' nozzles, which suggests the lack of cleaning vending machines throughout the slum. Supporting this result, the three sector leaders interviewed by team members indicated the lack of regulated maintenance of the machines in the sectors. Lack of maintenance poses a problem, according to background research, because maintenance of vending machines is necessary to ensure the proper functioning of filters. These results suggest lack of maintenance may have caused the pathogenic contamination of the vending machine in sector 2. The team concludes **vending machines lack regulated maintenance and cleaning, therefore affecting the effectiveness of the filters, which may worsen the quality of water.**

Based on the above conclusions in conjunction with others developed from all methods, the team created three main deliverables: a water quality report, a community water evaluation, and a water management model that address the current water situation of the Khlong Toei Slum.

#### Water Quality Report

The water quality report developed by the team indicates whether or not pathogens are present in the samples of water collected and tested and if the samples passed or failed the three tests conducted. The team incorporated results from the water testing, breaking the samples by sector and by source of water, and included the dates for collection and testing of the samples. Appendix K contains the water quality report.

#### Community Water Evaluation

The team developed a community water evaluation to represent the water usage and perceptions of the residents of the three sectors of the slum. The report includes the most commonly used drinking sources, the reasons for choosing those drinking sources, after collection practices, and the symptoms of the sick residents of the three sectors. Appendix L shows the community water evaluation.

## Sustainable Drinking Water Management Model

The drinking water management model for the Khlong Toei Slum aims to serve as a guideline for the Duang Prateep Foundation in order to address the current water quality issue in the community. The model consists of four main phases: (1) to conduct a trial maintenance, (2) to inform the community about the new program (3) to regulate the maintenance of vending machines, and (4) to periodically test random machines.

### Phase 1: Conduct a Trial Maintenance

The purpose of recommending a trial maintenance on three water vending machines is to conclude if maintained water vending machines are capable of successfully eliminate water contaminants. The trial maintenance includes six main steps described below.

#### **Step 1: Select Machines**

Select randomly machines in the Khlong Toei Slum to serve as prototypes for the trial maintenance program.

#### **Step 2: Pre-Maintenance Water Testing**

Conduct testing for Thai drinking standards determined by the Ministry of Public Health on the machines selected in the previous step.

- If there is **no presence** of contamination in the water from a machine, go back to step 1.
- If there is **presence** of contamination in the water from a machine, proceed to step 3.

Repeat steps 1 and 2 until three machines test positive for contamination. It is important to conduct the maintenance in contaminated machines in order to determine the effectiveness of maintenance in providing drinkable water

#### **Step 3: Conduct One Maintenance Cycle**

Change the filters of the three machines following the maintenance period indicated in Table 2-2, and clean the machines entirely, focusing on the nozzle and the internal parts.

#### **Step 4: One Month Post-Maintenance Water Testing**

Conduct testing for Thai drinking standards determined by the Ministry of Public Health on the three maintained machines. Keep record of the results of the testing for comparison with the final test conducted after a year.

#### **Step 5: Conduct Maintenance for One Year**

Change the filters of the three machines following the maintenance period indicated in Table 2-2, and clean the machines entirely, focusing on the nozzle and the internal parts.

#### **Step 6: One Year Post-Maintenance Water Testing**

Conduct testing for Thai drinking standards determined by the Ministry of Public Health in the maintained machines.

*Note: If funds are available, testing should occur monthly to capture as many data sets as possible.*

- If there is **no presence** of contamination in the water from the machines in any of the post-maintenance testing, proceed to recommend maintenance of machines to the community (phase 2).
- If there is **presence** of contamination in the water from one or more machines in any of the post-maintenance testing, discuss alternatives with stakeholders, and recommend residents to consume water from other sources.

The flowchart below outlines the process.



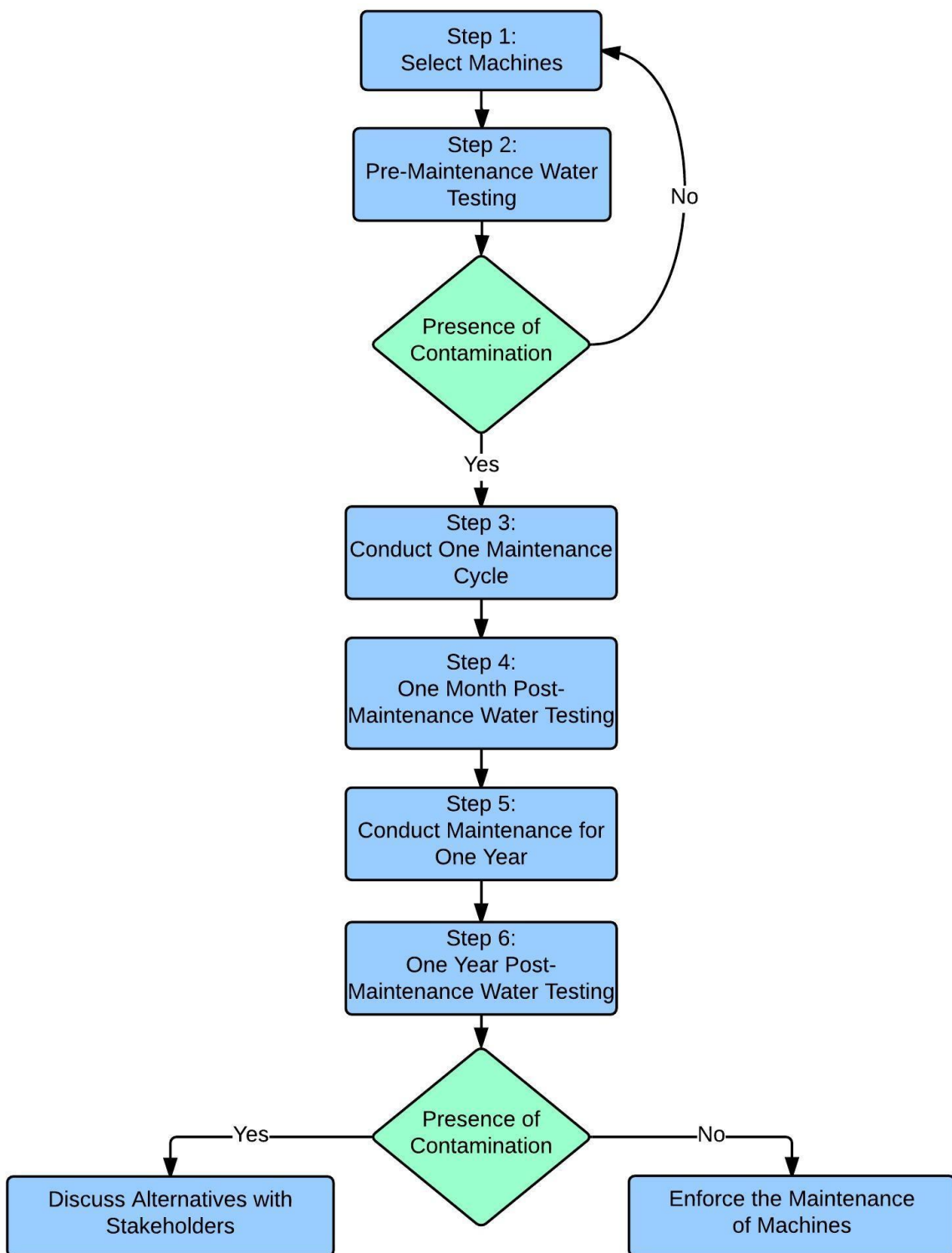


Figure 4- 17: Outline of Trial Maintenance Program









## Phase 2: Inform the Community about the New Program

With the help of sector leaders and government representatives, notify all owners of water vending machines about the new program. The new program requires maintenance of the machines which authorities will regulate starting two months after the notification, giving time to the machine owner to determine a way of funding the maintenance. Sector leaders, government representatives, and DPF officers will also introduce the machine owners to the sticker system, which consists of placing stickers on vending machines acknowledging the conduction of maintenance or lack of maintenance of the machine.

## Phase 3: Regulate the Maintenance of Vending Machines

Regulation of the maintenance of vending machines has two main parts: tracking filter replacement and placement of stickers in the water vending machines. To track filter replacement, the authority (DPF staff, government representative or sector leader) should keep record of the owner's name for each of the vending machines and the date of filter replacement and the owner's signature to authenticate the replacement. The table below shows an example of this record.

**Table 4- 3: Example Maintenance Record**

	1st Filter Change	2nd Filter Change	3rd Filter Change
<b>John Smith</b>	<u>Carbon Filter:</u> Feb 1, 2015 	<u>Carbon Filter:</u> April 20, 2015 	<u>Carbon Filter:</u> June 25, 2015 
	<u>Resin Filter:</u> February 1, 2015 	<u>Resin Filter:</u> May 10, 2015 	<u>Resin Filter:</u> August 3, 2015 
	<u>Membrane Filter:</u> February 1, 2015 	<u>Membrane Filter:</u> June 1, 2015 	<u>Membrane Filter:</u> No Record

The authority can track how often owners replace their filters based on an estimated number of months the company of the machine recommends filter replacement. To provide proof of the maintenance, the owner of the machine should provide the filter receipt to the authority. If an owner does not change their filter as suggested by the calculations made, for example John Smith missed his 3rd scheduled filter change for the membrane filter, the authority will place a red sticker, developed by the team, on the water vending machine. A red sticker will notify other residents that the owner has not maintained their machine according to the suggested schedule and that users of the machine should boil the water before drinking. The red sticker would be removed when

the owner replaces the filter. On the other hand, the authority will place a green sticker on the water vending machine when the owner does replace their filter as scheduled. When other residents in the slum see the green sticker, they should be more comfortable with obtaining their water from this source. Figure () shows an example of the red and green stickers developed by the team. For the implementation, the team recommends the stickers contain the official logo of the DPF or another authority to make it official.



Figure 4- 18: Maintenance Stickers

With the enforcement of the sticker system, not only will the water quality dispersed from the water vending machine be regulated, but it could improve profit for the owners of the water vending machines. By potentially increasing the profit of the vending machines, the sticker system would also serve as an incentive for vending machine owners to maintain their machine.

#### Phase 4: Test Random Machines Semiannually

Testing random machines semiannually for Thai drinking standards will determine the effectiveness of the maintenance program implemented. If maintained machines present contamination, the maintenance program should stop and vending machines should be discarded as a drinking water source. On the other hand, if the tests don't present contamination, the maintenance program is effectively ensuring residents of Khlong Toei receive drinkable water from the water vending machines.

#### 4.7 Trial Hygiene Education Program

After conducting the trial educational campaign, the team evaluated the effectiveness of the program based on information collected from both classrooms before and after the activities took place.

#### Both classrooms showed an increase of responses after the conduction of the three activities

The graphs below show a comparison of the number of responses for each of the five statements obtained through the assessment of knowledge pre-activity and post-activity. Figure 4-17 shows the results for classroom 1. The graph suggests children did not know germs travel from one person to another, and they were fully aware of how to protect themselves from germs and how to wash their hands properly.

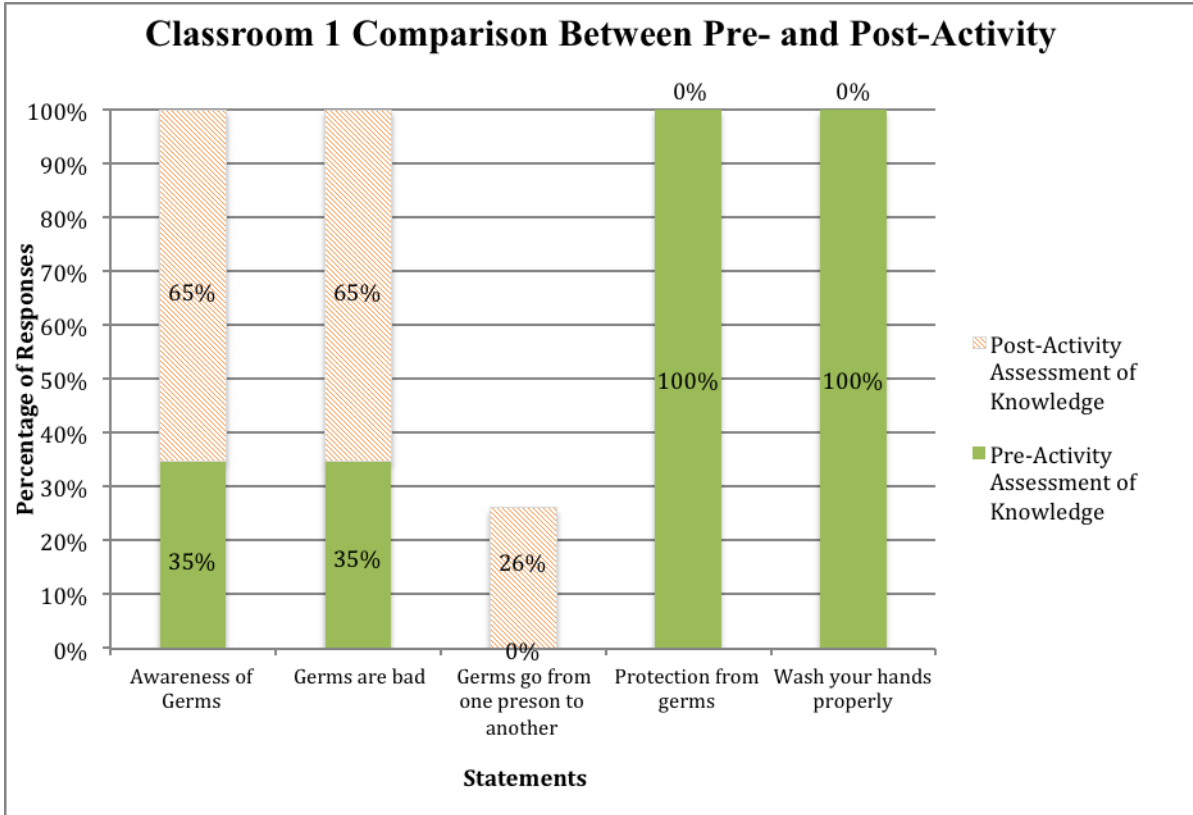


Figure 4- 19: Classroom 1 Comparison between Pre- and Post-Activity

Figure 4-18 shows the results for classroom 2. This graph suggests that half of the classroom was aware of the five statements, and after the conduction of the activities, the

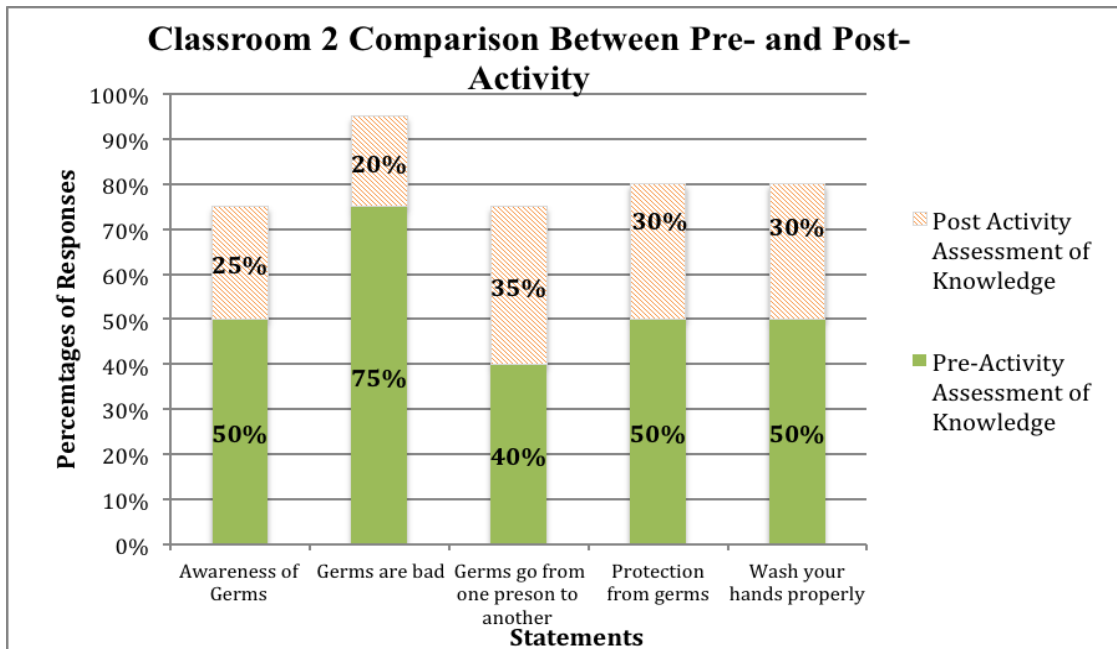


Figure 4- 20: Classroom 2 Comparison between Pre- and Post-Activity

awareness increased in at least 20% for all the statements.

### Implications

The results of these graphs suggest the **effectiveness of the educational campaign conducted in the Duang Prateep Foundation Kindergarten** on March 3<sup>rd</sup>, 2015. Therefore, the team will **recommend the conduction of the hygiene educational program in other schools around the slum.**

## 5 Recommendations and Conclusions

The team developed recommendations based on background research and results from our methods. This chapter will present our recommendations to improve the current water quality in the Khlong Toei Slum. The team believes that through the implementation of these recommendations, this project could stimulate healthy living in the Khlong Toei Slum and encourage slums throughout Thailand to take pro-active steps towards improving their water quality.

### 5.1 Recommendations to Raise Awareness of the Water Quality Issue

On February 20<sup>th</sup>, 2014, the team visited the Duang Prateep Foundation and presented the findings and preliminary recommendations of this project to sponsor representatives, sector leaders, residents of the community, and a representative from the Bangkok Metropolitan Administration. This presentation served as the first step in raising awareness of poor drinking water quality in the Khlong Toei Slum. However, to raise awareness throughout the entire slum, the team made the following recommendations.

**The team strongly recommends the Duang Prateep Foundation raise awareness, with the help of the Thai Ministry of Public Health, to community members of the Khlong Toei Slum about the effects of consuming poor quality drinking water.**

Fifty-two percent of the surveyed residents do not believe water can affect their health and wellness. The team recommends that the Duang Prateep Foundation and the Thai Ministry of Public Health, a governmental agency responsible for the promotion of health and disease control and prevention (Ministry of Public Health, 2012), work together in the slum to raise awareness about the implications and negative health effects of consuming water pathogens and other harmful toxins that may be present in the drinking water. Along with informing the community of effects of consuming poor quality water, the team recommends that the DPF and Thai Ministry of Public Health brief the residents on methods to combat the issue of contaminated water. The Ministry of Public Health could create a campaign focused on the negative side effects, symptoms, diseases that may affect consumers of contaminated water, and preventative measures.

**The team recommends the DPF meet with sector leaders and water vending machine owners to educate them about the water quality issue and present the team's water testing results.**

In order to inspire the improvement of water quality within sector leaders and vending machine owners, the team suggests the Foundation meets with both parties to present the water quality results and provide information regarding the effects of drinking contaminated water. Sector leaders and water vending machine owners can collaborate and work with the Foundation to help improve the water quality.

Sector leaders, not holding responsibility for the water in the slum, and residents, not regularly maintaining their water vending machines, exhibit one of the many difficult situations the Duang Prateep Foundation faces when solving this issue. Sector leaders and vending machine owners are each responsible for the wellness of the sector residents and the quality of the water provided from the machines respectively. The sector leaders are only responsible for the vending machines if a resident of the slum reports that a machine is dirty. The residents who buy the machines do not go through any type of approval or



application process to place one outside of their home or shop. The sector leaders are only required to regulate the location of the machines; residents cannot place the machines in areas where they will block roads or pathways.

Residents said they use water from vending machines because they think the machines have the best quality water. As the team's testing results point out the water contamination in vending machines, the residents are misinformed about the water quality. The sector leaders and vending machine owners should be informed of the issue before the Duang Prateep Foundation informs all residents in the slum about the water quality issue.

**The team recommends that the DPF contact Bangkok's Metropolitan Administration to obtain their support in authorizing a drinking water management system for the water vending machines in the Khlong Toei Slum and improving the welfare of its residents.**

Bangkok's Metropolitan Administration, the local government of Bangkok whose goal involves the provision of social welfare and the improvement of quality of life for the youth, women, elderly, and disadvantaged groups. The team recommends that the DPF inform the Metropolitan Administration about the coliform contaminated water from one of the water vending machine.

Contamination is present in the water vending machines and residents do not regularly maintain them. In order for the DPF to change the habits of vending machine owners, they need help from a more authoritative figure. Because Bangkok's Metropolitan Administration has the authority to administer inspection, shut down machines that do not pass inspection, and reinforce fees. Their support can reinforce the importance of filter replacement and machine maintenance and is helpful for the DPF in order to maintain friendly relations with residents.

## **5.2 Recommendations to Inform Residents of Point-of-Use Water Treatment Methods**

**The team recommends the DPF distribute information on the functionality of different types of filters and the required maintenance, along with information on the benefits of boiling water around the community.**

65% of the Khlong Toei Slum surveyed population uses in-home filters as their source of drinking water. Therefore, the team finds importance in informing the community about different filtration systems and their functionality, as well as emphasizing importance on maintenance. Nine percent of the slum residents, who participated in the survey, excluding those who drink from bottled water, boil their water before consuming. Even though water passes through a filtration system, not all filtration systems guarantee the elimination of bacteria and viruses. Boiling water eliminates the presence of bacteria, viruses, and other microorganisms. Therefore, the team recommends raising awareness about filter maintenance and the benefits of boiling water.

The team designed a pamphlet to raise awareness on proper filter and boiling methods. Also, the team designed a poster, which contained information about the benefits of boiling water and safe storage methods. The team recommends the DPF to distribute information following three strategies: (1) to give children in schools the pamphlet to bring to their parents, (2) to distribute the pamphlet under resident's doors or gates, (3) to request cooperation of health centers and local hospitals to distribute a

smaller version of the posters to visitors and patients, and (4) to display the posters around the slum, Distributing information to slum residents will raise awareness of proper filtration and boiling methods and help residents understand the water quality issue. Refer to Appendix P for the pamphlet in Thai and in English and Appendix Q for the poster.

### 5.3 Recommendation to Implement a Water Management Model

**The team recommends that the DPF, along with contributing parties, implement the team's proposed water management model.**

Analysis of results led the team to develop a water management model that entails water vending machine maintenance and in-home filter replacement. Section 4.6 outlines the water management model.

**The team recommends that the DPF determine one of the following three methods to fund the maintenance program: (1) Water vending machine owners pay in full, (2) an NGO or grant to fund the program in full, or (3) owners and an NGO to split the costs of the program.**

Implementing the water vending machine maintenance model will financially strain the owners of the water vending machines. Water vending machines, if properly maintained, could supply the slum with clean drinking water. The cost of maintenance is a factor to consider if implementation is deemed appropriate.

To fund the maintenance program, the team recommends the DPF choose one of the following three methods: (1) The vending machine owners must pay in full for maintenance of their machines, (2) the DPF may seek help from NGO's and grants to fund the program in full, or (3), the program is paid in part by the machine owner and in part by an NGO or grant. Since residents buy the water vending machines with their own money, the owners should hold full responsibility of the proper functionality of their machine. However, with the slow profit rate of the water vending machines and high prices of filters, the team understands the financial strain this may inflict for the owners. An option that holds responsibility to the water vending machine owners and alleviates financial strains would be for the owner and an NGO to pay for the filters together.

### 5.4 Recommendation to Implement a Hygiene Educational Campaign for Schools

**The team recommends the DPF to implement the hygiene educational campaign, developed by the team, in other schools around the Khlong Toei community.**

An educational campaign focusing on hygiene practices may be beneficial for the Khlong Toei Slum community because practicing good hygiene could reduce the chances of pathogen contamination affecting the community. The team's campaign focused on children because they are likely to be more vulnerable than adults to get sick from bacteria and pathogen contamination (Natural Resources Defense Council, 1997).

Our team developed an educational program concerning hygiene practices in schools targeting students aged three to six. The campaign focused on children because these children will one day be tomorrow's decision makers and leaders of the community. The team recommends the implementation of this campaign in schools throughout the Khlong Toei Slum.

### 5.5 Recommendation for Future Research in the Khlong Toei Slum

**The team recommends the conduction of water testing from the MWA water network, water vending machines, and in-home taps to test the water based on Thailand drinking standards.**

This project tested water from fire hydrants and water vending machines for pathogenic contamination in three sectors of the Khlong Toei Slum. Due to the team's limited time in Bangkok, the team was unable to test water in all 27 sectors of the Khlong Toei Slum. Moreover, concern for the teams safety in the slum, restricted our research from collecting water samples from in-home taps and filters. The team narrowed the water contamination investigation to pathogens because, if consumed, pathogens can have detrimental health effects on a person's health. However, other contaminants could be present in the water throughout the Khlong Toei Slum. Due to the team's limitations, the team recommends the DPF conduct further research, evaluating the quality of all drinking water in the Khlong Toei Slum based on Thai drinking standards.

This recommendation would establish the drinking water quality in the Khlong Toei Slum and identify all potential contaminants. It is important for the DPF to know all the contaminants in the water in order to implement a water management model that effectively eliminates all contaminants and distributes drinkable water for the residents of the Khlong Toei Slum.

### 5.6 Conclusions

The goal of this project was to address the issue of contaminated water in the Khlong Toei Slum and recommend a sustainable drinking water management model to improve the quality of life for the residents. Water testing established the need for improvement of the current water quality available to the residents and surveys and interviews identified that residents consume water from two main sources, water vending machines and in-home filters. The survey and interview results offer a starting point to launch a larger social project. These recommendations will benefit not only residents in the Khlong Toei Slum, but could also benefit slums globally facing similar water quality issues.

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## **Appendix A: The Duang Prateep Foundation**

The Duang Prateep Foundation is a nongovernmental organization based in Bangkok Thailand. The mission of this organization is to provide aid to the Khlong Toei Slum in three major areas. The first area is education to youth in impoverished communities. The second is to provide guidance in vocational studies and craftsmanship. Lastly, the Duang Prateep Foundation aspires to stimulate healthy living within communities (Hata, 2010)

Prateep Ungsongtham Hata founded the Duang Prateep Foundation in 1978. The founder lived and grew up in the Khlong Toei Slum. Realizing that the living conditions in the slum were unbearably poor, she became inspired to help this cause. Her primary goal focused on alleviating the distress these families faced and to give them hope.

The Foundation, operating for about thirty six years to date, is now working on over twenty projects to help change the lives of people living in the Khlong Toei Slum. They cover tasks such as educating the youth, running programs at the local community center, and ending drug and child abuse. The Foundation also currently runs a rehabilitation center as well as a public kindergarten school (Duang Prateep Foundation, 2004).

# Appendix B: Gantt Chart

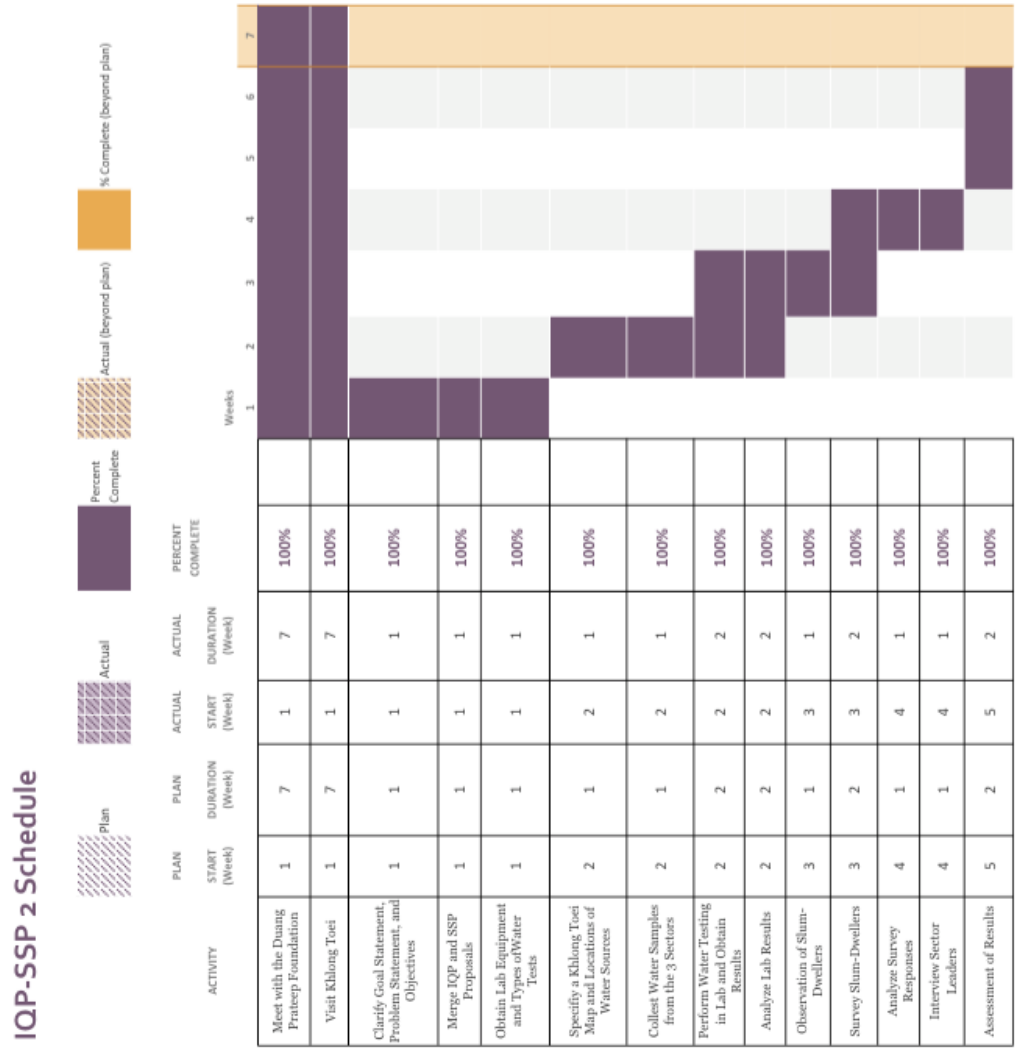


Figure B- 1: Gantt Chart

## Appendix C: Water Collection and Testing Procedures

### Collecting Water Samples

**Purpose:**

Collecting water samples is crucial in water testing to determine potential contamination of pathogens.

**Materials:**

1. 120 mL Sterile Collection Containers
2. Labels
3. Marker
4. Alcohol Swabs
5. Rubber gloves

**Procedure:**

1. After identifying the location of water collection, label code on the sterile collection container using the label and marker. Be sure to label clearly and reference this location in notes.
2. Turn on the water; allow the water to flow for 1-3 minutes, and then turn off the water.
3. At the source of water collection, take the alcohol swab, and diligently clean the rim of the nozzle. Wearing rubber gloves is needed while doing this step.
4. Turn on the water again; allow the water to flow for 1-3 minutes, and then turn off the water.
5. Wash your hands with the alcohol swabs.
6. Open sterile collection container and collect 120 mL water sample. Be sure not to touch the rim of the collection container.
7. Replace cap on sterile collection container.
8. Turn off water nozzle.
9. Take water sample to the laboratory for water testing.

## Presumption Test

### Purpose:

To determine the presence of coliform bacteria in a water sample and to obtain some index as to the Most Probable Number (MPN) of coliform bacteria present in the sample under analysis.

### Materials:

1. 120 mL Water Samples
2. 10 Single-Strength Lactose Fermentation Broths (LB1X)
3. Bunsen Burner
4. 10 Test Tubes
5. Test-Tube Rack
6. Pipette
7. Glassware Marking Pencil

### Procedure:

1. Prepare 10 test tubes with 10 mL LB1X.
2. Distribute 10 mL of collected water sample into each of the tubes containing LB1X.
3. Incubate all tubes for 24 hours at 37 °C
4. If there is no apparent reaction, continue incubating for another 24 hours at 37 °C.
5. After incubation, consider only tubes with presence of turbidity and bubbles produced from the fermentation (a positive result) to confirm the presence of coliforms.
6. A number of positive tubes will give a MPN value for indicating the drinkable water. Drinkable Water Standard MPN is  $< 2.2$  (less than 2 positive tubes).

## Confirmed Test

### Purpose:

To confirm the presence of coliform bacteria and determine the presence of *E. Coli*. in a water sample for which the presumption test was positive.

### Materials:

1. One 24-hour old positive lactose broth culture from each of the three series from the presumptive test
2. Brilliant Green Agar Plates
3. EC broth
4. Bunsen Burner
5. Glassware Marking Pencil
6. Inoculating Loop

### Procedure:

1. Label the covers of the Brilliant Green Agar plates with the source of the water sample.
2. Streak the surface of the Brilliant Green using a positive 24-hour lactose broth culture from the presumption test to obtain discrete colonies.
3. Incubate all plate cultures in an inverted position for 24 hours at 35.5 °C.
4. After incubation, the presence of green or yellowish in a bright green-yellow zone shows positive result for coliforms.
5. To further investigate for *E. Coli*. Culture positive tube from the presumption test and transfer into EC broth tube using sterilized inoculating loop.
6. Incubate all tubes for 24 hours at 44.5 °C.
7. After incubation, the presence of turbidity and bubbles shows positive result to determine the presence of *E. Coli*.

## Completed Test

### Purpose:

To determine whether the *E.coli* present in the water sample is fecal *E.coli* or not for which the confirmed test of EC broth was positive.

### Materials:

1. One 24-hour old positive lactose broth culture from each of the three series from the confirm test
2. Eosin-Methylene Blue Agar (EMB) Plates
3. Bunsen Burner
4. Glassware Marking Pencil
5. Inoculating Loop

### Procedure:

1. Label the covers of the EMB plates with the source of the water sample.
2. Streak the surface of the EMB using a positive 24-hour lactose broth culture from the presumption test to obtain discrete colonies.
3. Incubate all plate cultures for 24 hours at 37 °C.
4. After incubation, the presence of green-metallic sheen colonies shows positive result to confirm the presence of fecal coliforms.



## Appendix D: Interview Questions for Sector Leaders

### Appendix D-1: Interview Questions (English)

Your participation in this interview is strictly voluntary. Our team would like permission to conduct surveys within this sector. This interview is being conducted on behalf of the Duang Prateep Foundation to collect demographic information about your sector as well as daily routines of the residents to begin the survey process.

Name:

Sector Number:

1. Could you please identify and explain your responsibilities as leader of your sector? Specifically pertaining to water, what are your responsibilities?
2. Before a slum-dweller purchases a water vending machine, is there a process for them to go through in order to obtain permission from the sector leaders? Please explain the process and potential guidelines to get a machine.
3. Does the sector control or regulate maintenance of these water vending machines?
4. How many residents live in your sector? Are there more older or younger people living here?
5. Where and when do people gather together the most in the sector so that we can hand out surveys?
6. Which source do you think most of the residents living in your sector obtain drinking water? (If specified that residents mainly use in-home taps, ask if most residents have in-home water filtration)
7. Could you explain the history of this sector briefly?

## Appendix D-2: Interview Questions (Thai)

ข้อมูลที่ได้มาจากการสำรวจเชิงลึกในครั้งนี้จะถือเป็นความลับตามที่ระบุไว้ในกฎหมาย การเข้าร่วมนี้เป็นไปด้วยความสมัครใจ ผู้ให้ข้อมูลสามารถหยุดหรือข้ามคำถามได้ตามต้องการ และจะไม่มีภาระบุชื่อของบุคคลที่ให้ข้อมูลในรายงาน การสำรวจเชิงลึกนี้จะถูกจัดขึ้นในนามของมูลนิธิดวงประทีป เพื่อทำความเข้าใจถึงคุณภาพน้ำดื่มของชุมชนคลองเตยในปัจจุบัน

ชื่อ:

ชุมชนหมายเลข:

1. หน้าที่และความรับผิดชอบของคุณในฐานะประธานชุมชน? ส่วนที่เกี่ยวข้องกับน้ำมีอะไรบ้าง?
2. ก่อนที่ชาวบ้านจะซื้อตู้กดน้ำ ต้องมีการขออนุญาตจากประธานชุมชนหรือไม่ ถ้ามี ให้อธิบายกระบวนการนั้นๆ?
3. ทางชุมชนมีการดูแลรักษาตู้กดน้ำเหล่านี้หรือไม่?
4. มีประชากรอาศัยอยู่เท่าไรในชุมชนนี้? เป็นเด็กหรือผู้ใหญ่มากกว่ากัน?
5. พื้นที่และช่วงเวลาไหนที่มีคนมาพบปะกันมากที่สุดในชุมชนนี้?
6. คุณคิดว่าชาวบ้านส่วนใหญ่ในชุมชนนี้ได้น้ำดื่มมาจากไหน? (เช่น ตู้กดน้ำ น้ำประปาในครัวเรือน เครื่องกรองน้ำในครัวเรือน เป็นต้น)
7. ช่วยอธิบายประวัติพอสังเขปของชุมชนนี้?

## Appendix E: Survey for Residents

### Appendix E-1: Survey Questions (English)

*Hello, my name is \_\_\_\_\_. We are students from Chulalongkorn University and are conducting a study for the Duang Prateep Foundation. May I ask you a few questions? It will take no longer than 15 minutes. Do you live in this sector? Do you live in one of the three?*

The information given in this survey is confidential. Your participation is strictly voluntary and you can stop at any time or skip questions. No individually identifying data will be collected or reported. This survey is being conducted on behalf of the Duang Prateep Foundation to understand how the current water quality in the Khlong Toei Slum affects you.

- A. Where do you or your family members get water to drink?\*(If the response includes vending machines, skip question E, etc.)
1. Vending machines
  2. In-home taps
  3. Communal taps
  4. Filtration systems in schools
  5. Bottled water from store/marketplace
  6. In-Home Filters
- B. Why do you obtain your drinking water from these sources?
- C. What do you or your family members do after getting your water to drink?  
(Choose all that apply)
1. Boil it
  2. Drink right away
  3. Keep it in storage
  4. Refrigerate
  5. Other: \_\_\_\_\_
- D. Does you or your family use water vending machines? \_\_\_\_\_ (If no, move to question E.) What do you or your family members use the water from vending machines for?\*
1. Drinking
  2. Brushing teeth
  3. Washing hands
  4. Cleaning dishes
  5. Cooking
  6. Showering
  7. Washing Clothes
- E. If you or your family members do not use the vending machines, why?\*
1. Too expensive
  2. I can get water from my home

3. Too far away
4. I do not know where the vending machines are
5. Bad quality water
6. Other \_\_\_\_\_

F. Do you or your family use the water from the communal taps? \_\_\_\_\_ (If no, go to question G) What do you or your family members use the water from communal taps for? \*

1. Drinking
2. Brushing teeth
3. Washing hands
4. Cleaning dishes
5. Cooking
6. Showering
7. Washing Clothes

G. Do you personally think water can make people sick?\*

H. Do you or your family use the water from the in-home taps? \_\_\_\_\_ (If no, go to question I)

I. What do you or your family members use the water from in-home taps for?\*

1. Drinking
2. Brushing teeth
3. Washing hands
4. Cleaning dishes
5. Cooking
6. Showering
7. Washing Clothes

J. Do you think that quality of water is important for the health of your family?

The following two questions are related to you and your family's health. These questions will help the Duang Prateep Foundation and our team understand the health and well-being of the Khlong Toei Community Members.

K. Have you or your family members been sick in the past three months? \_\_\_\_\_ (If no, skip to demographics) What health symptoms did you or your family members experience?\*

1. Diarrhea
2. Stomach Cramps
3. Vomiting
4. High Fever
5. Nausea
6. We haven't experienced any of these symptoms

L. How were these health symptoms treated?\*

1. Saw a doctor at the hospital
2. Drank water
3. Slept
4. Buy medicines from pharmacy
5. Other \_\_\_\_\_

The following questions are designed to gained demographic information for the Duang Prateep Foundation and our team.

<p>Please select your age range:</p> <ol style="list-style-type: none"> <li>1. &lt;18</li> <li>2. 18-30</li> <li>3. 31-40</li> <li>4. 41-60</li> <li>5. &gt;60</li> </ol>	<p>Please select the sector of the slum you live in:</p> <ol style="list-style-type: none"> <li>1. Chum Chon Rim Khlong Pra Ka Nong</li> <li>2. Chum Chon Wud Khlong Toei Nai</li> <li>3. Chum Chon Mhoo Bann Pattana Jhet Sip Rai</li> </ol>
<p>How many years have you and your family lived in the slum?</p>	<p>How many children do you have, if any?</p>

## Appendix E-2: Survey Questions (Thai)

สวัสดีครับ ผมชื่อ \_\_\_\_\_ พวกเราเป็นนิสิตจากจุฬาลงกรณ์มหาวิทยาลัยทำงานร่วมกับ  
มูลนิธิดวงประทีป ขอถามคำถามไม่กี่ข้อนะครับ ใช้เวลาไม่เกิน 15 นาที ไม่ทราบว่า คุณอาศัยอยู่ใน ชุมชนนี้หรือไม่  
(ถ้าไม่ ถามต่อว่า คุณอาศัยอยู่ในชุมชน 1 ใน 3 นี้หรือไม่)

ข้อมูลที่ได้มาจากการสำรวจเชิงลึกในครั้งนี้จะถือเป็นความลับตามที่ระบุไว้ในกฎหมาย การเข้าร่วมนี้เป็น  
ไปด้วยความสมัครใจ ผู้ให้ข้อมูลสามารถหยุดหรือข้ามคำถามได้ตามต้องการ และจะไม่มีการระบุชื่อของ  
บุคคลที่ให้ข้อมูลในรายงาน การสำรวจเชิงลึกนี้จะถูกจัดขึ้นในนามของมูลนิธิดวงประทีป เพื่อทำความ  
เข้าใจถึงคุณภาพน้ำดื่มของชุมชนคลองเตยในปัจจุบัน

ก. คุณได้น้ำดื่มมาจากที่ไหน? (ถ้าคำตอบคือตู้กดน้ำดื่ม ข้ามคำถามข้อ ง.)

1. ตู้กดน้ำดื่ม
2. น้ำประปาในครัวเรือน
3. น้ำประปาสาธารณะ
4. เครื่องกรองน้ำในโรงเรียน
5. ชื้อจากร้านค้า

ข. ทำไมคุณถึงเลือกแหล่งน้ำดื่มนั้นๆ?

ค. คุณหรือครอบครัวของคุณได้มีการจัดการกับน้ำดื่มที่นำมาอย่างไรบ้าง? (เลือกได้มากกว่า 1 ข้อ)

1. ดื่ม
2. ดื่มทันที
3. เก็บไว้
4. อื่นๆ

ง. คุณหรือครอบครัวของคุณใช้บริการตู้กดน้ำดื่มหรือไม่? \_\_\_\_\_ (ถ้าไม่ ย้ายไปข้อ ง.)

คุณหรือครอบครัวของคุณใช้บริการตู้กดน้ำดื่มเพื่ออะไร?\*

1. ดื่ม
2. แปรงพื้น
3. ล้างมือ
4. ล้างจาน
5. ทำอาหาร

ง. ถ้าคุณหรือครอบครัวของคุณไม่ใช่ผู้ค้ำน้ำดื่ม ทำไม?

1. ราคาแพง
2. สามารถหาน้ำดื่มได้จากที่อื่น
3. ผู้ค้ำน้ำดื่มตั้งอยู่ไกล
4. ไม่ทราบว่าผู้ค้ำน้ำดื่มตั้งอยู่ที่ไหน
5. น้ำดื่มมีคุณภาพไม่ดี
6. อื่นๆ \_\_\_\_\_

จ. คุณหรือครอบครัวของคุณใช้บริการน้ำประปาสาธารณะหรือไม่? \_\_\_\_\_ (ถ้าไม่ ย้ายไปข้อ ฉ.)

คุณหรือครอบครัวของคุณใช้บริการน้ำประปาสาธารณะเพื่ออะไร?\*

1. ดื่ม
2. แปรงฟัน
3. ล้างมือ
4. ล้างจาน
5. ทำอาหาร

ฉ. คุณหรือครอบครัวของคุณใช้บริการน้ำประปาในครัวเรือนหรือไม่? \_\_\_\_\_ (ถ้าไม่ ย้ายไปข้อ จ.)

คุณหรือครอบครัวของคุณใช้บริการน้ำประปาในครัวเรือนเพื่ออะไร?\*

1. ดื่ม
2. แปรงฟัน
3. ล้างมือ
4. ล้างจาน
5. ทำอาหาร

ช. โดยส่วนตัวแล้วคุณคิดหรือไม่ว่าน้ำดื่มมีผลทำให้คุณไม่สบายได้?

ซ. คุณคิดหรือไม่ว่าคุณภาพของน้ำสำคัญต่อสุขภาพของคนในครอบครัวคุณ?

คำถาม 2 ข้อต่อไปนี้มีความเกี่ยวข้องกับสุขภาพของคุณและสมาชิกในครอบครัว ซึ่งจะช่วยให้เรา  
และมูลนิธิควงประทีปเข้าใจสุขภาพและชีวิตความเป็นอยู่ของสมาชิกในชุมชนคลองเตย



ฅ. ในระบะ 3 เดือนที่ผ่านมำคุณหรือสมำชิกในครอบครัวของคุณมีอำกรเจ็บป่วยหรือไม่? \_\_\_\_\_  
 (ถ้าไม่ ขำมไปคำถำมเกี่ยวกับสถิติทำงประชำกร) อำกรเจ็บป่วยอะไรที่เกิดขี้นกับคุณหรือสมำชิกใน ครอบครัว?\*

1. ท้องเสียบ
2. ปวดท้อง
3. อำเจียน
4. ไข้สูง
5. คลื่นไส้

ณ. มีกำรรักษำอำกรเจ็บป่วยเหล่านั้บอย่างไร?\*

1. ไปพบแพทย
2. ดื่มน้ำ
3. นอนพักผ่อบ
4. อื่นๆ \_\_\_\_\_

คำถำมต่อไปนั้เป็นการเก็บรวบรวมข้อมูลสถิติเชิงประชำกร

ช่วงอำยุ 1. <18 2. 18-30 3. 31-40 4. 41-60 5. >60	ชุมชนที่อำศัยอยู่ในปัจจุบัน 1. ชุมชนริมคลองพระโขนนง 2. ชุมชนวัดคลองเตยใน 3. ชุมชนหมู่บ้านพัฒนำ 70 ไร่
คุณและครอบครัวของคุณอำศัยอยู่ใน ชุมชนคลองเตยมำประมำนกี่ปี?	คุณมีลูกหรือไม่? ถ้ามี มีกี่คน?

## Appendix F: Hygiene Campaign

### Appendix F-1: Assessment of Effectiveness

Conduct a survey to see what students know about germs and pathogens by asking students to raise their hand if they agree with the following statements before and after the conduction of the activities.

1. I know what germs are.
2. Germs are bad.
3. Germs go from one person to another.
4. I know how to protect myself from germs.
5. I know how to wash my hands properly.

## **Appendix F-2: Lesson Plan**

Note: This lesson plan is in English but the BSAC team members ran the activities in Thai.

### **Activity 1: What are pathogens?**

#### **Overview**

Students will learn about the existence of pathogens and harmful microorganisms in the environment. The students will first listen to a story that demonstrates how pathogens and bacteria can affect their health. Afterwards, the students will color pathogen shapes.

#### **Intended Learning Outcome**

By the end of the lesson, students will be able to understand the existence of harmful organisms in the environment and the negative effect bacteria can have in their health.

#### **Materials**

- Story board
- Sheets of paper with pathogens drawn on them
- Crayons

#### **Procedure (Approximately 30 min)**

1. Prepare the classroom so children can be seated in the floor.
2. Read the storyboard out loud and show the images to the children while reading the text.
3. Ask the students if they have any questions.
4. Divide the group into little groups and organize them in circles.
5. Show a paper with a pathogen and explain to the children that the drawing represents what caused the disease to the character of the storyboard.
6. Proceed to give each student a piece of paper with a pathogen and some crayons and instruct them to color them.
7. Assist any student who needs help or has any question.

### **Activity 2: How are pathogens Transmitted?**

#### **Overview**

Students will learn about the transmission of bacteria from one object to a person and from one person to another person. Students will see they cannot see bacteria, it can be everywhere by the activity.

#### **Intended Learning Outcome**

By the end of the lesson, students will be able to understand that pathogens and bacteria travel from one person to another just by contact.

#### **Materials**

- UV light pen (Ink with sponge and light)

#### **Procedure (Approximately 30 min)**

1. Extract from the UV pen the sponge containing the “invisible” ink.
2. Prepare the classroom so children can be seated on the floor.
3. Explain to students that the bacteria they drew minutes ago spreads really easily and that you will show them.

4. Have the organizers put one sponge in their hands.
5. Shake hands with the students and ask them to shake hands with other students.
6. After 10 minutes, get all the students to sit and use the UV light to show them the invisible ink they have on their hands from shaking hands with the UV light
7. Explain that ink is similar to bacteria because it cannot be seen but it can be in your hands by just touching something or someone.

### **Activity 3: How to protect yourself from pathogens?**

#### **Overview**

Students will learn that washing their hands can protect them from pathogens. Students will be taught how to properly wash their hands by following a series of steps.

#### **Intended Learning Outcome**

By the end of the lesson, students will be able to wash their hands properly on their own and possibly increment the number of times they wash their hands per day.

#### **Materials**

- Liquid soap
- Elephant song
- Washing hands poster

#### **Procedure (Approximately 30 min)**

1. Have the elephant song ready to play.
2. Explain to the students how to properly wash their hands with a demonstration.
3. Use the washing hands poster as an example.
4. Play the song and simulate washing hands while singing the song twice.
5. Make groups of 3 students and start bringing them to the restroom.
6. Guide the three students through the steps of washing hands and sing the song twice while they do it.

**Appendix F-3: Educational Material  
Story Board**

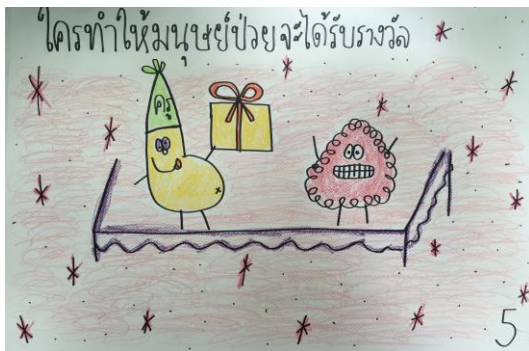


Figure F- 1: Storyboard

## Appendix F-4: Pictures from Hygiene Educational Campaign



Figure F- 2: Students Participating in Hygiene Educational Campaign



## Appendix G: Observations

Observations made January 28, 2015

Table G- 1: Observation

Water Usage	Physical Contamination	Community Behavior	Animal Presence
Bottled water for drinking	Trash in street and canal	Curiosity about water testing at machines and hydrants	Sleeping and injured dogs on streets and alleyways
Buckets to collect from vending machines	7 out of 9 vending machines had black residue in nozzle	Friendly	Dogs in people's homes
Big water tank under communal taps	Trash under homes	Excited to talk to us	Cats in people's homes
PVC on end of communal taps	Dirt and stagnant water near vending machines	Derogatory language used to describe or identify WPI students	Venders selling small birds and rabbits
Wash dishes with communal tap water	Animal feces near water sources	Invited team into home, offered chair, sometimes food	Goat in one shack
Sidewalk sink with fan filter	Open bathrooms and urinals	Some angry at team's presence	Aggressive dogs told to keep indoors when team walked by
Restaurants used large buckets to contain water	Dumping dirty and used water near vending machines	Given weird looks and sometimes stared at	Fish and tadpoles kept in large vases outside homes
Reuse bottles to fill at vending machines	Bio hazardous waste in streets near water	Women often at home during the day	People bandaging injured rabbit
	Animal feces commonly found in middle of sidewalk	Younger people speak a little English	Roosters kept in cages outside homes and businesses



## Appendix H: Geographical Coordinates of Water Testing Locations

Refer to Table 3-3 for coding of the testing sites.

**Table H- 1: Geographical Coordinates of Water Testing Locations**

Testing Site	Geographical Location
S1F1	13°42'27"N 100°35'24"E
S1V1	13°42'27"N 100°35'23"E
S1V2	13°42'25"N 100°35'24"E
S1V3	13°42'22"N 100°35'20"E
S2F1	13°42'36"N 100°33'42"E
S2V1	13°42'41"N 100°33'42"E
S2V2	13°42'37"N 100°33'45"E
S2V3	13°42'37"N 100°33'44"E
S3F1	13°42'36"N 100°34'31"E
S3V1	13°42'36"N 100°34'30"E
S3V2	13°42'34"N 100°34'29"E
S3V3	13°42'32"N 100°34'29"E

S = Sector      V = Water vending machine      F = Fire hydrant

## Appendix I: Maps of Testing Locations by Sector



Figure I- 1: Sector 1 Water Testing Locations



Figure I- 2: Sector 2 Water Testing Locations

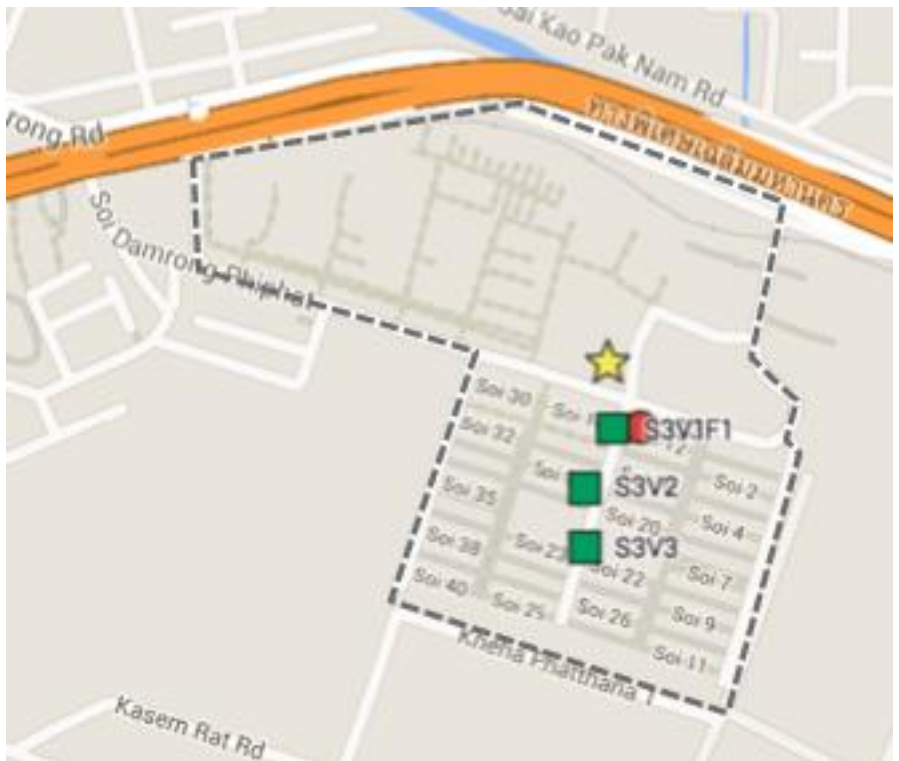


Figure I- 3: Sector 3 Testing Locations

## Appendix J: Interviews with Sector Leaders

### Appendix J-1: Sector 1 Leader Thai

ข้อมูลที่ได้มาจากการสำรวจเชิงลึกในครั้งนี้จะถือเป็นความลับตามที่ระบุไว้ในกฎหมาย การเข้าร่วมนี้เป็นไปด้วยความสมัครใจ ผู้ให้ข้อมูลสามารถหยุดหรือข้ามคำถามได้ตามต้องการ และจะไม่มีการระบุชื่อของบุคคลที่ให้ข้อมูลในรายงาน การสำรวจเชิงลึกนี้จะถูกจัดขึ้นในนามของมูลนิธิธิดวงประทีป เพื่อทำความเข้าใจถึงคุณภาพน้ำดื่มของชุมชนคลองเตยในปัจจุบัน

ชื่อ: Mr.Chaichayun Chaengcharoen

ชุมชนหมายเลข: 1

#### 8. หน้าที่และความรับผิดชอบของคุณในฐานะประธานชุมชน? ส่วนที่เกี่ยวข้องกับน้ำมีอะไรบ้าง?

**BSAC:** คืออยากจะถามว่าหน้าที่ในฐานะประธานชุมชนที่เกี่ยวกับน้ำนี้มีอะไรบ้าง

**Leader:** หือ

**BSAC:** เหมือนทำส่วนไหนบ้างอะไรเงี้ย หน้าที่ของประธานชุมชนนี้คือดูแลส่วนไหนบ้าง

**Leader:** มันไม่ได้เกี่ยวเรื่องน้ำ ไม่ได้เกี่ยวกัน

**BSAC:** เอาเรื่องอื่นก็ได้ค่ะ

**Leader:** ก็ดูแลสิ่งแวดล้อม ดูแล

**BSAC:** ชยะอะไรี่ปะคะ

**Leader:** ก็ชยะ เรื่องทั่วไปอะ มีเกือบทุกเรื่องอะ เตือดร้อนอะไรก็เข้าประชุมเขตประจำเดือน

#### 9. ก่อนที่ชาวบ้านจะซื้อตุ๊กตน้ำ ต้องมีการขออนุญาตจากประธานชุมชนหรือไม่ ถ้ามีให้อธิบายกระบวนการนั้นๆ?

**BSAC:** เออแล้วก็ตามชาวบ้านจะซื้อตุ๊กตน้ำเนี่ยคะ

ต้องมีกระบวนการมาขออนุญาตที่นั่นก่อนมัยคะ หรือว่าไม่

**Leader:** ไม่ต้องงๆ ซื้อเองเลย ซื้อกันเอง ใครจะทำอะไรทำไป

#### 10. ทางชุมชนมีการดูแลรักษาตุ๊กตน้ำเหล่านี้หรือไม่?

**BSAC:** แล้วก็ทางประธานเนี่ย

เออหมายถึงว่าทางชุมชนเนี่ยมีมาตรการการดูแลเครื่องกตน้ำในชุมชนหรือเปล่านั้น หรือว่าไม่

**Leader:** ก็คนซื้อก็ดูแล ก็ดูกันเองอะ ส่วนใหญ่ไม่ตีค่าก็ไม่เน้นกัน

#### 11. มีประชากรอาศัยอยู่เท่าไรในชุมชนนี้? เป็นเด็กหรือผู้ใหญ่มากกว่ากัน?

**BSAC:** เออแล้วในชุมชนนี้มีประชากรอาศัยอยู่ประมาณเท่าไรอะคะ

**Leader:** ตอนนีหรือครับ เออมันลดลงไปเยอะแล้ว

**BSAC:** เอาแบบประมาณอะคะ

**Leader:** ประมาณ 1000

**BSAC:** แล้วส่วนใหญ่เป็นเด็กหรือเป็นผู้ใหญ่อะคะ

**Leader:** ส่วนมากจะเป็นผู้ใหญ่ นะ เด็กส่วนน้อย

**12. พื้นที่และช่วงเวลาไหนที่มีคนมาพบปะกันมากที่สุดในชุมชนนี้?**

**BSAC:** บริเวณไหนที่คนมาพบปะกันมากที่สุด

**Leader:** ก็เนี่ยตรงนี้แหละ ลานกีฬาช่วงเย็น จะมี 2กลุ่ม 3กลุ่ม

**13. คุณคิดว่าชาวบ้านส่วนใหญ่ในชุมชนนี้ได้น้ำดื่มมาจากไหน? (เช่น ตักต้ำน้ำ  
น้ำประปาในครัวเรือน เครื่องกรองน้ำในครัวเรือน เป็นต้น)**

**BSAC:** ในความคิดของท่านประธานเนี่ยชาวบ้านส่วนใหญ่ในพื้นที่นี้ได้น้ำดื่มมาจากที่ไหนกัน

**Leader:** ก็ประปาเนี่ยแหละส่วนมากแล้วก็เค้าใช้เครื่องกรองน้ำ เครื่องกรองน้ำเค้ามีเกือบทุกบ้าน

**BSAC:** ก็คือเค้ามีเครื่องกรองน้ำที่บ้านไหม๊ยะคะ

**Leader:** ใช่ เค้าจะไม่กินน้ำก็อกสตาๆ

**14. ช่วยอธิบายประวัติพอสังเขปของชุมชนนี้?**

**BSAC:** ให้ช่วยอธิบายประวัติของชุมชนนี้แบบย่อๆได้มั๊ยะคะ ทราบมั๊ยะคะ ถ้าไม่ทราบก็ไม่เป็นไร

**Leader:** ประวัติอะ ก็เนี่ยคือ

โดยส่วนใหญ่เนี่ยคนในชุมชนนี้จะเป้นอดีตพนักงานองค์การฟอกหนังที่

ยุบไปเมื่อปี50 เป้นอดีตพนักงาน ตอนนั้นก็แยกย้ายไปบ้าง คนมาใหม่ก็มาอยู่บ้าง

## Appendix J-2: Sector 1 Leader English

Your participation in this interview is strictly voluntary. Our team would like permission to conduct surveys within this sector. This interview is being conducted on behalf of the Duang Prateep Foundation to collect demographic information about your sector as well as daily routines of the residents to begin the survey process.

Name: Mr. Chaichayun Chaengcharoen  
Number: 1

Sector

### **1. Could you please identify and explain your responsibilities as leader of your sector? Specifically pertaining to water, what are your responsibilities?**

**BSAC:** I would like to ask about the duty and role concerning water of being the sector leader?

**Leader:** Hmm...

**BSAC:** Like what specific part that you are looking after, within the sector

**Leader:** I'm not the one who is in charge of water

**BSAC:** How about other matter?

**Leader:** Like environmental matter

**BSAC:** Did you mean by trash?

**Leader:** Yes and also like general things, well most of the things. If anyone has problem, we arrange monthly meeting.

### **2. Before a slum-dweller purchases a water vending machine, is there a process for them to go through in order to obtain permission from the sector leaders? Please explain the process and potential guidelines to get a machine.**

**BSAC:** If the slum-dweller wants to own a water vending machine, is there any procedure before doing so?

**Leader:** No, they buy those machines whenever and wherever they want too.

### **3. Does the sector control or regulate maintenance of these water vending machines?**

**BSAC:** How about the regulation of maintenance on these water vending machines? Is there any staff of this sector who conducts the maintenance? or the owners just have to do it themselves?

**Leader:** The owners have to do it, mostly if the machines aren't good enough, they don't really care much.

### **4. How many residents live in your sector? Are there more older or younger people living here?**

**BSAC:** How many residents live in your sector?

**Leader:** At the present time? It is not as high as before

**BSAC:** Could you estimate the number?

**Leader:** Around 1000

**BSAC:** Mostly adults or children?

**Leader:** Adults for most of them, very few of children

**5. Where and when do people gather together the most in the sector so that we can hand out surveys?**

**BSAC:** Where do people gather most? and when?

**Leader:** Here right here where we are now; the basketball court. There'll a couple group of people gather here in evening.

**6. Which source do you think most of the residents living in your sector obtain drinking water? (If specified that residents mainly use in-home taps, ask if most residents have in-home water filtration)**

**BSAC:** In your opinion, where do most of people give their drinking water from?

**Leader:** Mostly, tap water but they'll have their own in home filters.

**BSAC:** Do they have it at their homes?

**Leader:** Yes, they would not drink directly from the tap.

**7. Could you explain the history of this sector briefly?**

Mostly the residents here are former workers for the leather tanning factory

**BSAC:** Could you explain the history of this sector briefly? This is not necessary if you don't know

**Leader:** For the history, Most of the residents here are former workers for the leather tanning factory that has now been abolished about 50 years ago. Some of them moved away but stay, and some are newcomers.



## Appendix J-3: Sector 2 Leader Thai

### คำถามเพื่อการสำรวจเบื้องต้นสำหรับประธานชุมชน

ข้อมูลที่ได้มาจากการสำรวจเชิงลึกในครั้งนี้จะถือเป็นความลับตามที่ระบุไว้ในกฎหมาย การเข้าร่วมนี้เป็นไปด้วยความสมัครใจ ผู้ให้ข้อมูลสามารถหยุดหรือข้ามคำถามได้ตามต้องการ และจะไม่มีกระบวนการระบุชื่อของบุคคลที่ให้ข้อมูลในรายงาน การสำรวจเชิงลึกนี้จะถูกจัดขึ้นในนามของมูลนิธิดวงประทีป เพื่อทำความเข้าใจถึงคุณภาพน้ำดื่มของชุมชนคลองเตยในปัจจุบัน

ชื่อ: Mr.Punya Silaluk

ชุมชนหมายเลข: 2

#### 1. หน้าที่และความรับผิดชอบของคุณในฐานะประธานชุมชน? ส่วนที่เกี่ยวข้องกับน้ำมีอะไรบ้าง?

**BSAC:** หน้าที่และความรับผิดชอบของคุณในฐานะประธานชุมชน

**Leader:** คิดทุกอย่างนะ ที่ลูกบ้านมีปัญหา ลูกบ้านมาแจ้ง เราทุกอย่าง น้ำไม่ไหล ไฟไม่ติด ความเป็นอยู่ของคนในชุมชน อำนวยความสะดวกให้ชุมชนไว้ ถนนหนทาง หน้าที่ประธาน

**BSAC:** แล้วเรื่องพวกน้ำดื่ม คุณภาพน้ำดื่มอะไรยังไงหะครับ มีได้ทำมั้งมั๊ยครับ

**Leader:** ก็ที่เค้าติดตั้งกันส่วนมาก ก็จะเป็นตู้น้ำหยอดเหรียญ หรือไม่ก็เป็นน้ำที่เค้าขายกันเป็นขวด ก็ไม่เห็นว่ามีผลอะไรกับชาวบ้านนะ ไม่เห็นชาวบ้านมาบอกอะไร ก็ใช้ได้ตามปกติ

**BSAC:** ต้องมีปัญหาก่อนไหมมั๊ยครับ ถึงค่อยมาแจ้ง

**Leader:** ส่วนมากลูกบ้านต้องคือ มีเรื่อง มีปัญหา ก่อน พวกปัญหาส่วนรวมนะ เรื่องของส่วนรวมนะ เราก็จะเข้าไปแก้ไข อย่างตู้น้ำหยอดเหรียญเนี่ย เราก็จะดูมัน ไม่สะอาด เราก็จะบอกว่า คนที่ดูแลเจ้าของที่ดูแล ต้องทำสะอาดหน่อยนะ

**BSAC:** เคยมีพบว่าตู้น้ำไม่สะอาดบ้างมั๊ยครับ

**Leader:** มันก็มีบ้าง เราก็ให้ลูกบ้านเราก็ดูว่า อันไหนมันไม่สะอาดบ้าง เรามีตัวเลือกหลายที่ หลายตู้ เราก็ไปเลือกตู้ที่ใช้ได้ สะอาดแทน มันก็จะมีคุณภาพมากกว่า

#### 2. ก่อนที่ชาวบ้านจะซื้อตู้กดน้ำ ต้องมีการขออนุญาตจากประธานชุมชนหรือไม่ ถ้ามีให้อธิบายกระบวนการนั้นๆ?

**BSAC:** ก่อนที่ชาวบ้านจะซื้อตู้กดน้ำ ต้องมีการขออนุญาตจากประธานชุมชนหรือไม่

**Leader:** ชื่อมาก็ตั้งได้เลย แต่คือ คุณต้องตั้งในสถานที่ที่ไม่เกะกะถนน ต้องอยู่ในเขตของบ้านคุณ ไม่เกะกะชาวบ้านเวลาสัญจรไปมา

#### 3. ทางชุมชนมีการดูแลรักษาตู้กดน้ำเหล่านี้หรือไม่?

**BSAC:** ทางชุมชนมีการดูแลรักษาตู้กดน้ำเหล่านี้หรือไม่

**Leader:** ถ้ามีอะไรผิดปกติ เราถึงค่อยบอกเจ้าของตู้ ให้มาดำเนินการ คือทุกอย่างถ้ามีลูกบ้านมาร้องเรียน เราก็จะเข้าไปจัดการให้ แต่ถ้าไม่มี ก็ไม่มีอะไรเกิดขึ้น ปกติ

#### 4. มีประชากรอาศัยอยู่เท่าไรในชุมชนนี้? เป็นเด็กหรือผู้ใหญ่มากกว่ากัน?

**BSAC:** มีประชากรอาศัยอยู่เท่าไรในชุมชนนี้? เป็นเด็กหรือผู้ใหญ่มากกว่ากัน?

**Leader:** 425 หลังคาเรือน ประมาณ 1600 คน มีทั้งผู้ใหญ่และเด็ก ในชุมชนเราจะไม่มีประชากรแฝง พวกต่างตัว พวกที่มาทำงานจากต่างจังหวัด ประมาณ20เปอร์เซ็นต์จะเป็นคนในพื้นที่

## 5. พื้นที่และช่วงเวลาไหนที่มีคนมาพบปะกันมากที่สุดในชุมชนนี้?

**BSAC:** พื้นที่และช่วงเวลาไหนที่มีคนมาพบปะกันมากที่สุดในชุมชนนี้?

**Leader:** สวนพักผ่อน ช้างๆคลองเก่า มีที่ออกกำลังกาย ชื่อ สวนริมคลองของชุมชน ชุมชนเราเป็นชุมชนที่จะไม่ค่อยมีพื้นที่เหลือ ก็จะมีพื้นที่ตรงนี้ ไว้ตอนเย็นจะมีคนมานั่งเล่นกัน เราใช้พื้นที่ให้คุ้มค่า ตอนเย็นๆก็จะมีเด็กมารวมกัน คลองนี้เป็นคลองเก่า ขึ้นมาได้เป็นคลองประวัติศาสตร์ ที่ขึ้นชื่อว่าคลองเตยก็เพราะคลองนี้ เมื่อก่อนคลองนี้จะใหญ่มาก ยาวไปทะเลคลองหัวลำโพง ด้านหลังติดแม่น้ำเจ้าพระยา นี่คือต้นของคลองเตยนี้อยู่ตรงนี้เลย ติดอยู่กับข้างวัด ข้างหลังก็จะเป็นแม่น้ำเจ้าพระยา คนจะเยอะประมาณเย็นๆ หกโมง วันธรรมดาจะไม่ค่อยเท่าไร ต้องวันเสาร์อาทิตย์ไว้จ้ะ เค้าพาลูกหลานมา บางทีเด็กๆก็จะไปเล่นกันในโรงเรียนบ้าง ลานวัดบ้างตีเบดกัน เพราะชุมชนเรามีอยู่แค่นี้ เราไม่มีสนามกีฬาไง เพราะเราบกรุกไม่ได้ละ ที่มันเต็ม

## 6. คุณคิดว่าชาวบ้านส่วนใหญ่ในชุมชนนี้ได้นำดีมมาจากไหน? (เช่น ตักตักน้ำประปาในครัวเรือน เครื่องกรองน้ำในครัวเรือน เป็นต้น)

**BSAC:** คิดว่าชาวบ้านส่วนใหญ่ในชุมชนนี้ได้นำดีมมาจากไหน?

**Leader:** ก็ส่วนมากที่เห็นบางบ้านที่เห็น ชาวบ้าน ที่เป็นคนในพื้นที่จริงๆ ก็จะใช้เครื่องกรองน้ำในบ้าน บางบ้านนะ บางบ้านก็จะมาหยอดเหรียญล้าง ซ็อน้ำล้าง แต่ส่วนมากก็ใช้เครื่องกรองน้ำในบ้านกันเยอะ คนในชุมชนนี้ก็มีส่วนนะ กลางๆ อะนะ เพราะเดี๋ยวนี้เครื่องกรองน้ำสามารถผ่อนได้ และไม่ได้แพงอย่างที่คิด บางทีเราก็ไม่รู้ว่่าเครื่องกรองน้ำที่เค้าเอามาเดินขายกันเนี่ย คุณภาพมันดีแค่ไหน มีนักขายตามบ้าน ผ่อนได้เดือนไม่กี่ร้อย ชาวบ้านเค้าอยากได้ความสะดวก เลยซื้อมาติดเอง

## 7. ช่วยอธิบายประวัติพอสังเขปของชุมชนนี้

**BSAC:** ช่วยอธิบายประวัติพอสังเขปของชุมชนนี้

**Leader:** ถ้านับจากผมนี่ ก็ตั้งแต่รุ่นพ่อแม่ พ่อแม่มาอยู่ เพราะผมเป็นเด็กที่เกิดที่นี่ พ่อแม่ก็มาอยู่กันที่นี้ ก็จะแบบว่า เมื่อก่อนก็จะมาทำงานทำแถวการทำเรือ จะมีงาน พวกจับกัง ก็มาที่นั่นดี ที่ละหนอยทยอยกันมา ค่อยๆ บกรุกกันมาเรื่อยๆ ที่ดินของการทำเรือ ที่เราอยู่กันนี้ เรายอมรับว่าเราบกรุกการทำเรือ แต่อยู่อาศัยมานานมาก ตั้งแต่รุ่นพ่อรุ่นแม่ เพราะตอนนั้นผมก็อายุ51แล้ว ถึงบอกว่าที่นี้ คนที่อยู่จะเป็นพื้นเพจริงๆ ไม่ค่อยมีบ้านเช่า เป็นชุมชนแรกๆ เพราะเมื่อก่อนจะไม่มิตึกอย่างนี้ จะเป็นทุ่งนา ทำเรือตรงนี้ เวลาที่มีสินค้ามาขึ้นเทียบ ชาวบ้านแถวนี้ก็จะเริ่มมา แรกๆรับจ้างก่อน ทำงานแบกหาม ที่นี้บางคนบ้านอยู่ไกล เห็นมีที่แถวๆการทำเรือ ก็เลยมาปลูกเพิงอาศัยอยู่ไปก่อน หลังจากนั้นก็ค่อยๆ ไปเรื่อยๆ มีคนเข้ามาจับจองกันอยู่ เมื่อก่อนจะเป็นสลัม ที่เป็นสลัมจริงๆ เพราะเมื่อก่อนจะไม่มีมีปูน ไม่มีอะไรเลย มีน้ำค้ำา เดินบนสะพานไม้ ที่ชาวบ้านช่วยกันทำเดินเข้าบ้าน เราบกรุกตั้งแต่เป็นเลน เป็นเพิง พออยู่มาแน่น ในระดับที่เริ่มเป็นชุมชนแออัดละ ขนาดที่ว่าไก่อบิน คนเดินไม่ตกหลังคา เดินบนหลังคาได้ตลอดไม่มีตก อย่างชุมชนของผมนี่ ประมาณปี34-35 เกิดเหตุเพลิงไหม้ครั้งใหญ่ ทั้งหมดที่ดินทั้งหมดที่เราอยู่7ไร่ โดนหมดเกลี้ยง ก็เลยมีการพัฒนาให้หมู่บ้านมั่นคงจนปัจจุบันนี้ จัดสรร เข้ามาแบ่งกันให้เท่ากัน เมื่อก่อนจะไม่เป็นแบบนี้ เป็นเพิง เป็นไม้ สองชั้น ชั้นเดียวบ้าง ตอนแรกๆ พอหลังจากไฟไหม้ครั้งใหญ่ ถึงค่อยมาเป็นแบบนี้ จัดสรรเข้า มีประธานชุมชน มีอะไรขึ้นเพื่อมาเป็นตัวแทนจากชาวบ้าน ไปติดต่อหน่วยงานราชการต่างๆ ประสานงาน เริ่มมาเป็นปูน เริ่มสะดวกสบายขึ้น หลายๆหน่วยงานก็เข้ามาช่วยกันพัฒนา จัดเป็นบ้านที่เป็นสัดส่วน คือทุกบ้านต้องสูงเท่ากัน ความกว้างความยาวเท่ากันหมด ไม่มีใครเหลื่อมล้ำกัน ถนนก็จะเป็นสวนกลาง

บ้านสูงไม่เกินสองชั้น ต้องสะดวกในการ ถ้าเกิดเหตุฉุกเฉินมาจ้ ทุกคนต้องสะดวก ขอยนี้ต้องเป็นตัวยุ  
ทะลุหากันได้หมด ห้ามตัน วนออกได้หมด มีการวางแผน อย่งไฟไหม้ครั้งล่าสุด ถ้าเป็นแบบครั้งที่ผ่านมา  
นี้ไม่เหลือ แล้วเราก้มีเพื่อนบ้านดี อย่างบริษัทเซล คือที่เค้าบอกว่าไม่ยากให้มีคลังน้ำมันใหญ่ๆ  
อยู่ใจกลางเมือง แต่ทำไมเราอยู่กันไม่ได้ เพราะเป็นเพื่อนบ้านที่ดี เค้าคอยมาดูแลเรา  
เราจะไปทำความเดือดร้อนให้เค้าตลอด บางทีมีเหตุอะไร เค้าเลยสร้างถาวรไปเลย ท่อแดง  
ได้จากงบประมาณ ฟังทำเสร็จสามเดือนก่อนสิ้นปี งบประมาณเซลให้สามล้านบาท ต่อท่อเดินรอบชุมชน  
เราถึงบอกว่าที่เราใหม่เมื่อวันที่ 1 มกราคม เราเสียหายน้อยที่สุด เพราะเรามีน้ำ ชุมชนไหนถ้าขาดน้ำ  
แย้เพราะมัน ไม่มีการดับเพลิง ชุมชนคลองเตยเวลามีเหตุที่เรื่องใหญ่ เพราะบ้านมันติดกัน  
มันขาดแหล่งน้ำที่จะดับไฟ

## Appendix J-4: Sector 2 Leader English

Your participation in this interview is strictly voluntary. Our team would like permission to conduct surveys within this sector. This interview is being conducted on behalf of the Duang Prateep Foundation to collect demographic information about your sector as well as daily routines of the residents to begin the survey process.

Name: Mr. Punya Silaluk  
Number: 2

Sector

### **8. Could you please identify and explain your responsibilities as leader of your sector? Specifically pertaining to water, what are your responsibilities?**

**Leader:** Usually everything that is problematic to the residents. When problem arise we have to go and check on the issue. When the residents notify us, we fix everything. Such as water and electric utilities not working, well-being of the residents, or the condition of the road, everything falls under our responsibility.

**BSAC:** What about responsibility regarding the drinking water?

**Leader:** Normally, the residents use the vending machines or brought bottled water. Never heard of any complain though or see any effects on the residents though. The residents usually do not notify us regarding the drinking water. If there is any complain then we will examine and fix it. For instance, if a vending machine is dirty, we will notify the owner of the machine that its need maintenance. There are some cases regarding the vending machines through, when that happens we tell the residents to find and use another machine. There are plenty of machines to be chosen from.

### **9. Before a slum-dweller purchases a water vending machine, is there a process for them to go through in order to obtain permission from the sector leaders? Please explain the process and potential guidelines to get a machine.**

**Leader:** No, as long as they are not blocking road.

**BSAC:** Does the slum residents need to ask for permission if they want to install the vending machines?

**Leader:** They can install it immediately without our permission as long as it is not blocking the road. The machine must be inside the territory of their home and not blocking the route when other residents need to use the road.

### **10. Does the sector control or regulate maintenance of these water vending machines?**

**Leader:** Yes, if there is notification from dwellers.

**BSAC:** Are there any maintenance for these machines?

**Leader:** If there are any complain then we order the owner to maintain and clean the machines. That mean if there are notification from the residents then we will conduct

maintenance, but no we do not conduct any maintenance if there are complains or notification from the residents.

**11. How many residents live in your sector? Are there more older or younger people living here?**

**BSAC:** How many people live in this sector? Between children and adults, which types of people populate your sector the most?

**Leader:** 425 households in total with approximately 1600 people. The number of children and adult is almost the same. We don't have a lot of illegal immigrants nor have the people from other provinces living in our sector, most of the people here stayed here for a long time.

**12. Where and when do people gather together the most in the sector so that we can hand out surveys?**

**BSAC:** Where and does the residents gather the most? we would like to know a great location to conduct our interview.

**Leader:** The garden near the old canal, we also have fitness center there. Even Though our sector has limited free space, we have the garden area for relaxing in the evening. At evening there are children playing around that area. The old canal has history. In fact it is call "historic canal". In the old days, the reason the whole community is call Khlong Toei is because of this canal. It used to be a lot wider and it goes all the way to the Hua Lumpong canal. The canal runs from the Chao Praya River.

**BSAC:** When is the most appropriate time?

**Leader:** The people gather there at around 18pm and later on in the evening. There are not many people during weekdays though. But a lot of people bring their children to play on the weekends. Sometimes children gather at the temple field and at the school field. We have limited free space and we cannot intrude anymore places.

**13. Which source do you think most of the residents living in your sector obtain drinking water? (If specified that residents mainly use in-home taps, ask if most residents have in-home water filtration)**

**BSAC:** Which source of drinking water do you think the residents of this sector get their water?

**Leader:** From my observation, residents of this sector sometime get water from the water vending machines, but most of the time they have in-home filter. Most the residents of this sector are middle class people, and in-home water filtration doesn't have to be paid in full. Nowadays they can pay for it monthly. The in-home filtration system is not as expensive as most people think. There are salesman come and go out of this place all the time selling cheap in-home filtration system. The residents wanted convenience so they install them.

#### **14. Could you explain the history of this sector briefly?**

**Leader:** At first there were no buildings like nowadays. At the time when my parents first move here, many people including my parents are moving here to find the job near the port. This land belong to the port, it was an open field near the port. My parents and many people intruded and settled in this land. There were no concrete roads, solid structures, nor any infrastructures you see these days. It is really a slum. After a while there are more and more people that try to find jobs and pouring in to occupying free spaces to the point where there are no more spaces left. After that there is a great fire during the year 1991 which wipes out the entire neighborhood. After that reconstruction is made and we keep improving ever since. There were no sector leaders, community representatives, nor organized system like in these days. We just got 3 million baht fund from Shell Company last year to install fire hydrant pipeline around the sector. The pipeline was just finished installing before New Year. If we didn't have the water from the pipeline during the New Year fire then whole neighborhood could be burnt down again like during the great fire.

## Appendix J-5: Sector 3 Leader Thai

ข้อมูลที่ได้มาจากการสำรวจเชิงลึกในครั้งนี้จะถือเป็นความลับตามที่ระบุไว้ในกฎหมาย การเข้าร่วมนี้เป็นไปด้วยความสมัครใจ ผู้ให้ข้อมูลสามารถหยุดหรือข้ามคำถามได้ตามต้องการ และจะไม่มีการระบุชื่อของบุคคลที่ให้ข้อมูลในรายงาน การสำรวจเชิงลึกนี้จะถูกจัดขึ้นในนามของมูลนิธิดวงประทีป เพื่อทำความเข้าใจถึงคุณภาพน้ำดื่มของชุมชนคลองเตยในปัจจุบัน

ชื่อ: Mr.Thongkum Saekow  
ชุมชนหมายเลข: 3

### 1. หน้าที่และความรับผิดชอบของคุณในฐานะประธานชุมชน? ส่วนที่เกี่ยวข้องกับน้ำมีอะไรบ้าง?

**BSAC:** คำถามแรกก็คือ เอ่อ

อยากจะทราบว่าหน้าที่และความรับผิดชอบของแบบท่านประธานอะครับ  
ในฐานะประธานชุมชนอะครับที่เกี่ยวข้องกับน้ำมีอะไรบ้างครับ

**Leader:** น้ำดื่มไข่ม้อย

**BSAC:** ใช่ครับ

**BSAC:** ออ แล้วคือประธานมีหน้าที่ทำอะไรครับ

**Leader:** มีหน้าที่เรื่องขยะ

**BSAC:** ส่วนใหญ่จะเป็นเรื่องขยะไข่ม้อยครับ

**Leader:** ขยะแล้วก็เรื่องสาธารณสุขในชุมชน เรื่องขยะ เรื่องความเป็นอยู่

**BSAC:** ออแต่ว่าเรื่องน้ำนี่ก็คือไม่ได้ทำอะไรมาก

**Leader:** ไม่ได้ดูๆ

**BSAC:** ออครับ ส่วนมากก็มีแต่เรื่องขยะ

**Leader:** เรื่องถนน เรื่องความเรียบร้อย เรื่องขยะเรื่องน้ำท่วมน้ำอะไรพวกนี้อะ

**BSAC:** ออแล้วคือพวกน้ำขังน้ำอะไรแบบนี้ประธานก็ดูไข่ม้อยครับ

**Leader:** ดูแลๆ

**BSAC:** แล้วแก้ปัญหาอย่างไรอะ

**Leader:** เราก็แก้ปัญหาที่ ถ้าเป็นหลุมเป็นบ่อ เราเอาถนนตัดใหม่

**BSAC:** ออ ให้มันเท่ากันไข่ม้อยครับ

**Leader:** แล้วก็ท่อระบายน้ำ ก็มีพนักงานและพนักงานชุมชนไปเก็บขยะทุกเดือน ถุงพลาสติก โฟมของที่บ้านโยนๆไว้เยอะๆอะ เราก็ไปเก็บตรงนั้น

**BSAC:** ครับ แล้วเอ่อพวกหัวแดงอะครับท่านประธานได้มีแบบการบำรุงรักษาอะไรมั้ยครับ

**Leader:** มีสำรวจ บำรุงรักษา

**BSAC:** ระยะเวลาเท่าไรอะครับ

**Leader:** ทุกๆ1เดือน

**BSAC:** ออ ก็คือเมคซัวร์ว่ามันใช้งานได้

เพื่อมีโอเมอเจนซีเหตุฉุกเฉินอะไรจะได้แบบเสียบยิงได้เลยไข่ม้อยครับ

**Leader:** ใช่ๆตรงนี้สำคัญมากเรื่องหัวแดงเนี่ย เราต้องตรวจสอบอยู่

แล้วก็มีฝ่ายดับเพลิงของการท่าเรืออัย ของคลองเตยมาเปิดหัวแดงตลอด ดูว่าน้ำใช้ได้มั้ย

ถ้าเกิดมีปัญหาเรื่องเกิดเพลิงไหม้มาเราต้องใช้ได้เลยอันนี้สำคัญ

### 2. ก่อนที่ชาวบ้านจะซื้อตุ๊กต่น้ำ ต้องมีการขออนุญาตจากประธานชุมชนหรือไม่ ถ้ามีให้อธิบายกระบวนการนั้นๆ?



**BSAC:** แล้วก็ก่อนที่ เอ่อชาวบ้านจะซื้อตุ๊กตานั้นอะคะ ต้องมาขอ มีการขออนุญาตจากท่านประธาน ก่อนมั๊ยคะ

**Leader:** ไม่ ไม่ขอ

**BSAC:** ก็คือตัวใครตัวมัน ถ้าเงินถึงก็คือซื้อแล้วก็ติดเลย

**Leader:** ใช่เค้าซื้อเค้าเองก็คือส่วนมากจะไม่ผ่านเรา ไม่ผ่านเลยอะ

**BSAC:** แล้วเค้ามีแจ่มมั๊ยครับว่าแบบซื้อแล้วนะท่านประธาน

**Leader:** ไม่ ไม่มี

**BSAC:** ก็คือบางที่เราเดินไป เอ้า ซื้อมาแล้วหรืออะไรแบบนี้

**Leader:** ใช่ๆ ถูกต้อง

**BSAC:** ครับ

### 3. ทางชุมชนมีการดูแลรักษาตุ๊กตานั้นเหล่านี้หรือไม่?

**BSAC:** เพราะฉะนั้นเอ่อ การดูแลรักษานี้ก็ขึ้นอยู่กับเจ้าของใช่มั๊ยคะ

**Leader:** ใช่ คือเราไม่เกี่ยว

### 4. มีประชากรอาศัยอยู่เท่าไรในชุมชนนี้? เป็นเด็กหรือผู้ใหญ่มากกว่ากัน?

**BSAC:** อ่อแล้วก็อยากทราบจำนวนผู้อยู่อาศัยที่ชุมชนนี้อะคะ

**Leader:** เอ่อ 9000คน ทั้งเด็ก ทั้งผู้ใหญ่อะไร ประมาณ 9000

**BSAC:** ส่วนใหญ่เป็นเด็กหรือผู้ใหญ่อะคะ

**Leader:** ผู้ใหญ่

**BSAC:** เอ่อมีบ้านกี่หลังครับ

**Leader:** ประมาณเอ่อ 1183หลังคาเรือน

**BSAC:** อ่อคะ แล้วสมมติถ้าตลอดลูกไรแจ๊ย เค้าต้องมาแจ่มมั๊ย

**Leader:** ไม่แจ่มครับ ไม่แจ่ม

**BSAC:** แล้วเราจะอัพเดทยังไงอะคะว่ามีสมาชิกเพิ่ม

**Leader:** อันนี้เอ่อประมาณเอา เพราะเราไปที่สาธารณสุขแล้วเราจะประมาณเอาได้ มันผิดพลาดบวกลบคุณหารไม่เท่าไร

**BSAC:** มันเยอะแบบนี้มาตั้งแต่ไหนแต่ไรแล้วปะครับ

**Leader:** ใช่ๆ

### 5. พื้นที่และช่วงเวลาไหนที่มีคนมาพบปะกันมากที่สุดในชุมชนนี้?

**BSAC:** อ่อแล้วก็อยากทราบว่าพื้นที่บริเวณไหนที่มีคนมาพบปะกันมาก

**Leader:** ก็จะเป็นถนน 9เมตร ถนนสายหลักอะ คนจะมาตรงนี้เยอะ เป็นที่จับจ่ายซื้อของ

**BSAC:** ช่วงไหนคนเยอะสุดอะครับช่วงเช้า เย็น

**Leader:** เช้า 7โมง เย็นก็ 4-5โมงอะ คนเยอะ เยอะมาก

### 6. คุณคิดว่าชาวบ้านส่วนใหญ่ในชุมชนนี้ได้นำดื่มมาจากไหน? (เช่น ตุ๊กตานั้น น้ำประปาในครัวเรือน เครื่องกรองน้ำในครัวเรือน เป็นต้น)

**BSAC:** แล้วประธานคิดว่าชาวบ้านส่วนใหญ่ในชุมชนนำน้ำดื่มมาจากไหน

**Leader:** ส่วนมากจะมาจากที่บ้าน

**BSAC:** มีเครื่องกรองน้ำที่บ้าน?

**Leader:** ส่วนมากจะมีเครื่องกรองน้ำเยอะ บ้านใครบ้านมัน มีเยอะ มีเกือบทุกหลัง เปอร์เซนต์น้อยที่จะไม่มี

#### 7. ช่วยอธิบายประวัติพอสังเขปของชุมชนนี้?

**BSAC:** ช่วยอธิบายประวัติพอสังเขปของชุมชนนี้แบบที่มาอะคะ

**Leader:** คือคนจากชุมชนนี้อะนะจะเป็นคนดั้งเดิมมาจากชุมชนลือค12 แล้วก็ทำเรือใช้ที่เลยต้องย้ายมาชุมชนหมู่บ้านพัฒนา 70ไร่แทน ตั้งแต่ ตุลาคม พ.ศ. 2528 ปัจจุบันก็เป็นเวลา 30ปีพอดี

## Appendix J-6: Sector 3 Leader English

Your participation in this interview is strictly voluntary. Our team would like permission to conduct surveys within this sector. This interview is being conducted on behalf of the Duang Prateep Foundation to collect demographic information about your sector as well as daily routines of the residents to begin the survey process.

Name: Mr. Thongkum Saekow  
Number: 3

Sector

### **1. Could you please identify and explain your responsibilities as leader of your sector? Specifically pertaining to water, what are your responsibilities?**

**BSAC:** The first question is, could you please explain your responsibilities as leader of your sector towards water?

**Leader:** Drinking water?

**BSAC:** Yes, sir

**Leader:** Mostly my main job is to monitor the trash in the sector. And well-beings of the people.

**BSAC:** Water is not included?

**Leader:** No, I don't look after for water.

**BSAC:** Ok, so just trash mainly?

**Leader:** Yes, and also roads, society and some stagnant water issues.

**BSAC:** How do you solve stagnant problems?

**Leader:** If there's a hole or gap within roads, we gave them to make them level. There'll be staff to collect trash such as plastics, bottles and bags in the sewage.

**BSAC:** How about the fire hydrant? Is there maintenance for that?

**Leader:** Yes, there is. Monthly.

**BSAC:** So just to make sure that those hydrants are working properly right?

**Leader:** Yes, in case something happens, we can use them. People from port will open and check the hydrant monthly.

### **2. Before a slum-dweller purchases a water vending machine, is there a process for them to go through in order to obtain permission from the sector leaders? Please explain the process and potential guidelines to get a machine.**

**BSAC:** Before slum-dweller can own a water vending machine, do they need permission from you?

**Leader:** No, they don't.

**BSAC:** So if they can afford, they'll just buy by themselves?

**Leader:** Yes, pretty much.

**BSAC:** Do they tell you after the installment of the machines?

**Leader:** No.

**BSAC:** So sometimes you see the new machine unexpectedly?

**Leader:** Yes, it has happened.

**3. Does the sector control or regulate maintenance of these water vending machines?**

**BSAC:** So the maintenance is up to the owner, right?

**Leader:** Yes.

**4. How many residents live in your sector? Are there more older or younger people living here?**

**BSAC:** How many people live in your sector?

**Leader:** A total of 9000

**BSAC:** Adults or children mostly?

**Leader:** Adults

**BSAC:** How many houses?

**Leader:** 1183

**BSAC:** What if someone gives a birth, do they need to inform you?

**Leader:** No, they don't.

**BSAC:** So how could you keep track of the population number?

**Leader:** The number is an estimate from Ministry of Public Health, they will have records.

**BSAC:** Has it always been this high? The population

**Leader:** Yes.

**5. Where and when do people gather together the most in the sector so that we can hand out surveys?**

**BSAC:** Where do most people gather? And when?

**Leader:** Morning 7am and evening 4pm at the main road (9 meter rd.) because there's a market

**6. Which source do you think most of the residents living in your sector obtain drinking water? (If specified that residents mainly use in-home taps, ask if most residents have in-home water filtration)**

**BSAC:** Which source do you think most of the residents living in your sector obtain drinking water?

**Leader:** Mostly from their homes

**BSAC:** In-home filters?

**Leader:** Yes, most of them have it, very few don't.

**7. Could you explain the history of this sector briefly?**

**BSAC:** Could you explain the history of this sector briefly?

**Leader:** Mostly former residents of the Lot 12 community, they moved here when the port was requesting for the land back.

## Appendix K: Summary of Coded Interview Questions

Table K- 1: Coded Interview Questions - Sector Leaders

Codes	Sector 1 (Chom Chun Rim Klong Pra Kra Nong)	Sector 2 (Chum Chon Wat Khlung Toei Nai)	Sector 3 (Chum Chon Mhoo Bann Pattana Jhet Sip Rai)
<b>Interviewee</b>	Mr. Chaichayun Chaengcharoen	Mr. Punya Silaluk	Mr. Thongkum Saekow
<b>Yellow: Vending Machines</b>	<p>They buy those machines whenever and wherever they want too.</p> <p>The owners have to do it, mostly if the machines aren't good enough, they don't really care much.</p>	<p>Notify the owner of the machine that its need maintenance</p> <p>They can install it immediately without our permission as long as it is not blocking the road. The machine must be inside the territory of their home and not blocking the route when other residents need to use the road.</p>	<p>A: Do they need permission from you? B: No, they don't. A: So if they can afford, they'll just buy by themselves? B: Yes pretty much.</p>
<b>Green: Demographics</b>	<p>Adults for most of them, very few of children</p> <p>Around 1000 [residents]</p>	<p>425 households</p> <p>1600 people</p> <p>Number of children and adult is almost the same</p> <p>Most the residents of this sector are middle class people</p>	<p>A total of 9000 [people]</p> <p>Adults [mostly]</p> <p>1183 [houses]</p>

<p><b>Blue: Background Information</b></p>	<p>[Residents] moved away but stayed, and some are newcomers.</p> <p>[Most residents are] former workers for the leather tanning factory that has now been abolished about 50 years ago</p>	<p>We don't have a lot of illegal immigrants nor the people from other provinces living in our sector, most of the people here have stayed here for a long time</p> <p>The old canal has history. In fact it is call "historic canal". In the old days, the reason the whole community is call Klong Toei is because of this canal. It used to be a lot more wide and it goes all the way to the Hua Lumpong canal. The canal run from the Chao Praya River.</p>	<p>Former residents of the Lot 12 community, they moved here when the port was requesting for the land back.</p>
<p><b>Purple: Drinking Source</b></p>	<p>Not drink directly from the tap</p> <p>In-home filters</p>	<p>Vending machines or brought bottled water</p> <p>In-home water filtration doesn't have to be paid in full. Nowadays they can pay for it monthly. The in-home filtration system is not as expensive as most people think. There are salesmen that come and go out of this place all the time selling cheap in-home filtration systems. The residents wanted convenience so they installed them.</p>	<p>Most of them have [in-home filters], very few don't.</p>



<p><b>Red: Role and Responsibility</b></p>	<p>If anyone has problem, we arrange monthly meeting.</p> <p>I'm not the one who is in charge of water</p>	<p>Such as water and electric utilities not working, well-being of the residents, or the condition of the road, everything falls under our responsibility.</p> <p>[When] that happen[s] we tell the residents to find and use another machine</p> <p>We order the owner to maintain and clean the machines</p>	<p>Mostly my main job is to monitor the trash in the sector. And well-beings of the people</p> <p>Yes, and also roads, society and some stagnant water issues</p> <p>If there's a hole or gap within roads, we pave them to make them level. There'll be staff to collect trash such as plastics, bottles and bags in the sewage.</p> <p>People from port will open and check the hydrant monthly.</p> <p>Maintenance is up to the owner</p> <p>A: How about the fire hydrant? Is there maintenance for that? B: Yes, there is. Monthly.</p>
<p><b>Orange: Gathering Places</b></p>	<p>The basketball court</p>	<p>Garden near the old canal</p> <p>Fitness center</p> <p>People gather there at around 18pm and later on in the evening. There are not many people during weekdays though</p> <p>Children gather at the</p>	<p>Morning 7am and evening 4pm at the main road (9 meter rd.) because there's a market.</p>

		temple field and at the school field	
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## Appendix L: Results for Survey Questions

A. Where do you or your family members get water to drink? (Choose all that apply)

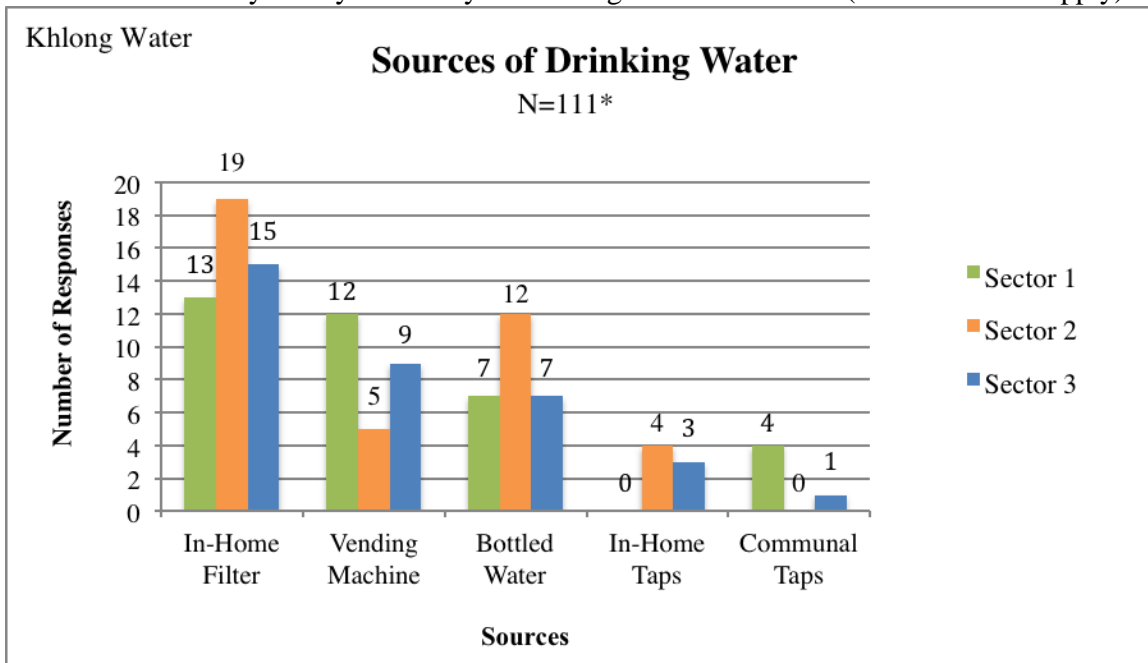


Figure L- 1: Sources of Drinking Water

B. What do you or your family members do after getting your water to drink? (Choose all that apply)

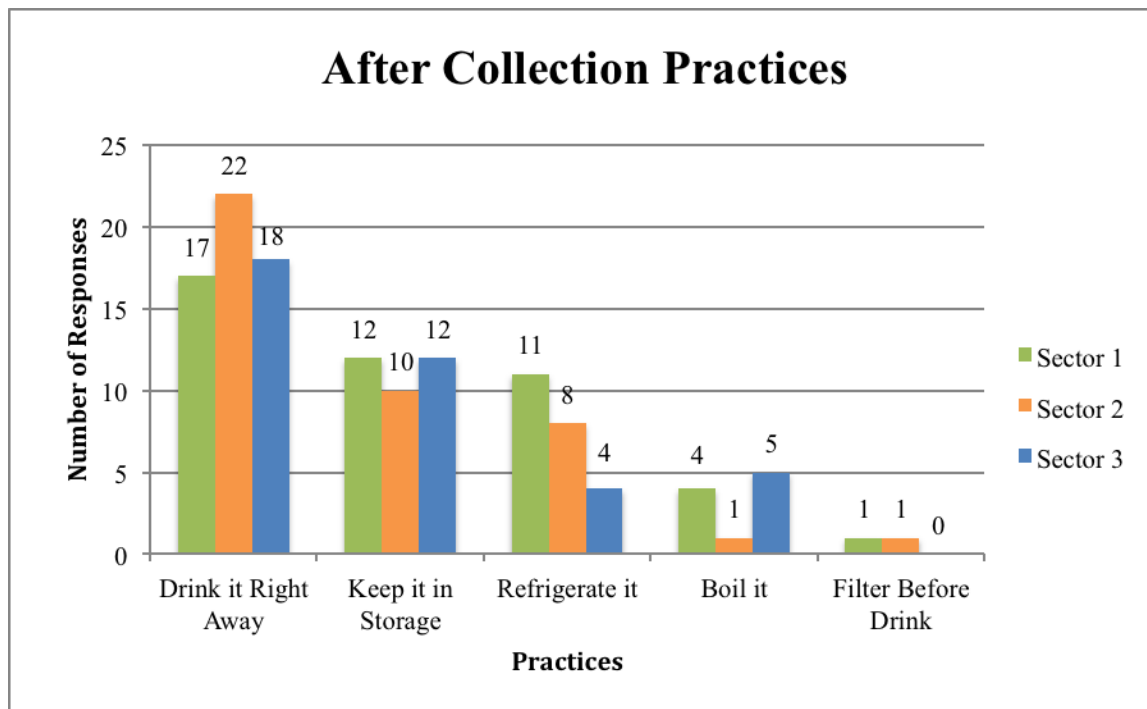


Figure L- 2: After Collection Practices

C. Does you or your family use water vending machines?

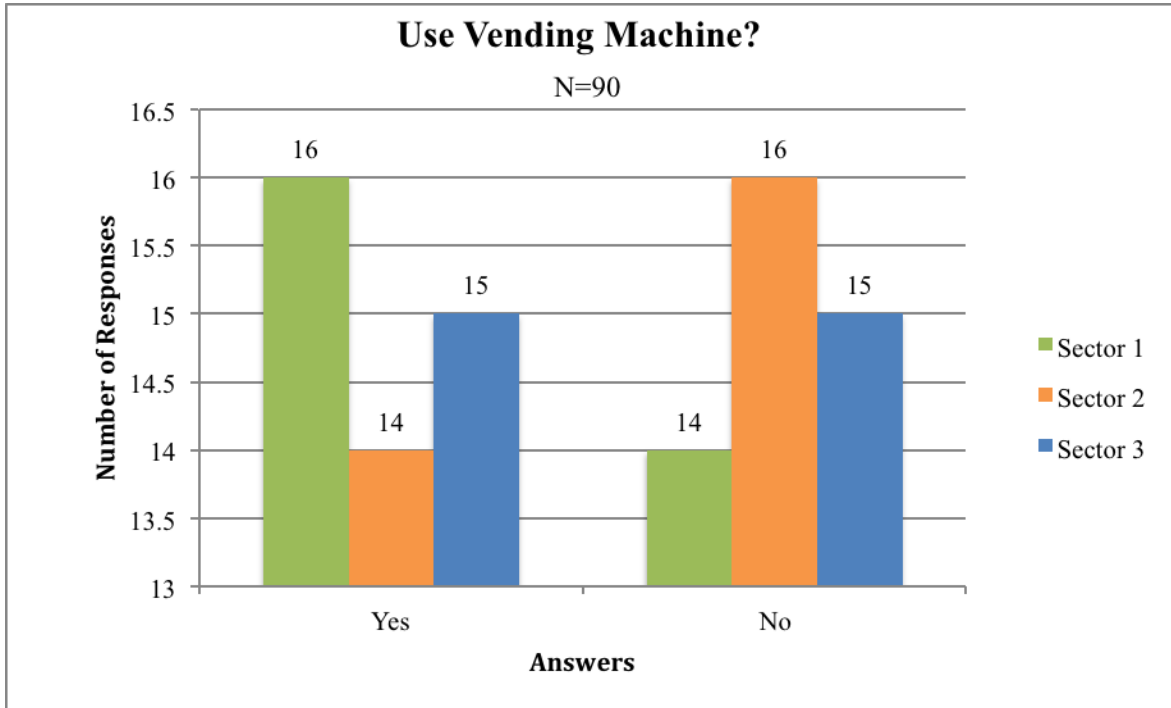


Figure L- 3: Water Vending Machine Usage

D. What do you or your family members use the water from vending machines for?  
(Choose all that apply)

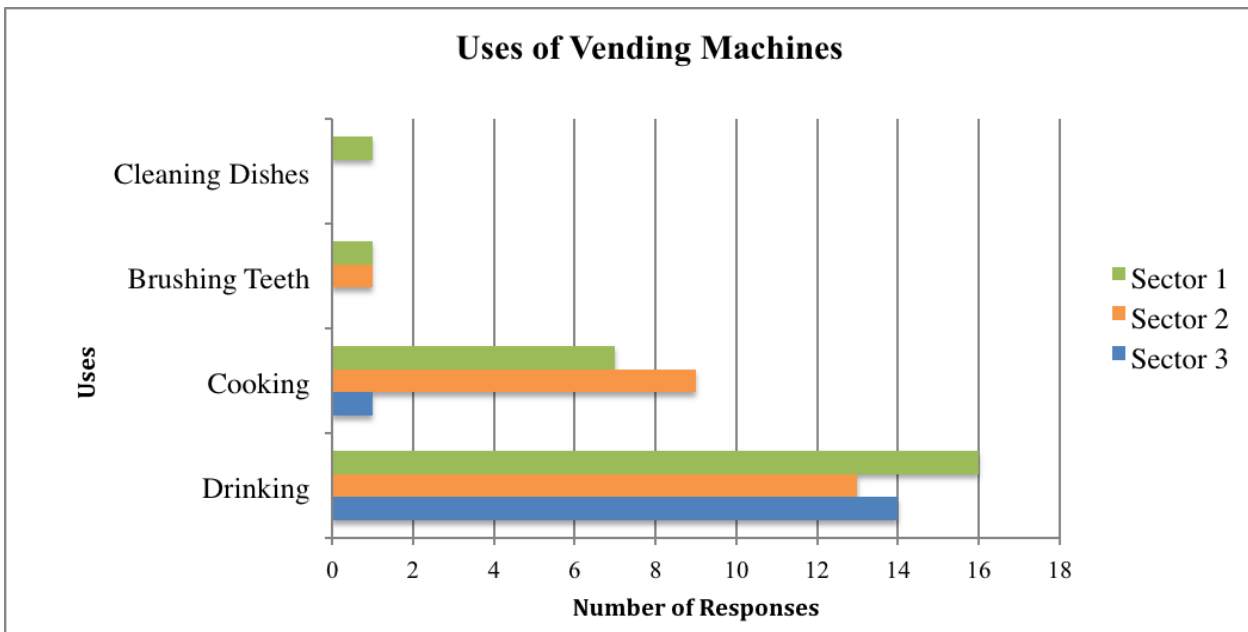


Figure L- 4: Uses of Vending Machines

E. If you or your family members do not use the vending machines, why?

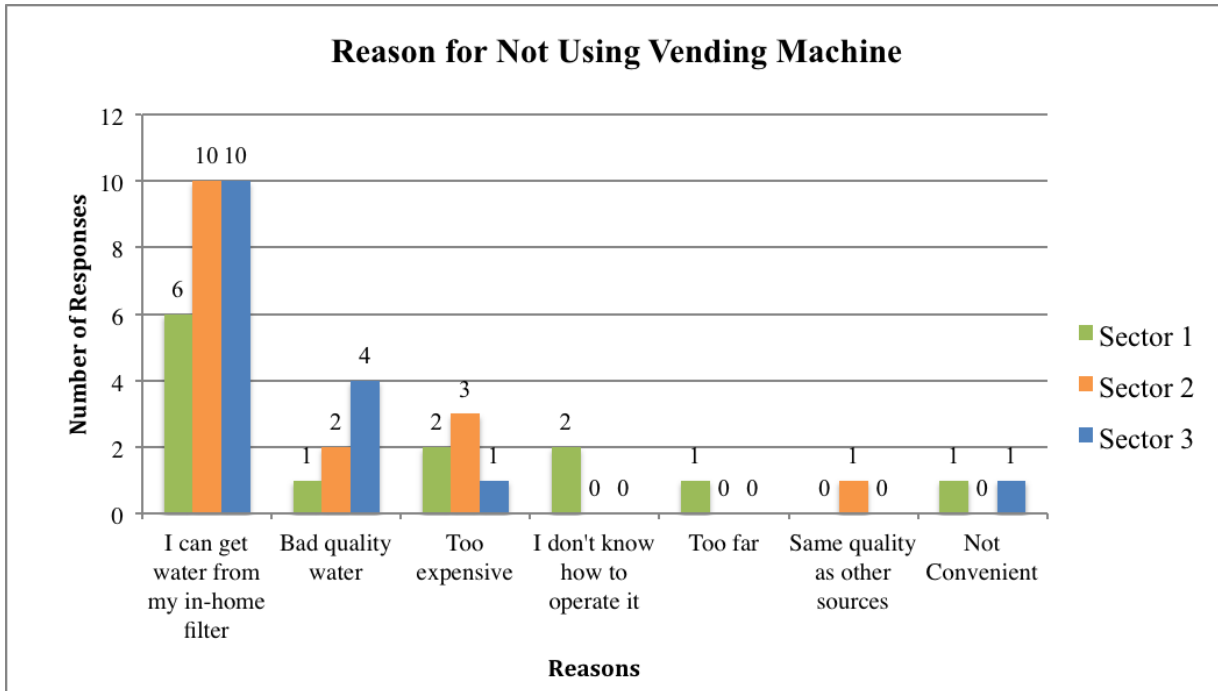


Figure L- 5: Reasons for Not Using Vending Machines

F. Do you or your family use the water from the communal taps?

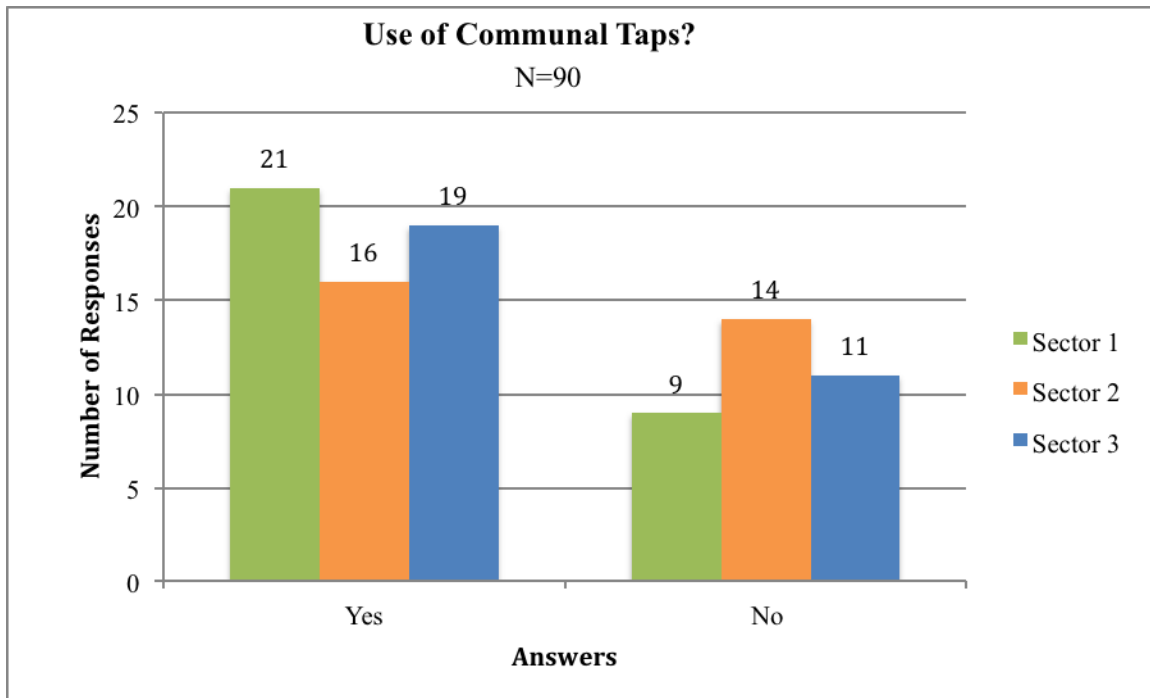


Figure L- 6: Communal Tap Usage

G. What do you or your family members use the water from communal taps for?

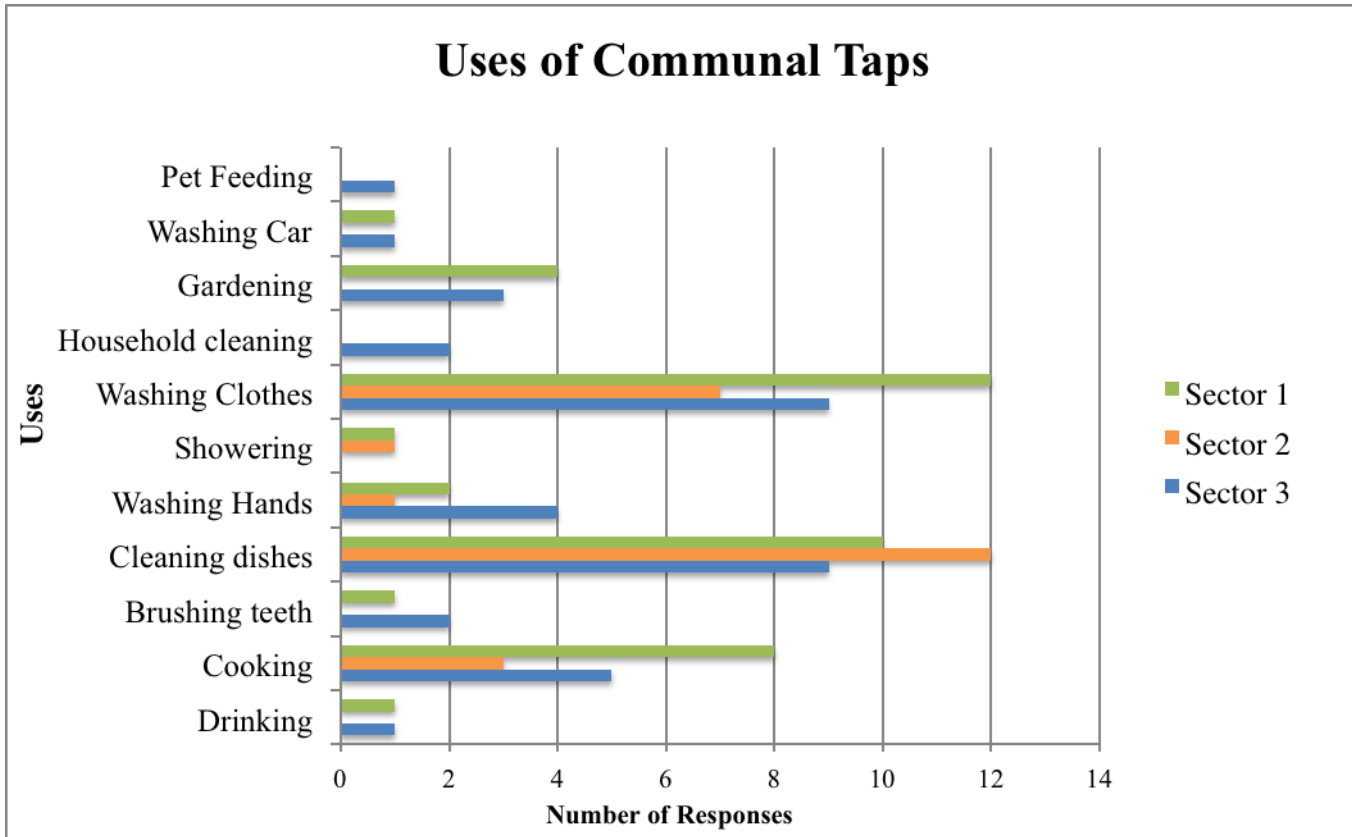


Figure L- 7: Use of Communal Taps

G. Do you or your family use the water from the in-home taps?

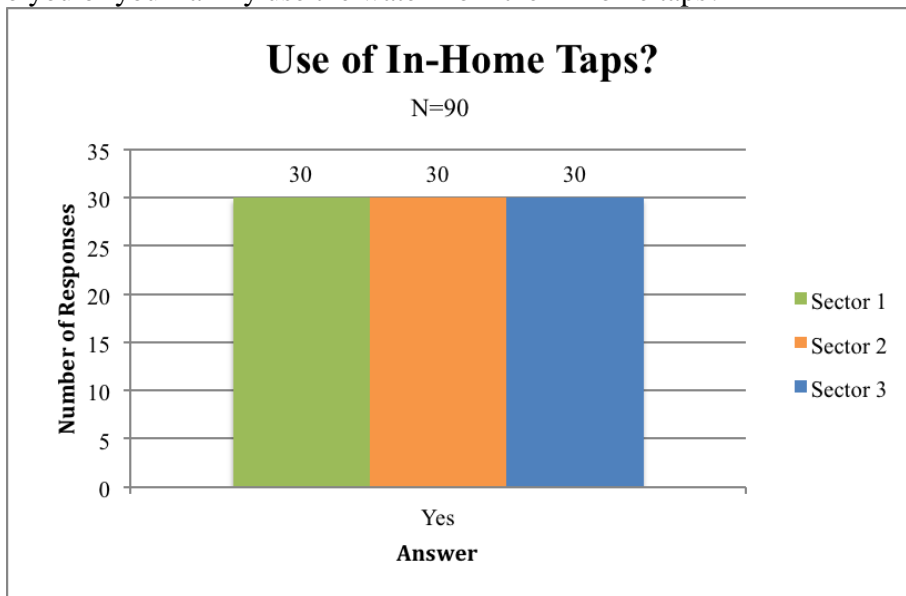


Figure L- 8: Residents that Use In-Home Taps

H. What do you or your family members use the water from in-home taps for?

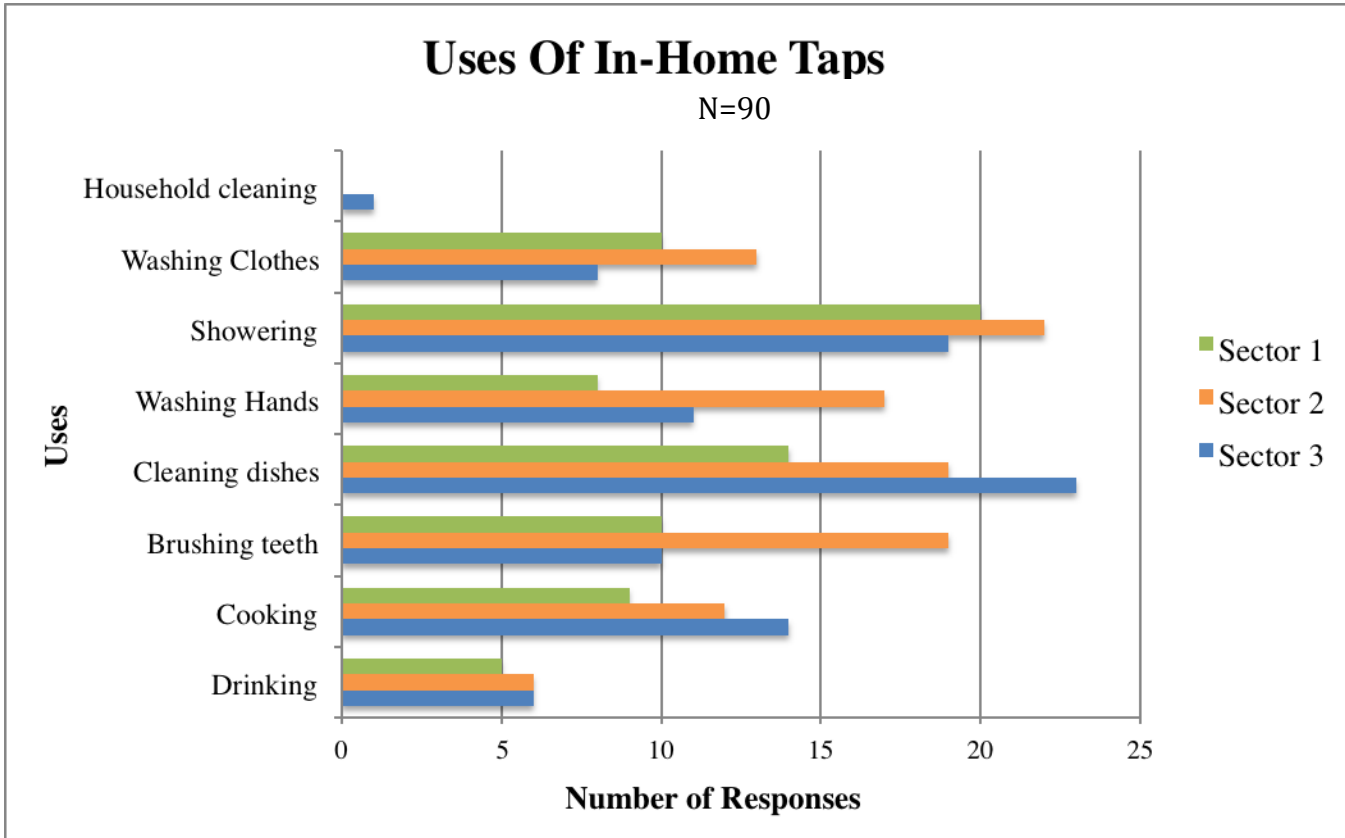


Figure L- 9: Use of In-Home Taps

H. Do you personally think water can make people sick?

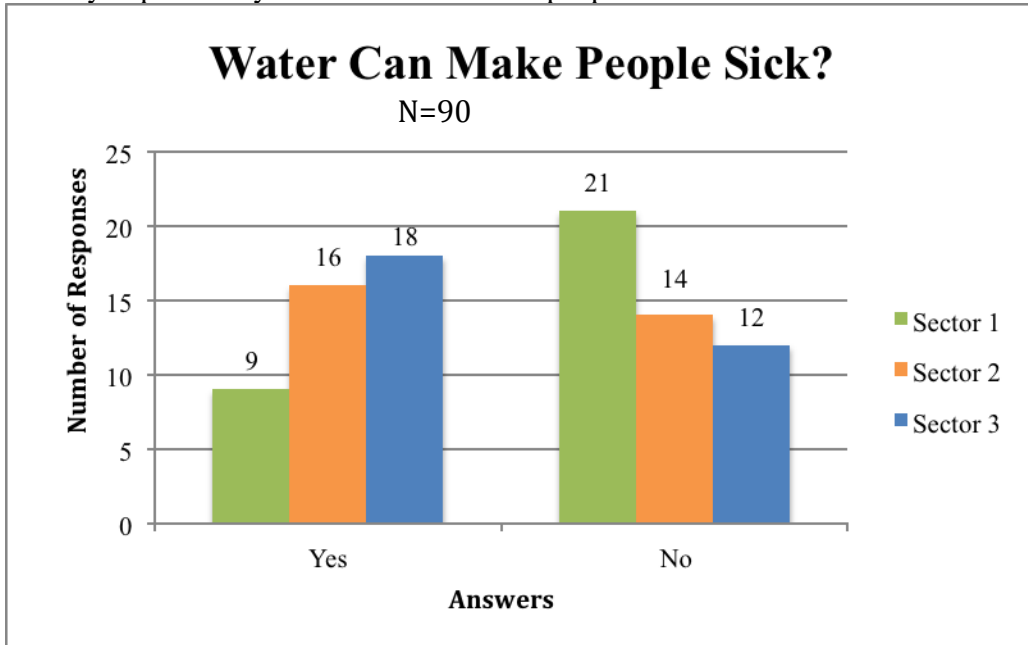


Figure L- 10: Can Water Make You Sick?

I. Do you think that quality of water is important for the health of your family?

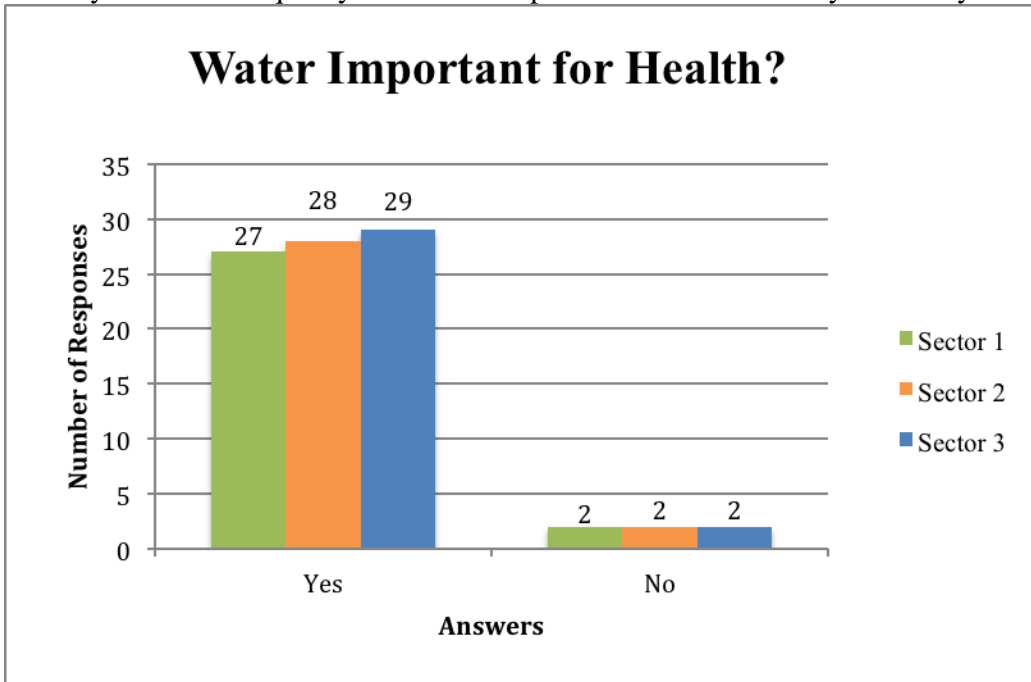


Figure L- 11: Is Water Important for Your Health?



J. Have you or your family members been sick in the past three months?

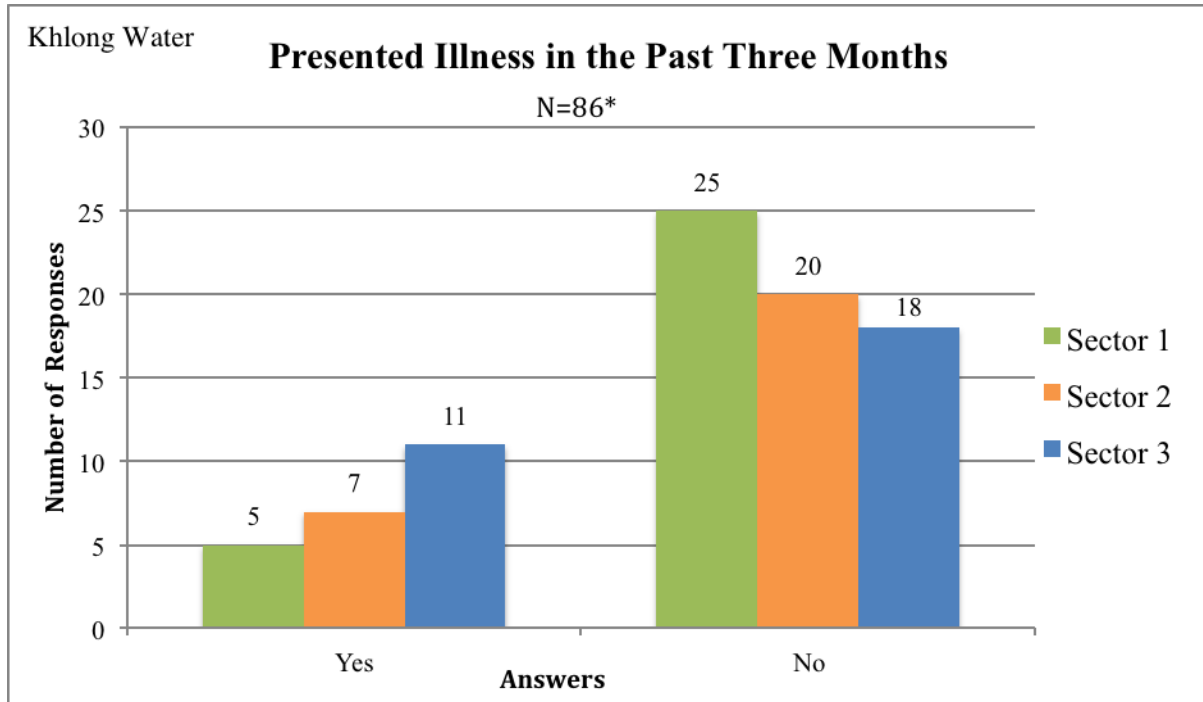


Figure L- 12: Illnesses in the Past Three Months

K. What health symptoms did you or your family members' experience?

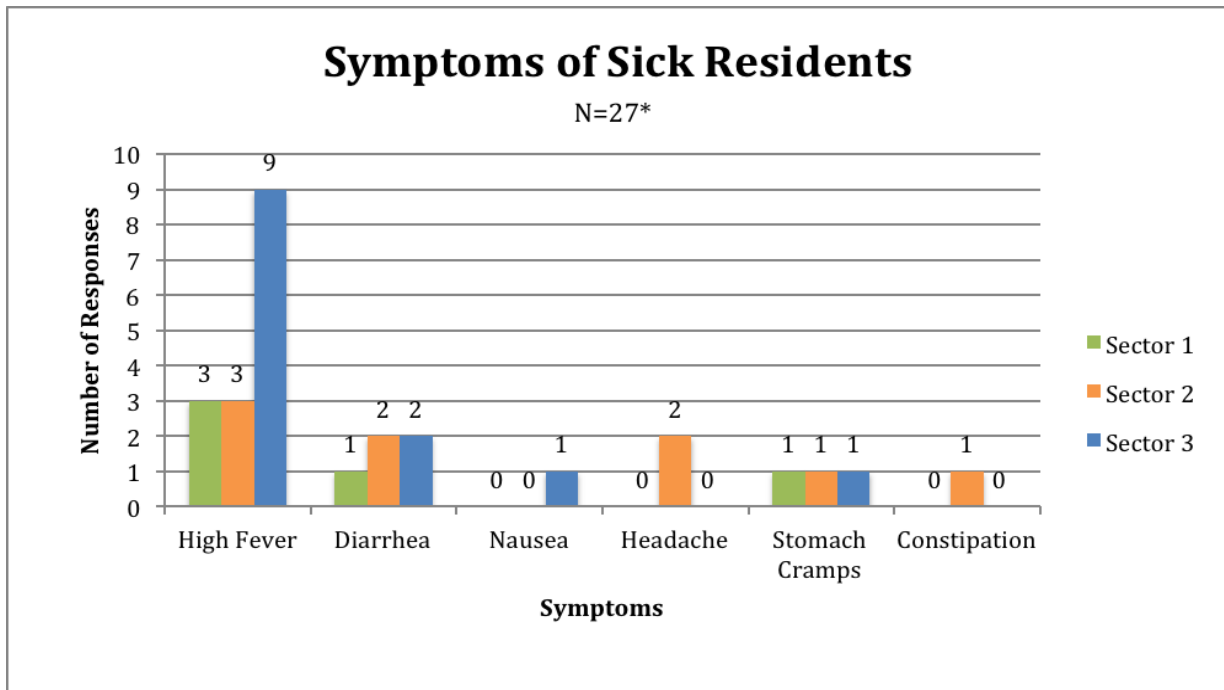


Figure L- 13: Symptoms of Sick Residents

L. How were these health symptoms treated?

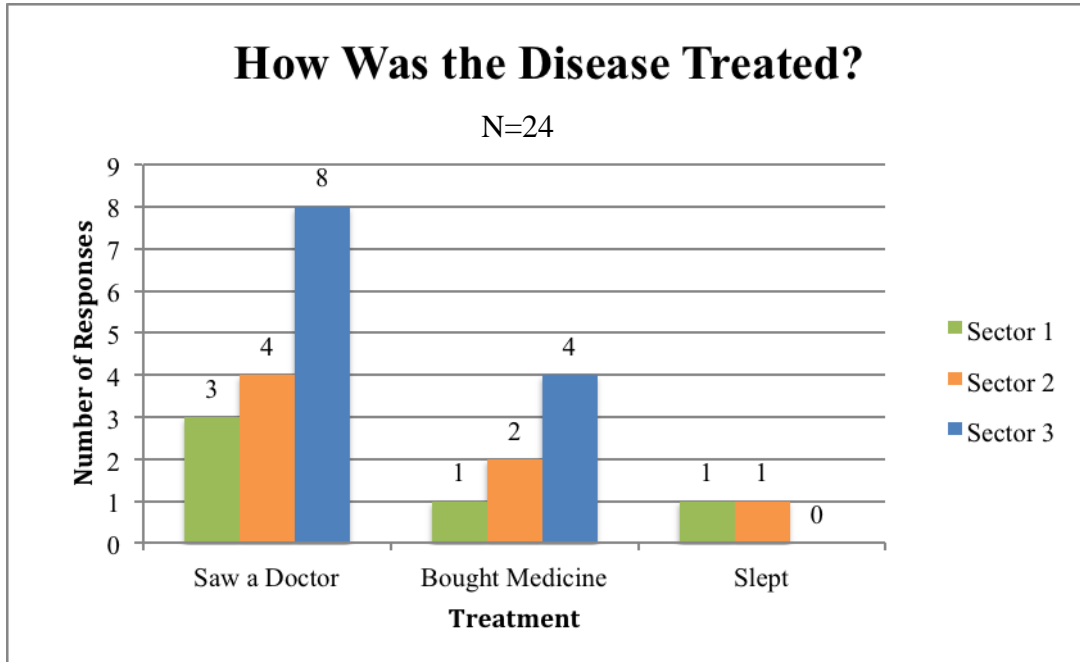


Figure L- 14: How was the Disease Treated?

## Appendix M: Coded Responses for Slum-dweller Survey

Table M- 1: Coded Responses from Slum-Dweller Surveys

	Vending Machines	In-Home Filters
Green: Convenience	<p><i>"It can give you large amount of water"</i></p> <p><i>"It's convenient"</i></p>	<p><i>"It's convenient"</i></p>
Red: Quality Beliefs	<p><i>"The water from the communal and in-home taps smells bad. We drink from the vending machines because it is better"</i></p> <p><i>"Because is cleaner than any other water"</i></p> <p><i>"There is no odor of chlorine"</i></p> <p><i>"It is cleaner than tap water"</i></p> <p><i>"The taste is also better than tap water"</i></p>	<p><i>"I think the machine is dirty"</i></p> <p><i>"I trust in the quality of water from in-home filter"</i></p> <p><i>"I trust in the quality of water from in-home filter that it will not cause kidney stone"</i></p> <p><i>"Because it is great quality, there is no odor or bad taste"</i></p> <p><i>"Water pipeline is not clean"</i></p> <p><i>"I think taps water is dirty"</i></p>
Purple: Lack of Other Options	<p><i>"My in-home filter broke I used to have my own filter but it doesn't work anymore"</i></p>	<p><i>"I had installed in-home filter before water vending machine was installed in the slum"</i></p>
Blue: Financial Reasons	<p><i>"In-home filter is expensive, it costs electricity"</i></p>	<p><i>"If you have your filter is cheaper than buy bottles and using machine"</i></p>
Yellow: Familiarity	<p><i>"I have been doing this for long time"</i></p>	<p><i>"I am familiar to get water from in-home filter"</i></p>

## Appendix N: Water Quality Report

**Samples Collected:** January 20<sup>th</sup>, 2015

**Samples Tested:** January 20<sup>th</sup> – 23<sup>rd</sup>, 2015

**Locations:** (1) Chum Chon Rim Khlong Phra Kra Nong  
 (2) Chum Chon Wat Khlong Toei Nai  
 (3) Chum Chon Mhoo Baan Pattana Jed Sib Rai

Table N- 1: Test Results from Fire Hydrants

Fire Hydrants Water Test Results			
Pathogen Indicator	S <sub>1</sub> F	S <sub>2</sub> F	S <sub>3</sub> F
Turbidity	Detected	Not Detected	Not Detected
Fecal Coliform	Detected	Not Detected	Not Detected
E. Coli	Not Detected	Not Detected	Not Detected
Quality	Pass	Pass	Pass

Table N- 2: Test Results Water Vending Machines

Vending Machines Water Test Results									
Pathogen Indicator	Sector One			Sector Two			Sector Three		
	S <sub>1</sub> V <sub>1</sub>	S <sub>1</sub> V <sub>2</sub>	S <sub>1</sub> V <sub>3</sub>	S <sub>2</sub> V <sub>1</sub>	S <sub>2</sub> V <sub>2</sub>	S <sub>2</sub> V <sub>3</sub>	S <sub>3</sub> V <sub>1</sub>	S <sub>3</sub> V <sub>2</sub>	S <sub>3</sub> V <sub>3</sub>
Turbidity	Not Detected	Not Detected	Not Detected	Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Coliform	Not Detected	Not Detected	Not Detected	Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
E. Coli	Not Detected	Not Detected	Not Detected	Detected	Not Detected	Not Detected	Not Detected	Not Detected	Not Detected
Quality	Pass	Pass	Pass	Fail	Pass	Pass	Pass	Pass	Pass

\*Disclaimer: The tests conducted did not test for all Thai drinking water standards. Therefore, the data does not conclude if the water is potable, only if it passed or failed the Most Probable Number (MPN) test for pathogens. Refer to Section 3.4 and 4.3 for more details.

## Appendix O: Community Water Evaluation

This community water evaluation represents residents' water usage and perceptions of the water quality issue in three sectors of the Khlong Toei Slum. This evaluation serves as a summary of the team's findings from surveys, focused on the viewpoint of the survey participants. Refer to Section 3.6 and 4.5 for more detail.

**Table O- 1: Most Commonly Used Drinking Sources**

<b>Most Commonly Used Drinking Sources</b>				
Drinking Water Source	Sectors			Percent Used
	1	2	3	
In-home Filters	13	19	15	42.3 %
Water Vending Machines	12	5	9	23.4 %
Bottled Water	7	12	7	23.4 %
In-home Taps	0	4	3	6.3 %
Communal Taps	4	0	1	4.5 %

**Table O- 2: After Collection Practices**

<b>After Collection Practices</b>				
Practices	Sectors			Percent Used
	1	2	3	
Drink it Right Away	17	22	18	45.2 %
Keep it in Storage	12	10	12	26.9 %
Refrigerate It	11	8	4	18.3 %
Boil It	4	1	5	7.9%
Filter Before Drink	1	1	0	1.6 %

Table O- 3: Symptoms of Sick Residents

Symptoms of Sick Residents				
Practices	Sectors			Percent Used
	1	2	3	
High Fever	3	3	9	55.6 %
Diarrhea	1	2	2	18.5 %
Nausea	0	0	1	3.7 %
Headache	0	2	0	7.4 %
Stomach Cramps	1	1	1	11.1 %
Constipation	0	1	0	3.7 %

### Quotes from Residents

#### *Vending Machines*

- “It can give you large amount of water”
- “It's convenient”
- “The water from the communal and in-home taps smells bad. We drink from the vending machines because it is better”
- “Because is cleaner than any other water”
- “There is no odor of chlorine”
- “It is cleaner than tap water”
- “The taste is also better than tap water”
- “My in-home filter broke
- I used to have my own filter but it doesn't work anymore”
- “In-home filter is expensive, it costs electricity”
- “I have been doing this for long time”

#### *In-Home Filters*

- “It's convenient”
- “I think the machine is dirty”
- “I trust in the quality of water from in-home filter”
- “I trust in the quality of water from in-home filter that it will not cause kidney stone”
- “Because it is great quality, there is no odor or bad taste”
- “Water pipeline is not clean”
- “I think taps water is dirty”
- “I had installed in-home filter before water vending machine was installed in the slum”
- “If you have your filter is cheaper than buy bottles and using machine”
- “I am familiar to get water from in-home filter”

# Appendix P: Point-of-Use Pamphlet

## Appendix P-1: Pamphlet (English)

### SAFE HANDS WASH PRACTICES

Chulalongkorn University  
จุฬาลงกรณ์มหาวิทยาลัย  
Pillar of the Kingdom

**WPI**

This pamphlet is the result of an eight week long project conducted by students of Chulalongkorn University and students from Worcester Polytechnic Institute. With the aid of the Duang Prateep Foundation, this project aimed to address the presence of contaminated drinking water in the Khlong Toei Slum. This pamphlet serves as a means to educate residents on water treatment to improve the water quality consumed by the community.

### IMPROVING YOUR LIFE THROUGH WATER TREATMENT

- Benefits of boiling water
- Benefits of in-home filters
- Prevention of pathogens
- Safe hands wash practices

### BENEFITS OF BOILING WATER

Contaminated water when filtered and treated can remove impurities but not all filters eliminate pathogens. Boiling helps removing pathogens from the water.

**How**

1. Heat the water until bubbles come out
2. Store the treated water safely

**ATTENTION:** Wait until boiled water cools down to refrigerate

### BENEFITS OF IN-HOME FILTERS

Water filters are used to eliminate the presence of suspended particles, heavy metals, pathogens or any other contaminants that are possibly in the tap water.

**Types of Filters**

FILTERS	FUNCTIONS	PRICE	MAINTENANCE
<b>Sediment and Polypropylene (PP) Filter</b> 	Removes suspended particles	80 Baht	Check every 1-2 months. If dirty, replace
<b>UV Filter</b> 	Sanitizes bacteria, pathogens and viruses	150 Baht	Bulbs: annually Quartz sleeve: when broken
<b>Ion Exchange Resin Filter</b> 	Removes inorganic and heavy metal contaminants	170 Baht	Cation exchange: every 7 years Anion exchange every: 4 years
<b>Carbon Filter</b> 	Removes the taste and odor from disinfection	350-650 Baht	Every 8-12 months, or when water has an unpleasant odor

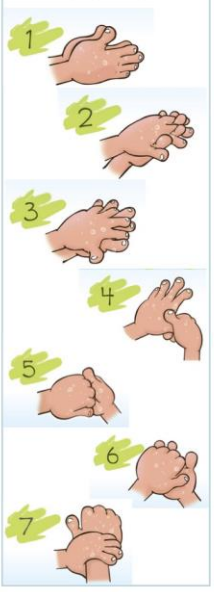
### PREVENTION OF PATHOGENS

Pathogens are harmful bacteria that can be easily transmitted through physical contact. You can reduce the risk of pathogenic contamination and improve your health by **washing your hands**

Figure P- 1: Point-of-Use Pamphlet in English


## Appendix P-2: Pamphlet (Thai)

### ขั้นตอนการล้างมือ ที่เหมาะสม




- 1
- 2
- 3
- 4
- 5
- 6
- 7

Chulalongkorn University  
จุฬาลงกรณ์มหาวิทยาลัย  
Pillar of the Kingdom



แผ่นพับนี้เป็นผลงานจาก  
โครงการของนิสิต จุฬาลงกรณ์  
มหาวิทยาลัยและนักศึกษา  
สถาบันวอชิงตันเทคโนโลยี  
ร่วมกับมูลนิธิดวงประทีป มีจุดมุ่ง  
หมายเพื่อที่จะแก้ไขปัญหาการ  
ปนเปื้อนของน้ำดื่ม ในชุมชน  
แออัดคลองเตย  
แผ่นพับนี้ได้ถูกจัดทำขึ้น  
เพื่อให้ความรู้ในเรื่องของการ  
จัดการน้ำดื่มแก่ผู้อาศัย ซึ่ง  
สามารถนำไปสู่การพัฒนา  
คุณภาพน้ำดื่มของชุมชนต่อไป  
ในอนาคตได้


### การจัดการน้ำดื่ม เพื่อการพัฒนา คุณภาพชีวิต



- ประโยชน์ของการต้มน้ำ
- ประโยชน์ของเครื่องกรองน้ำ
- การป้องกันเชื้อโรค
- ขั้นตอนการล้างมือที่เหมาะสม


### ประโยชน์ ของการต้ม



น ้ ทนทานการกรองแบบต้ม ท  
สะอาด แต่อาจมีเชื้อโรคปนเปื้อนอย  
ดงในการต้ม จึงมีความส าคัญ  
เพราะการต้ม สามารถ อดเชื้อ  
โรคที่ลอยภายใน ได

**อย่างไร**

1. ต้มจนกวน จะเดือด
2. เบน ไวในภาชนะที่ปิดเรยบรอย







**ข้อควรระวัง:** ควรระวังการระง ัน กลบส  
อดหมกหมองแล้วจึงน ้ ไปเชย

### ประโยชน์ของเครื่องกรอง

เครื่องกรอง สามารถ อด สางแขวนลอย โลหะหนัก เชื้อโรคและส งบปนเปื้อนอื่นๆ ใน ได

**ชนิดของไส้กรอง**

ไส้กรอง	ประโยชน์	ราคา	การดูแลรักษา
 <b>ไส้กรอง PP</b>	กรองผง ฝ ัน สารแขวนลอย ส งบเหล็ก โคลนและส งบสกปรกต่างๆ	80 บาท	ควรเปลี่ยนทุกๆ 1-2 เดือน
 <b>ไส้กรอง UV</b>	ฆ่าเชื้อจุลินทรีย์ต่างๆ เช่น แบคทีเรีย เชื้อรา ไวรัส	150 บาท	ควรเปลี่ยนหลอด UV เป็นประจำ ทบ และถอดล้างท ความสะอาด 2-3 ครั้ง/ปี (เฉพาะภายนอก)
 <b>ไส้กรองเรซม</b>	ลดปริมาณฝ ันปน สารอินทรีย์ และโลหะหนัก ช่วยลดความกระด้างของน	170 บาท	ขบวัก: ควรเปลี่ยนทุกๆ 7 ปี ขลบบ: ควรเปลี่ยนทุกๆ 4 ปี
 <b>ไส้กรองคาร์บอน</b>	ดดขบกลน ส สารเคมี คลอรีน และส งบสกปรกต่างๆ	350-650 บาท	ควรเปลี่ยนทุกๆ 8-12 เดือนหรือน ้น เรมมกลนไ้ทงประส ้งค

**การป้องกันเชื้อโรค**

เชื้อโรคคอส ้งมขบขบขนาดเลกมกทเขาส ้งรกายแล้วอาจก่อให้เกิดอาการเจ็บป่วย ซง  
สามารถแพร่กระจายด้วยการสัมผัสคตเชื้อ หรือของเหลวจากคตเชื้อขณะจาม ไ้ หรือสนทนา ซง  
เราสามารถลดการแพร่กระจายของเชื้อโรคได้ด้วย **การล้างมือ**

Figure P- 2: Point-of-Use Pamphlet in Thai



## Appendix Q: Poster to Encourage Boiling and Filtering Water

### Appendix Q-1: Poster to Encourage Boiling and Filtering Water (English)



Figure Q - 1: Poster in English



Figure Q - 2: Poster in Thai