Health and Water Quality Monitoring of Pure Home Water's Ceramic Filter Dissemination in the Northern Region of Ghana

By

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ABSTRACT

Pure Home Water (PHW) is a social enterprise that promotes and disseminates household drinking water technologies in the Northern Region of Ghana. Currently their main product is a pot-shaped Potters for Peace-type ceramic water filter, locally known as the *Kosim* filter. This study used household surveys and water quality testing to monitor the success of their filter program. This work builds upon the household surveys and water quality testing done by Rachel Peletz of predominately modern middle class PHW customers in January 2006 by gathering data that is newly available now that PHW has filter users in traditional communities. Thirty-five households from traditional communities and six households from modern communities were surveyed. For the water quality tests, a drinking water sample was collected from households without a filter, and unfiltered and filtered water samples were collected from households with a filter. These samples were tested for turbidity and for bacterial contamination using membrane filtration, 3M™ Petrifilm™, and hydrogen sulfide techniques.

The surveys determined that PHW is reaching poor communities: 0% of traditional filter users have access to improved water or sanitation, and monthly expenses averaged US $6.30 (GHC 57,000) per person per month. A risk assessment analysis found that people living in traditional households with filters had a 69% lower risk of diarrhea than people in households without the filters (p-value = 0.008). Also, the water quality tests found fairly effective removal rates. In the membrane filtration tests, filters in traditional households removed 99.7% of *E. coli* and 99.4% of total coliform. In modern households, the numbers were lower since the source water was of higher quality; the filters removed 85% of *E. coli* and 90% of total coliform. In addition to removing bacterial contamination, the filters also removed 92% and 68% of turbidity in traditional and modern households, respectively. Because of these health and water quality improvements and also positive responses from filter users, PHW is successfully disseminating an appropriate technology with significant health benefits to traditional low-income households.

Key Words: ceramic filtration, diarrheal prevalence, household surveys, bacterial water quality testing, Ghana, 4 Ps

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LIST OF ABBREVIATIONS

AFA Guatemala: Asociación Guatemalteca para la Familia de las Americas
CFU: Colony Forming Unit
CT: Ceramica Tamakloe
E. coli: Escherichia coli
G-Lab: Global Entrepreneurship Lab
GSS: Ghana Statistical Service
H_2S: Hydrogen Sulfide
HWTS: Household Drinking Water Treatment and Safe Storage
JMP: Joint Monitoring Programme
MAP: Medical Assistance Programs
MEng: Master of Engineering
MF: Membrane Filtration
MGDs: Millennium Development Goals
MIT: Massachusetts Institute of Technology
NTU: Nephelometric Turbidity Units
P/A: Presence Absence
PHW: Pure Home Water
PFP: Potters for Peace
STDV: Standard Deviation
USAID: United States Agency for International Development
VIP Latrine: Ventilated and Improved Pit Latrine
WHO: World Health Organization

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1.0 Introduction[1]

1.1 The Global Need for Improved Water and Sanitation

According to the World Health Organization (WHO), 1.1 billion people did not have access to an improved water supply in 2002, and 2.3 billion people suffered from diseases caused by contaminated water. Each year 1.8 million people die from diarrheal diseases, and 90% of these deaths are of children under five. Figure 1 below shows the per-capita deaths per million related to water and sanitation in each country in 2000. Besides causing death, water-related diseases also prevent people from working and leading active lives (WHO/UNICEF 2004).

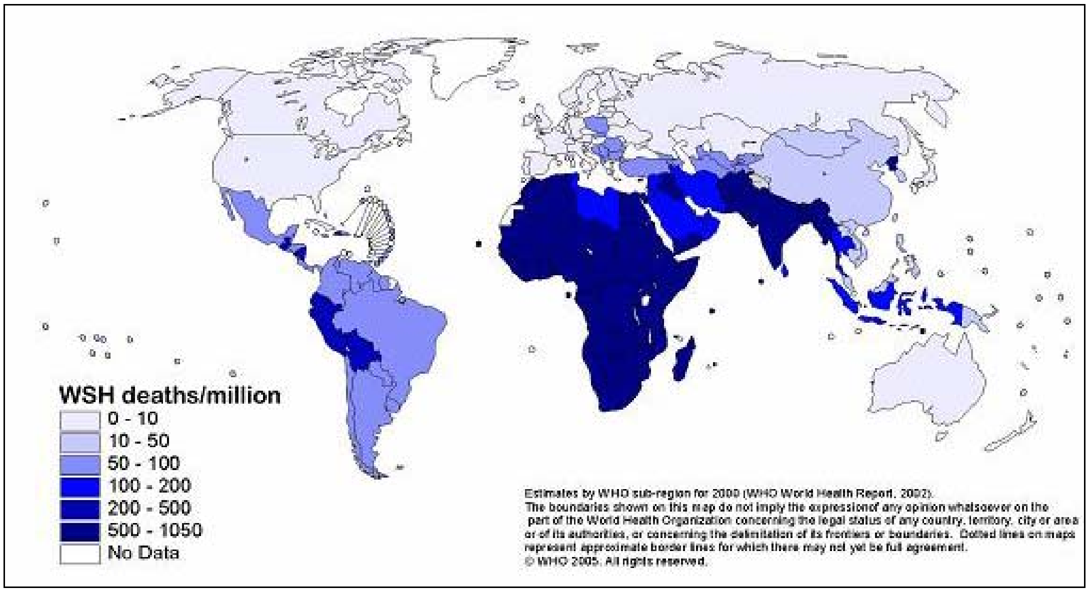


Figure 1: Deaths caused by unsafe water, sanitation, and hygiene for the year 2000, by country (WHO 2002).

In 2000, 189 nations adopted the United Nations Millennium Declaration, and from that the Millennium Development Goals (MDGs) were derived. The MDGs include 8 main goals, 18 targets, and more than 40 indicators. Their purpose is to focus efforts, promote study, raise awareness, and encourage strong alliances. Goal 7 addresses environmental sustainability, and Target 10 is to "halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation" (UN-NGLS 2006). According to the United Nations report, 80% of the world's population used an improved drinking water source in 2004, up from 71% in 1990. Although improvement has been made, there will be challenges as populations increase. A large number of people still will not be covered by Target 10, and, significantly, an improved water supply is not necessarily a safe water supply.

[1] Parts of this chapter were written in collaboration with Teshamulwa Okioga and Iman Yazdani.

1.2 Guidelines for Drinking Water Quality

In recent years, the WHO has moved away from defining set values for microbiological water quality levels, to providing recommendations using a more realistic risk-based approach. Table 1 shows the levels of *E. coli*[2] in drinking water, and respective risk levels:

Table 1: Categorization of drinking water systems based on compliance with performance and safety targets (WHO 2004)

	Proportion (%) of samples negative for *E. coli*		
	Population size:		
Quality of water system	**<5000**	**5000–100 000**	**>100 000**
Excellent	90	95	99
Good	80	90	95
Fair	70	85	90
Poor	60	80	85

It is highly recommended that there be an *E. coli* count of zero colony forming units (CFU) per 100ml water. In many cases, particularly in the developing world, this is difficult to achieve, making the above guidelines particularly useful.

1.3 Ghana Background

Ghana is located in West Africa (Figure 2) and has a total area of about 240,000km^2 and a population of approximately 22.5 million. The climate is tropical in the south near the coast, and semi-arid towards the north. Although the official language of Ghana is English, more than 70 other local languages are spoken. Sixty-three percent of the population is Christian, 16% are Muslim (mostly in the Northern region) and 23% follow traditional indigenous beliefs (CIA 2006).

[2] *E. coli* is a microbial indicator of fecal contamination in water.

Figure 2: Map of Ghana (CIA 2006).

The current environmental concerns in Ghana include soil erosion due to deforestation and overgrazing, recurring drought in the north which affects farming, and inadequate supplies of potable water (CIA 2006).

The major diseases prevalent in Ghana are malaria, yellow fever, schistosomiasis (bilharzias), typhoid, and diarrhea. Diarrhea is of particular concern since this has been identified as the second most common disease treated at clinics and one of the major contributors to infant mortality (Mattelet 2006), which currently stands at about 55 deaths per 1,000 live births (CIA 2006). Furthermore, the under-five childhood mortality rate is significantly higher in the Northern Region of Ghana, at 154 deaths per 1,000 live births (GSS 2004). The major cause of diarrheal disease is lack of appropriate hygiene, safe and sufficient drinking water, and adequate sanitation. After Sudan, Ghana has the highest prevalence of Dracunculiasis (guinea worm disease) in the world. Seventy-five percent of these cases have been reported in Ghana's Northern Region (WHO 2006).

1.4 Pure Home Water

Pure Home Water (PHW) is a social enterprise established in 2005 to promote household drinking water and safe storage (HWTS) products to low income customers in the Northern Region of Ghana (Figure 3). Currently, PHW's main focus is on the promotion and sales of the Potters for Peace-type ceramic pot filters, locally known as *Kosim* filters, although there is intention to make a variety of HWTS products available in the future.

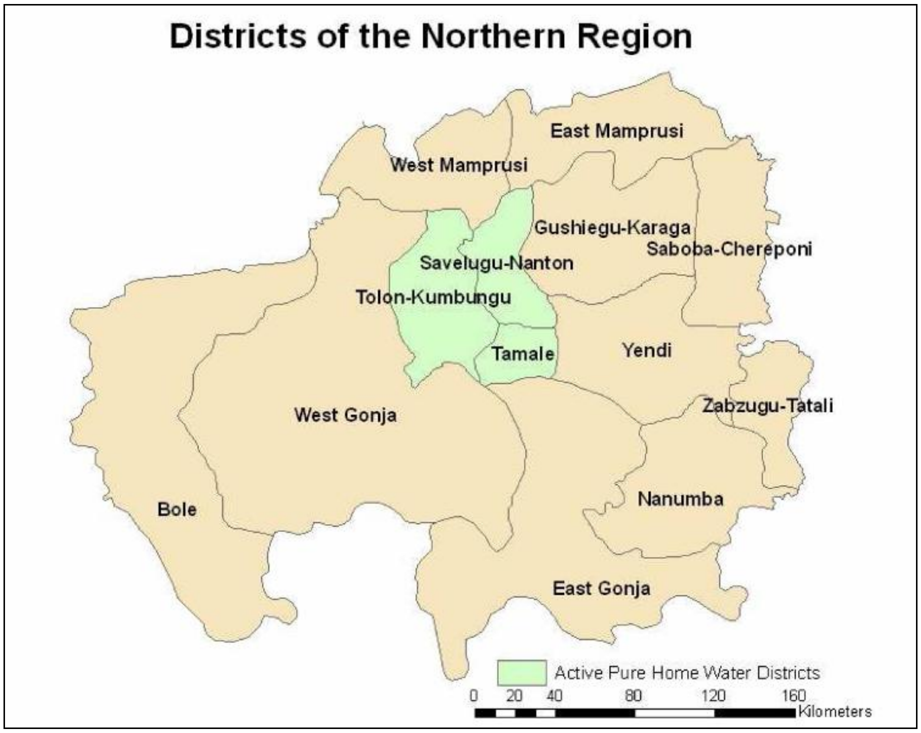


Figure 3: Target regions of Pure Home Water in the Northern Region of Ghana (VanCalcar 2006).

1.5 Solutions for Safe Water

Because large water infrastructure systems are unavailable in many developing areas, especially in rural areas and periurban settlements, household water treatment and safe storage (HWTS) systems offer good intermediate solutions. To be sustainable, these technologies must be technically effective, inexpensive, easy to use, locally made, and socially acceptable. Broad HWTS treatment categories include disinfection systems, particle-removal technologies, adsorption, and membrane processes. Safe storage may be incorporated with these technologies or may exist as a stand-alone method. Because Pure Home Water's main product is the pot-shaped ceramic water filter, the sections below describe particle-removal systems broadly and then give more thorough information on the PHW ceramic water filter.

1.5.1 Particle-Removal Systems

Various particle-removal methods can effectively contribute to the removal pathogens. They also may contribute to making the water visibly clearer, which enhances product acceptance. Sand, gravel, fabric, and ceramics are common media used in point-of-use filtration.

Families can construct slow sand filters locally and inexpensively. Palmateer et al. (1999) tested the Manz intermittent slow sand filter for its ability to remove bacteria, parasites, and toxicants. They determined that the filter could remove 83% of heterotrophic bacteria, 100% of Giardia cysts, 99.98% of Cryptosporidium oocysts, and 50-90% of toxicants. A study by Bellamy et al.

(1985) found 1 to 2 log removal rates for total coliforms. The filters require regular cleaning and maintenance.

Fabric filtration is an even simpler option. Colwell et al. (2002) determined that fabric folded four to eight times removed particles and pathogenic organisms greater than 20 microns in size. This can result in the removal of smaller microbes such as vibrio cholera that may attach onto other particles. The researchers implemented fabric filtration in 65 villages in Bangladesh and found a 48% reduction in cholera cases. The method was socially acceptable since unfolded sari cloths are commonly used to filter drinks in Bangladesh. Unfortunately, many pathogens can pass through folded fabric, so it is not entirely effective.

Cloth filters with 100-120µm pore sizes are commonly used in Ghana to remove the copepods that carry guinea worm vector (Mortensen 2007). These filters are distributed for free through the Guinea Worm Eradication Campaign.

Ceramic filters rely on gravity to pass water through a porous medium. Two common designs include candle-shaped filters and pot-shaped filters, as shown in Figure 4. Both designs use a colloidal silver coating that is reputed to prevent biofilm growth and which may slightly reduce bacteria levels.

Figure 4: Katadyn candle system (Katadyn 2007). Right, Potters for Peace system (PFP 2007).

The Katadyn drip filter is patented and made in an industrial manufacturing process (Smith 2005). Clasen et al. (2004) tested the Katadyn filters in a Bolivian community. They found that water in intervention households was 100% free of thermotolerant coliforms, while only 15.5% of samples in the control households were free of thermotolerant coliforms. Also, diarrheal risk was 70% lower in the intervention households. The authors claim that the 0.2-micron pore size and the colloidal silver make the candle filters effective. The filter system used in the study cost US $25, greater than the $9.25 average that users said they were willing to pay in that Bolivian community.

Chauduri et al. (1994) tested the long-term performance of the candle filters. They found good turbidity removal, but they suggest that pore sizes must be less than one micron to effectively remove all bacteria. At such small pore sizes the flow rates would likely go down significantly. Sometimes flow rates can be very slow, and some types of candle filters are expensive. The candles can become clogged over time, especially if water is highly turbid, and they require regular cleaning.

Because the Potters for Peace pot-shaped *Kosim* filter design is the focus for this thesis project, a detailed history of it is given below.

1.5.2 Potters for Peace Pot-Shaped Filters

In 1981, the InterAmerican Bank devised a list of criteria for sustainable filters and funded a study to find the best filter (PFP 2007). These criteria included fast flowing, effective against bacteria, locally made, inexpensive, and easy to distribute. The Central American Research Institute for Industry received the funding for this study, and Dr. Fernando Mazariegos created the first pot-shaped ceramic water filter with a colloidal silver coating. In 1984 Medical Assistance Programs (MAP) began to spread the colloidal silver ceramic filter design. Mazariegos worked with MAP to train Quechua potters in Ecuador to make the filters, and soon other groups turned to the filters as a solution. When Asociación Guatemalteca para la Familia de las Americas (AFA Guatemala) had problems with chlorine tablet misuse in rural communities, several organizations worked with AFA Guatemala to conduct a study that introduced the filters into homes. This study lasted from the end of 1993 until September 2005, and the organizations found that the filters could reduce diarrhea by 50% (Donachy 2004). After Hurricane Mitch destroyed the homes of millions of people in 1998, Potters for Peace began a large initiative to mass-produce filters in affected areas. The filter system they created now goes by the name *Filtron* in some locations (Figure 4, Figure 5).

Figure 5: Diagram of the *Filtron* system (PFP 2007). Water passes through a clay filter at the top into a lower storage receptacle. The spigot allows users to access the filtered water.

Currently, Potters for Peace has helped establish workshops in more than eight countries around the world (Murcott 2007), and many international organizations use the technology. This spread has been possible because construction requires few supporting technologies. A filter factory in Managua, Nicaragua, uses a mixture of 40% sawdust and 60% clay by volume (Smith 2005). Filter molds and a hydraulic press are the best way to form the clay (Figure 6), but the clay can simply be molded inside another pot. A kiln or fire pit is then used to fire the filters (Figure 7). The sawdust combusts during the firing and makes the filter porous. The filters are then coated with 2mL of 3.2% colloidal silver solution, which is supposed to prevent biofilm buildup and serve as a disinfectant (Smith 2005). The ceramic filter measures 30cm in diameter and 24cm in height. Lastly, a flow rate test determines if the filters are flowing at about 2L/hour. Extremely low flows are not acceptable for the user, and high flows might imply cracks. There is no patent on the filter, and information about it is available to the public (PFP 2007). Overall, pot-shaped ceramic filters have many advantages over some other HWTS systems. They are relatively inexpensive, are easy to use, can remove turbidity, and leave no aftertaste. In fact, some users prefer the earthly taste of the filtered water.

In 2004, filter manufacturing began at Peter Tamakloe's factory Ceramica Tamakloe Ltd. in Accra, Ghana. The Dutch organization *De Oude Beuk Foundation* provided funding for Ron Rivera, an experienced filter ceramicist and founder/director of the Potters for Peace filter program, to train Tamakloe and his employees (Mattelet 2006). Originally the filter went by the name C.T. Filter in Ghana, and now it is known at the *Kosim* filter in the Northern Region. The figures below show steps involved for filter manufacturing at Ceramica Tamakloe Ltd.

Figure 6: Hydraulic press used to make the filter in Accra, Ghana.
Photo Credit: Ron Rivera

Figure 7: Kiln for firing ceramic filters in Accra, Ghana.
Photo Credit: Ron Rivera

1.6 Project Background and Goals

Last year three MIT Master of Engineering (MEng.) students and four MIT Sloan School of Management students of the Global Entrepreneurship Lab course (G-Lab, 15.389) worked in Ghana during January 2006. The engineering students' projects included GIS mapping, an epidemiological study of water and sanitation practices, and ceramic water filter evaluation using three different tests (Mattelet, Peletz, VanCalcar 2006). The business students spent most of their time with PHW's social entrepreneurs and focused on the "4Ps," product, price, place, and promotion.

This year's MEng students include Teshamulwa Okioga, Iman Yazdani, and the author Sophie Johnson. The students worked at MIT in the fall and spring semesters, and during January 2007 they traveled to Ghana for three weeks of field research. Okioga researched sachet water vending, and Yazdani examined solar disinfection. The author analyzed both business aspects and effectiveness of the ceramic filters. She surveyed households to determine how well PHW's new business strategy is reaching the poor and how acceptable the filters are to users. She also collected water samples to evaluate how well the *Kosim* ceramic filters are performing in the field.

PHW's social entrepreneurs include Wahabu Salifu, Hamdiyah Alhassan, Bernice Senanu, and Shakool Ibrahim. Elizabeth Wood served as PHW's project manager from mid-2006 through early 2007, and Ernest Ansah and Edward Abrokwah are on the Board of Directors. Other students involved include Alfinio Flores, Alioune Dia, Melinda Foran, Eric Adjorlolo, and Silpa Kaza. Susan Murcott, a Senior Lecturer in the Department of Civil and Environmental Engineering at MIT, has managed the project since its inception in summer 2005.

2.0 Context and Methods for the Epidemiological Survey

2.1 Background

Past epidemiological studies have examined how improvements in drinking water quality can have a positive impact on health. A meta-analysis by Fewtrell and Colford (2004) found that water quality improvements can reduce diarrhea by 39%. The researchers looked at 12 studies that dealt with household water treatment, nine of which found that household treatment could reduce diarrhea illness by a statistically significant amount. With one poor-quality paper ignored, all types of household treatment interventions performed similarly.

Gundry, et al. (2004) also reviewed past studies to find links between disease and water quality improvements from point-of-use technologies. Specifically, the researchers looked at cholera and diarrhea cases. They found a clear link between cholera cases and the presence of the bacteria that causes the disease, *Vibrio cholerae*. However, no conclusive link was found between point-of-use water quality and diarrheal prevalence.

More specifically, work related to the Potters for Peace-type ceramic filters has been done to examine their effectiveness and/or health impact, as has been described in previous MIT studies (Lantagne 2001, Peletz 2006) and by other researchers (Van Halem 2006). A recent study by Brown and Sobsey (2006) is described below.

Brown and Sobsey (2006) studied pot-shaped ceramic water filters in Cambodia. Resource International Development introduced approximately 1,000 filters in Kandal Province, and International Development Enterprises introduced over 1,000 in Kampong Chhang and Pursat Provinces. The study involved a cross-sectional examination of 506 households that received the filters to find the variables associated with filter uptake and use. Also, the researchers carried out a longitudinal prospective cohort study that looked at the microbiological effectiveness and health impacts for 80 households with the filters and 80 without.

In the cross-sectional study, researchers found that continued filter use depended on many factors. The likelihood of continued filter use declined 44% every six months. Breakage, the largest reason for disuse, caused 2% of filters to fail each month after implementation. Also, the source water was a factor for disuse. People who used groundwater from deep wells were less likely to continue use, which could be due to its perceived cleanliness or to clogging from insoluble ferric iron. A cash investment in the filter, at any level, also correlated to a higher chance of continued filter use. The surveys also found that respondents who practice other safe water, sanitation, and hygiene methods were more likely to keep using the filter.

The longitudinal study provided important results about filter use and effectiveness as well. The filters were able to reduce *E.coli*/100ml counts by a mean of 95.1%. Time in use did not reduce the filters' microbiological effectiveness. Also, households with the filters had a 46% reduction in diarrheal disease compared to the control households. Lastly, recontamination was found in many cases, which indicates that education on proper cleaning is a crucial element to the system's success.

2.2 Objective

The surveys for this project collected data for both *Kosim* filter users and non-users in the Northern Region of Ghana. Survey questions:

- Obtained baseline data on hygiene practices, sanitation access, and water use.
- Compared filter users and non-users in traditional communities.
- Determined filter acceptability for the users and highlighted any problems from the users' perspective.
- Ensured that Pure Home Water (PHW) is reaching communities most in need of the technology.
- Followed-up on a sub-set of filter users interviewed by Peletz in January 2006.

The results are intended to enable PHW to spread the *Kosim* filter more effectively.

2.3 Survey Design

MIT Master of Engineering student Rachel Peletz (2006) conducted a cross-sectional study of 50 households in the Northern Region of Ghana to obtain baseline data on drinking water and sanitation practices. The aim was to help PHW in its efforts to spread household drinking water treatment and safe storage (HWTS) technologies.

Peletz's study tried to minimize confounding factors, which are hidden variables that affect the factor(s) in question. To do this, she tried to select participants as randomly as possible. Peletz also used restriction to limit the study to only one level of confounder. Her restriction was to limit survey participants to the woman of the household with at least one child under five.

In addition to avoiding confounding factors, Peletz also minimized bias. Selection bias was difficult to avoid because the PHW entrepreneurs, Hamdiyah Alhassan and Wahabu Salifu, or the village guide often chose the households to visit. She minimized observation bias by using the same question order. However, Peletz notes that people may respond differently to male and female visitors, so the presence of either Alhassan or Salifu could have had an effect.

Peletz chose questions that would be of value to PHW, and she received feedback from project advisor Susan Murcott, epidemiology professor Julie Buring, the social entrepreneurs Hamdiyah Alhassan and Wahabu Salifu, and William Duke, M.D., from the Centre for Affordable Water System Technology. Peletz's survey instrument was submitted to and approved by MIT's Institutional Review Board, called the Committee on the Use of Humans as Experimental Subjects. Because the study involved minimal risk to participants, it qualified for "exempt status." All of Peletz's survey participants gave their informed consent.

2.4 Survey Implementation

2.4.1 Community selection

The original goal of this new research was to visit 30 households from traditional communities and to revisit several of the eight ceramic filter users from modern communities that Peletz surveyed in January 2006. Time allowed for 35 households from six traditional communities and six households from two modern communities to be surveyed. The traditional communities were chosen from those recently reached by PHW's rural outreach strategy. By January 2007, PHW had done community presentations and had sold filters in eight traditional villages. Five of these villages, including Gbanyamni, Chenshegu, Taha, Gbalahi, and Shenshegu, were chosen for surveying based upon convenience of access and quantity of filters sold. One traditional village, Kalariga, was chosen because Alioune Dia, a Masters student at Brandeis University, was conducting a study there.

Peletz interviewed 50 households, including eight pot-shaped ceramic filter users from three different modern communities, Kamina Barracks, Vitin Estates, and Jisonayili. At the time of Peletz's study, PHW had not sold any filters in traditional communities, so her study could only include filter users from modern communities. Kamina Barracks and Vitin Estates were both revisited, surveyed, and sampled by the author. Because Peletz surveyed just one filter user in Jisonayili, this community was not revisited.

2.4.2 Household and Participant Selection

PHW's rural marketing strategy involves recruiting a community liaison who serves as a link between PHW and the village. In return for a commission on each filter sale, the liaison conducts information sessions on the filters and markets them throughout the community. The community liaison from five of the villages helped the author select households for the surveys. If the liaisons had cellphones, they were called in advance to setup a visit. Upon arrival, the liaison was found, and a visit was made to the village chief to get permission to conduct the surveys. Then the liaison was asked to choose several homes with filters and several without filters. Although the liaison was asked to choose the households randomly, there could have been selection bias. Even though most households visited had children under five, it was necessary in some cases to visit homes without young children because of the limited number of households with filters. In Kalariga, because there is not a PHW community liaison, households were selected by the interim chief. If a woman of the household was not at home, another household was chosen.

Most men in the traditional households have several wives, and household members chose one woman to respond to the survey. Oftentimes the senior wife was the respondent. Women were interviewed because they are usually responsible for water provision and are assumed to know the most about diarrhea occurrence in children. The participation rate of women asked was 100%.

In the modern communities, only filter users who were visited by Peletz were chosen. She interviewed 4 filter users in Kamina Barracks, and because one woman had moved, only 3 were revisited. She also interviewed 3 filter users in Vitin Estates, and since two of the users were not home, a son and a niece or the original respondents were interviewed instead.

2.4.3 Logistical Details

Although English is Ghana's official language, all of the interviews in the traditional communities were conducted in local dialects. Wahabu Salifu and Shakool (Shak) Ibrahim served as translators, and Alioune Dia often helped record answers. Because water quality tests had to be done within six hours of collection, sometimes Salifu and Dia went to homes without filters, while Ibrahim and the author went to homes with filters in order to save time. Oftentimes the community liaison and many family members were present as well. Having so many people present, especially foreigners, could have influenced the responses. In the modern communities, fewer family members were present, and several of the surveys were conducted in English.

Surveys took 15 to 45 minutes. In traditional communities, four to eight households were surveyed in a day. In the modern communities, only filters users surveyed by Peletz were visited, so just three households were surveyed each day.

Responses were recorded on copies of the survey and were subsequently entered into the statistics program SPSS (originally Statistical Package for the Social Sciences) within a week. Although SPSS could have been used for calculations, the entries were copied from SPSS into Excel for all analyses.

2.5 Survey Questions

As explained previously, Peletz's survey instrument was used for this study. Based on conversations with her and with PHW entrepreneur Wahabu Salifu, a few minor changes were made, as noted below. The final version of the survey is included in Appendix A. Data was gathered in the following six categories.

2.5.1 Household Information

Questions were collected on general household information, including age of the respondent, total number in the household, age distribution of those in the household, education level of respondent, home type, and sources of information. Although Peletz's survey divided monthly household expenses into categories, respondents were only asked for an estimate of their total monthly expenses. This was changed because of the time required to determine expenses. Peletz's convention for the Northern Region of Ghana is used to define a modern community as one with concrete homes and a traditional community as one with mud-brick homes arranged in circles. Traditional communities typically use firewood and charcoal for energy and frequently lack sanitary latrines. The modern communities usually have electricity at least for part of the day and have latrines or indoor toilets.

2.5.2 Diarrheal Knowledge and Prevalence

Because diarrhea is an indicator for water-borne diseases, respondents were asked questions to determine how prevalent diarrhea is and how much they know about its causes. Respondents were asked if anyone in the household had had diarrhea in the past week. If the answer was yes, they were asked for the ages of those with diarrhea and the number of days each person had it. Also, the respondents were asked what they thought the main cause of diarrhea is. After their response, they were asked if certain things, such as dirty water or dirty food, could cause diarrhea. Respondents were also asked how they treat diarrhea. Peletz's survey included a question about cost per year for each treatment option, but this was eliminated. Respondents were also asked who in the family cares for people sick with diarrhea to determine whether or not women bear most of the responsibility.

2.5.3 Hygiene Practices

Respondents were asked when they wash their hands and whether or not they use soap. Although Peletz read aloud possible options, such as after the toilet, before eating, and before cooking, no options were given. This change results in a lower number of people practicing adequate hand-washing.

2.5.4 Sanitation Access

Questions were asked about the type of toilet facility respondents normally use, how long it takes to reach it, and whether hand-washing facilities are available. Definitions from the UNICEF/WHO Joint Monitoring Programme (2006) were used to determine if a household has access to improved sanitation. Improved sanitation sources include connection to a public sewer, connection to a septic system, pour-flush latrines, simple-pit latrines, and ventilated-improved pit (VIP) latrines. The facilities must be private or shared and must separate human excreta from human contact (JMP 2006).

2.5.5 Water Access and Storage

Information was gathered about where respondents get their water both during the wet season and during the dry season since sources in the Northern Region vary greatly throughout the year. Questions were asked about who collects the water, the collection frequency, and the time of each collection to determine the magnitude of the burden and whether women bear an unequal portion of it. These answers were used to determine if the respondent had access to an improved water supply. The UNICEF/WHO Joint Monitoring Programme (2006) defines an improved water supply as access to a household connection, public standpipe, borehole, protected dug well, protected spring, or rainwater collection within one kilometer from the user's home. Instead of asking about the distance to the water source, respondents were asked how long each collection trip took. Round trips longer than 30 minutes were considered unimproved. Respondents were also asked about their water source when away from home. Because improper water storage can introduce contaminants, respondents were asked where they store their water, whether the container is covered, and how the water is accessed.

The respondents were asked if their source of water is safe, and if not, why. They were also asked what, if any, treatment they perform before drinking their water.

2.5.6 Household Treatment and Safe Storage

In households without ceramic filters, questions were asked about the respondent's desire to treat water additionally. Households with the filters were asked a range of questions about the filter's purchase, its acceptability, and its operation and maintenance. The questions asked are discussed in greater detail in Section 4.3 of Chapter 4.0 Business Analysis Context and Methods.

3.0 Context and Methods of Water Quality Testing

3.1 Background

3.1.1 Past Research

Many studies have been done to test the water quality performance capabilities of the pot-shaped ceramic water filter both in the laboratory and in the field, and some of these are discussed in Section 2.1 and below (Lantagne 2001, Hwang 2003, Camm 2006, Mattelett 2006, Van Halem 2006, Brown and Sobsey 2006).

In 2001, the US Agency for International Development (USAID) sponsored investigations of the Potters for Peace ceramic filters (Lantagne 2001). Daniele Lantagne of MIT and Alethia Environmental tested the filters in 24 homes, and she determined that the filters could remove a high percentage of thermotolerant bacteria. Lantagne also found that NGOs must follow-up with families in order to make sure that the filters are used and maintained properly since contamination of the receptacle and improper storage can introduce coliforms and bacteria. Lantagne found that the colloidal silver lining did not cause unhealthy silver concentrations in the filtered water. The study recommends that the filters come with a cleaning kit so users can remove solids and disinfect the receptacle.

Hwang (2003) conducted field testing on the ceramic filters for six-months in Nicaragua, and she found that the filters removed of 97.6% of *E. coli* and 89.3% of total coliforms through membrane filtration testing.

Camm et al. (2006) of the company WRc conducted laboratory tests on the pot-shaped ceramic filter. They found removal efficiencies for *E.coli* of over 99% (2 $\log_{10}$) reduction. However, the filters were less effective at eliminating heterotrophic bacteria. The filters were found to perform better after a month of operation, but cleaning reduced efficiency for a short period of time. The researchers concluded that the ceramic filter should be used as part of a multiple barrier system to treat water, and not as the sole water treatment.

Mattelet (2006) conducted laboratory tests on the *Kosim* filters (previously called the Ceramica Tamakloe (C.T.) Filter) made from Peter Tamakloe's factory in Accra, Ghana. She found that they performed better than two other types of filters, the Nnsupa candle filter and the Everest Aquaguard candle filter. The *Kosim* filter removed 99.5 to 100% total coliform when tested with membrane filtration and 3M™ Petrifilm™, respectively.

Van Halem (2006) examined how well pot-shaped ceramic filters remove pathogenic microorganisms, determined physical characteristics like pore sizes of the filters, and investigated the effect of the colloidal silver coating. In the bacterial tests, no total coliforms were detected in 93% (134/144) of the filtered samples, and $\log_{10}$ reductions of *E. coli* were between four and seven. The effective pore size diameters averaged 40μm with a bubble-point test and were between 16 and 25μm with mercury intrusion porosimetry testing. Although these pore sizes were higher than the desired 1μm, microorganisms were still removed. The results on the effectiveness of the colloidal silver were mixed.

3.1.2 Indicator Organisms

Because it is impossible to test for all possible pathogens, indicator organisms are used instead to test for the likelihood of having pathogens present. Indicators organisms should be present whenever the pathogens are present, but they should not be pathogenic. Total coliform, *Escherichia coli (E. coli),* and hydrogen sulfide-producing bacteria were used as indicator organisms in this thesis. Total coliform bacteria are commonly used as an indicator for microbial drinking water quality. They are rod-shaped, gram-negative organisms that ferment lactose at 35°C. *E. coli* is a subset of the total coliform group, and these bacteria are almost always of fecal origin. Finally, hydrogen sulfide-producing bacteria can also be used as an indicator for microbial contamination, but many kinds of non-pathogenic bacteria can create hydrogen sulfide, leading to false-positives. Sobsey (2002), Low (2002), and Mattelet (2006) describe these indicator organisms further.

3.2 Overview of Methods

Tests were conducted on filtered and unfiltered samples from households as part of the monitoring and evaluation of Pure Home Water's ceramic filter program.

3.2.1 Sampling Methods

Two samples of water were taken from each surveyed household. Respondents without ceramic filters were asked for a drinking water sample, and those with filters were asked for both an unfiltered and filtered water sample. Figure 8 shows how respondents typically provided unfiltered samples. In homes with ceramic filters, the unfiltered water came from inside the ceramic element when water was there, representing the water that had not yet passed through the filter. If no water was inside the ceramic element, unfiltered water was collected from a point of storage in the household. The water was collected in Whirlpack bags at the end of each interview and then stored in a cooler with ice packs during transport. Once back at the field laboratory, the samples were refrigerated until the water quality tests were performed. The testing occurred within six hours of sample collection.

Figure 8: Woman providing an unfiltered water sample by dipping a cup into a ceramic vessel behind her.

3.2.2 Water Quality Testing Methods

The MIT Team stayed at GILLBT Guesthouse in Tamale, Ghana, where the team's bungalow was equipped with two kitchens, one of which was dedicated as the field laboratory, shown in Figure 9. Electricity and running water were usually working, and a gas stove with four burners was always available. Membrane filtration testing requires a source of water completely free of total coliforms. Because distilled water could not be produced in the field laboratory, attempts were made to boil filtered water and store it in a plastic container with a spigot. Unfortunately this water still led to coliforms in the blanks, so distilled water from the laboratory at World Vision was brought to the guesthouse. Again, there were problems with the water, so subsequent tests were done using bottled water, which proved to be a good source resulting in blanks that came out blank. Reusable supplies such as pipette tips and Petri dishes were disinfected by placing them in boiling water on the gas stove.

Figure 9: Teshamulwa Okioga working in the field laboratory in GILLBT Guesthouse.

In the field laboratory, two different procedures, membrane filtration and 3M™Petrifilm™, tested for levels of total coliform and *E. coli*, and one procedure tested for the presence or absence of hydrogen sulfide-producing bacteria. In addition to the three bacteria analyses, samples were tested for turbidity. Any contamination in the filtered water showed a weakness in the filter's ability and/or indicated contamination in the storage receptacle. Tests for pH were incorrect because the thiosulfate tablets in the sampling bags raised the pH.

3.3 Bacteria Analysis

Three tests were conducted to assess the bacterial quality of water. The cost of each is shown below in Table 2.

Table 2: Cost of microbial tests (Okioga 2007).

Test Type	Approximate Cost per Single Test (US$)
Membrane Filtration (with recyclable Petri dish)	2.53
3M™ Petrifilm™	1.50
Hydrogen Sulfide	0.27

3.3.1 Membrane Filtration Testing

Membrane filtration was performed to quantify total coliform and *E. coli* levels in the water samples. This procedure required 100mL of sample.

Membrane Filtration Materials:

- Millipore portable unit, including filter holder and pump
  (part of Millipore, XX63 001 50)
- m-ColiBlue24 media

- 47mm absorbent pad
- 0.45µm, 47mm, white gridded filter pad
- Metal Petri dishes
- Candle
- Matches
- Tweezers
- Magnifying glass
- Incubator (Millipore Environmental Incubator (Portable), XX 63 200 00)
- Bottled water
- Automatic pipette
- Metal cup
- Methanol

The procedure below is adapted from Millipore's *Water Microbiology: Laboratory and Field Procedures.*

1. Filter holder sterilization
   - Remove the stainless steel receiver flask.
   - Soak the adsorbent ring with methanol.
   - Light the ring.
   - Place the receiver flask over the funnel base.
   - Wait 15 minutes to remove the cup.

2. Petri dish preparation
   - Label the dish.
   - Put the adsorbent pad in the dish with flame-sterilized tweezers.
   - Pour the m-ColiBlue24 media from the 2mL ampoule onto the pad. Rotate the dish to distribute it and then pour off the excess, leaving one drop.

3. Filtration
   - Place the receiver cup onto the base.
   - Flush the funnel walls and screen with ~30-50mL of bottled water.
   - Position the 0.45µm filter pad grid-side up onto the screen with sterile tweezers.
   - If a diluted sample is required, use an automatic pipette to obtain the necessary volume. Empty the volume into a sterilized metal cup, and add bottled water until the volume reaches 100mL.
   - Add the 100mL sample and/or a dilution of that sample.
   - Create a vacuum by pumping the syringe plunger.
   - Rinse the device with a volume of bottled water equal to the sample size and repeat.

4. Filter removal
   - Use flame-sterilized tweezers to remove the filter.
   - Place the filter in the Petri dish, using a rolling method to avoid trapping air bubbles.

5. Incubation
   - Place the Petri dish upside-down in the incubator.

- Incubate the sample at 35ºC for 24 hours.

6. Examination
   - Count the colony forming units (CFUs) with a magnifying glass. The number of colonies should be between 20 and 80 CFU for total coliform and between 20 and 60 CFU for *E.coli.*

7. Disinfection/Disposal of test waste
   - Disinfect complete coliform tests by placing filter paper into a plastic container with bleach. After 30 minutes, put the filter paper in a plastic bag for disposal.

3.3.2 3M™ Petrifilm™ Testing

Like the membrane filtration testing, 3M™ Petrifilm™'s E. coli/Coliform Count Plate also quantifies the level of total coliform and *E. coli* contamination in a sample. The 3M™ Petrifilm™ is a much simpler, less time-intensive test to perform. It involves a sample-ready culture medium that has Violet Red Bile nutrients, a gelling agent, and indicators for glucuronidase activity and tetrazolium (3M™ Petrifilm™ 2001). The test only requires 1mL of sample.

3M™ Petrifilm™ Materials:
- 3M™ Petrifilm™ plate
- Plastic spreader
- Automatic pipette
- Tongs
- Candle
- Matches
- Incubator (Millipore Environmental Incubator (Portable), XX 63 200 00)

The procedure below is adapted from the 3M™ Petrifilm™ Interpretation Guide (2001).

1. Storage of packages
   - Both opened and unopened packages of plates were refrigerated. Although opened packages are not supposed to be refrigerated, they were because of the high ambient temperatures, as done by Mattelet (2006).

2. Inoculation
   - Place Petrifilm on a flat surface.
   - Use pipette to obtain 1mL of sample. Raise cover and empty the sample into the center of the film.
   - Slowly roll the film down to prevent trapping air bubbles.
   - Place the spreader onto the film with the flat side down. Press gently to distribute the sample.
   - Remove the spreader and wait one minute for the gel to solidify.

3. Incubation
   - Place plates in incubator with clear sides up with no more the 20 plates in a stack.
   - Incubate for 24 hours at 35 °C.

4. Analysis
   - Use a lit magnifying glass to count total coliform and *E. coli.* Red colonies with entrapped gas nearby (within approximately a one diameter of the colony as done by Mattelet (2006)) are coliform colonies. Blue colonies with entrapped gas nearby are *E. coli* colonies. Red and blue colonies without entrapped gas are not counted. An example is shown below in Figure 10.

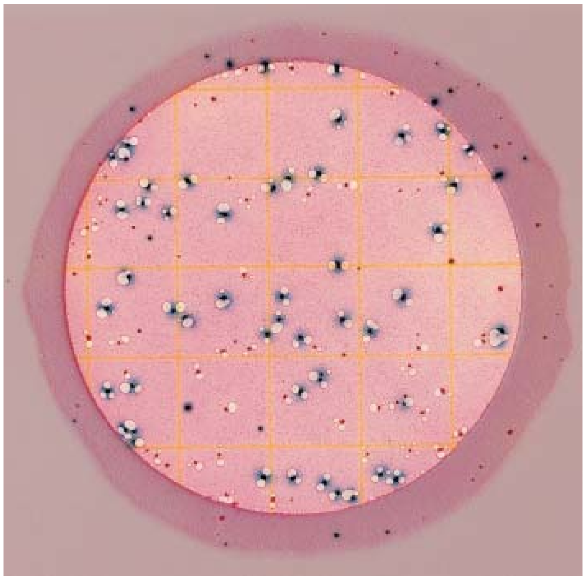


Figure 10: Results from a Petrifilm test, where the blue colonies near entrapped gas indicate *E.coli,* and the red colonies near entrapped gas indicate total coliform (3M Petrifilm 2001).

3.3.3 Hydrogen Sulfide (H_2S) Presence/Absence Testing

The H_2S Presence/Absence test is simpler to perform than membrane filtration, and the results are easier to read than either membrane filtration or 3M™ Petrifilm™. The test determines whether or not the sample contains H_2S-producing bacteria, which are indicators of fecal contamination. The sample turns black if H_2S bacteria are present because of a reaction between the H_2S gas and iron in the media that results in iron sulfide, a black precipitate (Peletz 2006).

H_2S Presence/Absence Materials:
   - HACH PathoScreen Medium (for 20mL)
   - 30mL glass bottle with screw-on cap
   - Scissors
   - Candle
   - Matches

- Tongs
- Rubbing alcohol

The following procedure is adapted from Hach (2003).

1. Preparation
   - Fill one glass bottle with 20mL of water. Use a permanent marker to draw a 20mL line on the other sampling bottles, using the first bottle as a reference.
   - Sterilize the bottles and caps by boiling. Remove with sterile tongs and cap bottles until use.

2. Media addition
   - Pour sample into glass bottle until it reaches the 20mL line.
   - Wipe the PathoScreen packet with rubbing alcohol and tear open. Use sterile scissors if tearing is difficult. Empty all contents into the sample.
   - Screw the cap on the bottle.
   - Shake the bottle until the media dissolves.

3. Incubation
   - Incubate the sample at 25–35 °C for 24-48 hours. Because incubator space was not available for the bottles, they were kept in an oven (turned off). If no black precipitate is present after 24 hours, check the samples again after 48 hours.

4. Analysis
   - Examine the color of the sample. A black sample indicates the presence of H_2S bacteria, while a yellow sample indicates its absence, as shown in Figure 11.

Figure 11: Results from H_2S test. The black sample on the left is positive, and the yellow sample on the right is negative.

3.4 Turbidity Analysis

Turbidity was analyzed in the field laboratory with a Hach 2100P Turbidimeter, as shown in Figure 12. A water sample was added to the 30mL glass bottle. Silicone oil was wiped on the glass bottle, and the bottle was placed in the turbidimeter for reading.

Figure 12: Hach 2100P Turbidimeter used for testing.

3.5 pH Testing

Originally, samples were tested for pH using pH strips. However, each of the Whirlpack bags contained a sodium thiosulfate tablet, which was used to eliminate any chlorine residual in the water sample. Because the tablets raised the pH, it was not possible to accurately test the samples.

4.0 Business Analysis Context and Methods

The business aspect of this thesis analyzes PHW's new ceramic filter marketing approach. The goal of the business analysis is to determine how well the implementation strategy is working in terms of Product, Price, Place, and Promotion.

4.1 Social Marketing and the "P's" Framework

Beginning in the 1970's, efforts to spread information on environmental or educational issues focused on a top-down marketing approach. This method has evolved to a better, more effective approach called "social marketing." Social marketing campaigns can have varying emphasis on social and/or financial goals. Campaigns, which can be for ideas, behaviors, and products, direct messages to targeted audiences to have the most effect. Borden (1991) devised a list of 12 activities that comprise an organization's marketing program, and he explains that changing the "marketing mix" can drastically influence an organization's effectiveness. Four of these 12 elements, product, price, place, and promotion (4 Ps), are a popular framework for evaluating an organization's marketing strategy. As Dolan (1997) and Hoffman (2006) explain, the 4 Ps framework is useful for developing a social marketing campaign. Hoffman adds four additional "Ps," and all of them are listed below with a short description of their meaning in the context of Household Water Treatment and Safe Storage (HWTS). The first four listed: product, price, place, and promotion, are more commonly known and used than the last four, and therefore this work will focus on the former.

- Product – the water treatment technology
- Price – a cost that must be affordable to the user
- Place – locations for buying both the initial system and replacement parts
- Promotion – strategy to advertise the technology's purpose and appeal
- Publics – both internal groups like the promoters and external groups such as the audience and policy-makers
- Partnership – collaboration among organizations
- Policy – guidelines for maintaining sustainable programs
- Purse strings –the governments or foundations upon which many HWTS programs rely

4.2 Pure Home Water Approach[3]

4.2.1 Global Entrepreneurship Lab Assessment

Last year, students in the Global Entrepreneurship Lab (G-Lab) course used the four P's listed above to evaluate PHW's approach and to make recommendations for improved marketing and sales. Starting with Product, the team found that PHW's efforts to promote six different HWTS technologies complicated targeted promotion and supply-chain management. The team determined that PHW did not have the capacity to effectively market multiple products and that success would be better ensured if they targeted their single "best" product. The original set of products included modified safe storage clay pots, plastic safe storage containers, Ceramica Tamakloe (CT) filters, Nnsupa candle filters, biosand filters, household chlorination, and SODIS (solar disinfection). Based on results from the engineering team, the group recommended that

[3] Parts of this section were written in collaboration with Teshamulwa Okioga

PHW focus on the CT Filter, the biosand filter, and safe storage. For Price, the G-Lab team devised a new pricing scheme according to a breakeven analysis. Also, the team negotiated with Ceramica Tamakloe in Accra to obtain a verbal agreement for a 37% price reduction. For Promotion, the students worked to develop marketing materials, organized market day sales events, improved the sales pitch, and made activity goals. These goals included four organization presentations per week, one market day per week, and one community visit per week. Lastly, to improve Place aspects, the students focused on improving communication with retailers of the products, and they also helped coordinate monthly training sessions with potential sales agents.

Unfortunately the Year 1 breakeven was not achieved because of the high filter prices. According to the 2006 G-Lab team (Gordon 2006), PHW bought the filters from Ceramica Tamakloe for US $12.20 (GHC 110,000) and paid US $2.70 (GHC 24,000) for cleaning brushes, tap fixing, and transport from Accra to Tamale. PHW's selling price was initially US $16.70 (GHC 152,000), but this was raised to US $20 (GHC 180,000) to try to breakeven. As a social business, PHW has a "double bottom line." Although self-sufficiency and independence from outside funding is important, the organization's other primary goal has been to reach low-income families without improved drinking supplies or safe drinking water. Because the high ceramic filter prices excluded the people PHW wanted to reach the most, they turned to a segmented market approach in Year 2, as described in the following section.

4.2.2 Year 2 Strategy

In August 2006, Elizabeth Wood, a recent Harvard graduate, and Howard Shen, a recent graduate of MIT Sloan's Leader in Manufacturing program, conducted a one-month assessment of PHW's first year and recommended major revisions to its pricing, marketing, and promotion strategy. Towards the end of the year 2006, PHW implemented this Year 2 Strategy, which included new outreach initiatives that especially targeted the poor. Two prices were set for the filter: a "retail price" for urban areas and a "rural price" for rural areas. For the retail price, PHW sells to retailers for US$ 11.10 (GHC 100,000), who then sell the filters to customers for US$ 13.30 (GHC 120,000). PHW sells filters to distributors in rural communities for US$ 5.60, and they are resold for US$ 6.70 (GHC 60,000). At these prices, PHW estimates that it could generate profit if the filters were manufactured locally for about US$ 6 (GHC 54,000).

Marketing Strategies

The Year 2 Strategy was categorized into three main areas based on the marketing approach and the target population, as follows:

1. Urban Outreach

In this outreach approach, business owners referred to as "retailers" are approached to sell filters at the "retail" price for a commission. The filters can be purchased by the retailers in installments, with the first installment being at least half the filter price and the remaining paid once the filters are sold. The retailers are trained on how to use and clean the filters, so that they can demonstrate to potential customers. They are also provided with promotional materials which include posters and pamphlets.

2. Hospital and School Outreach

The hospital outreach program is similar to the urban outreach in that filters are sold to individuals who resell them at the "retail" price and receive commission on sales made. In the hospital outreach program, the liaisons are primarily nurses who market the filters to patients that visit the hospital. In this program, free filters are also provided for each ward for the purpose of demonstration and use in the hospital. The nurses identified as retailers are responsible for cleaning and maintaining the free filters at the hospital on a voluntary basis.

In the school outreach approach, the PHW team works in collaboration with the Ghana Educational Services to reach out to schools. Identified teachers act as liaisons and give demonstrations to both school children and their fellow teachers on the use of the ceramic pot filter. The school children are asked to share information on the filter with their parents and members of their households. As in the Hospital Outreach Program, free filters are given out to each class for use and demonstrations, and they are maintained by the school liaisons.

3. Rural Outreach

This is a community level outreach approach, which involves identifying and training key opinion leaders such as chiefs, community elders, and other respected members of the rural society on use of the ceramic pot filter and providing them with free filters. The opinion leaders are expected to open their homes to their communities, show the filter in use, and allow visitors to taste and sample filtered water. Since the leaders are respected members of the society, it is expected that other members of the community will more readily consider what has already been accepted by the leader and become interested in purchasing a filter for their own family.

In the rural outreach, PHW also works with community liaisons who are generally responsible for reaching out to members of their communities by holding demonstration meetings on the use of the ceramic pot filter, distributing the filters to opinion leaders, and selling them at a subsidized price to other members of the rural communities. The liaisons earn a commission on filters sold at the subsidized price. The community liaisons also act as a link between the rural communities and PHW by obtaining user feedback information on the filter and answering questions posed by the communities.

Local Manufacturing Goal

Part of PHW's Year 2 Strategy is to manufacture its own ceramic filters in the Northern Region by December 2007 in order to reduce costs and enable the production and distribution of filters to be self-sustaining. The local manufacturing option is also expected to enhance quality control of the filter production. Other plans for the Year 2 Strategy include acquiring a vehicle to transport filters for distribution and sale.

4.3 Methods

During the household surveys described in Chapter 2.0, additional questions were asked to evaluate PHW's rural marketing strategy and find ways to improve it. The results were assessed in terms of the 4Ps framework described above.

Households without filters were asked questions about their interest in treating their water and how much they would be willing to spend on treatment. They were asked who in the family typically decides what to buy. Because of PHW's rural outreach program, respondents were asked if they were aware of ceramic filters in their village, if they had drunk water from a filter, and if so, what they thought of the filter's performance. They were also asked if they had attended the PHW village presentation.

Households with the filters were asked many questions about its purchase, its acceptability, and its operation and maintenance. Respondents were asked if they had attended a PHW village presentation, where they found out about the filter, and who decided to purchase it. They were asked how often they use the filter and whether they treat all the water the family uses for drinking. Data was also gathered on perceived health improvements. For acceptability, respondents were asked if they were happy with the technology, if it is easy to use, if they would recommend it to others, and if they have had any problems with it. For operation and maintenance, they were asked how often they clean it, whether they would buy a new one if it broke, how much they would pay for a new one, and whether their neighbors would buy one for that price.

5.0 Epidemiological Survey Results

5.1 General Results

The results from all 41 households are summarized below and shown in Table 3. Complete survey results can be found in Appendix B: General Household Survey Data and Appendix C: Water Treatment Survey Responses. Charts include arithmetic averages and standard deviations (STDV).

5.1.1 Household Information

Surveys were conducted in six traditional villages and in two modern communities. Sometimes respondents gave estimates for the number of household members since they were unsure of the exact number. The average size of all households was 12 people. Usually other wives, neighbors, and children were present during the interviews in traditional households.

Most respondents were asked to give their age, and an estimate was given when the exact age was unknown. The respondents averaged 39 years old. In general the respondents were mothers of children under five, but there were some instances when this was not possible. In the modern communities, households surveyed by Peletz (2006) were intentionally revisited. In two cases, the original respondent was not home, and another family member (niece and son) were surveyed instead. It is assumed that these respondents provided information similar to that of the original respondents. The overall average years of education of the survey respondents was 1.7 years.

An estimate of each household's average expenses was also recorded. Many figures given were rough ballpark estimates, and some women declined answering since they were not sure. The average for all households per person per month was US $8.60 (GHC 78,000).

Respondents were also asked about their sources of information, and many listed the radio, friends, and family members.

Most families used firewood and charcoal (88% and 73%, respectively). Only 22% had electricity and only 9.8% had gas.

5.1.2 Diarrheal Knowledge and Prevalence

Respondents were asked about diarrheal prevalence for family members within one week of the survey. These responses were used to determine diarrheal prevalence for households, people, and children under five, respectively. To calculate the diarrheal prevalence for all households, the number of households with at least one person with diarrhea was divided by the total number of households. The diarrheal prevalence for all people was found by dividing household members with diarrhea by the total number of members. Likewise, the prevalence for children under five was found by dividing the number of children with diarrhea by the total number of children under five. Diarrheal prevalence for people was 4.4%, for households was 37%, and for children under five was 16%. The 2003 *Ghana Demographic and Health Survey* (GDHS) for the Northern Region found that 15.3% of children under 5 had had diarrhea in the past two weeks at the time of the survey (GSS 2004). The numbers are comparable even though the GDHS used two weeks as opposed to the one week used for this work.

When respondents were asked what causes diarrhea, most answers were dirty food, water, or environment. Other responses included sweets, children teething, and dirt. After the general question, respondents were prompted if certain things caused diarrhea, and almost all said yes to each prompt. To be considered knowledgeable about diarrhea, respondents had to answer affirmatively that unclean water, food, and hygiene could cause diarrhea. Although the unprompted question usually indicated a certain level of diarrheal knowledge, the respondents could have been aiming to please the interviewer during the prompted questions. Ninety-five percent of respondents were found to be knowledgeable about diarrheal causes. Respondents typically treat diarrhea with medicines, and some go to hospitals or clinics for severe cases. Only 9.8% (4/41) of respondents cited oral rehydration salts (ORS) as a treatment method.

5.1.3 Hygiene Knowledge

Respondents were asked to give the times that they wash their hands, whether they use soap, and whether they had soap at the time of the interview. Respondents were considered to practice appropriate hand-washing if they said that they wash with soap, have soap, and wash their hands after using the toilet, before eating, and before cooking. Because no prompts were given for hand-washing, many respondents did not list all three critical hand-washing times. Many said that they wash their hands before praying or whenever they are not clean. Only 34% of the respondents were considered to practice appropriate hand-washing, compared to 86% of Peletz's respondents. This is likely due to the difference in how the question was asked and also partially due to the fact that this survey pool was comprised largely of traditional households, whereas Peletz's survey pool was comprised of equal numbers of modern and traditional households.

5.1.4 Sanitation Access

None of the traditional households and all of the modern households had access to improved sanitation facilities. The traditional households primarily used nearby outdoor areas, and one community had public ventilated and improved pit (VIP) latrines. According to the UNICEF/WHO Joint Monitoring Programme (2006), public latrines are not considered improved. All modern households surveyed used private or shared flush toilets, which are considered improved. An estimate of the time to the facility was recorded, and facilities inside homes were assigned times of zero. The average time to facility for all households was 3.8 minutes.

5.1.5 Water Access and Practices

Primary Water Sources

Primary water sources included household taps, standpipes, rainwater collection, dams, unprotected wells, and tanker trucks. Of these sources, household taps and standpipes are considered improved, and 12% of households surveyed always used an improved source. Primary sources varied significantly during the dry and wet seasons; the use of unprotected wells and rainwater collection increased and the use of dam water decreased during the wet season. None of the traditional households always used an improved water source throughout the year. Five out of six modern households always use nearby or in-home standpipes or household taps, which are considered improved. Several of the household taps only provide water 1-2 days per week, so those families must store water in large drums.

Water Collection

Respondents were asked how many trips were taken each day to collect water during the dry and wet season, and estimates of how long each trip took were recorded. Collection times averaged 70 minutes during the dry season but only 14 minutes in the wet season when sources are closer. Because times could be as great as several hours in the dry season, the number of daily trips was lower at 3.7, compared to 4.2 during the wet season. Usually women and children are responsible for water collection, but when closer sources become dry, sometimes young men travel on bikes to collect water. Figure 13 shows the primary water collectors in traditional households, and these numbers contrast with those collected by the Ghana Statistical Survey (2005) that had men spending comparable amounts of time as women collecting water.

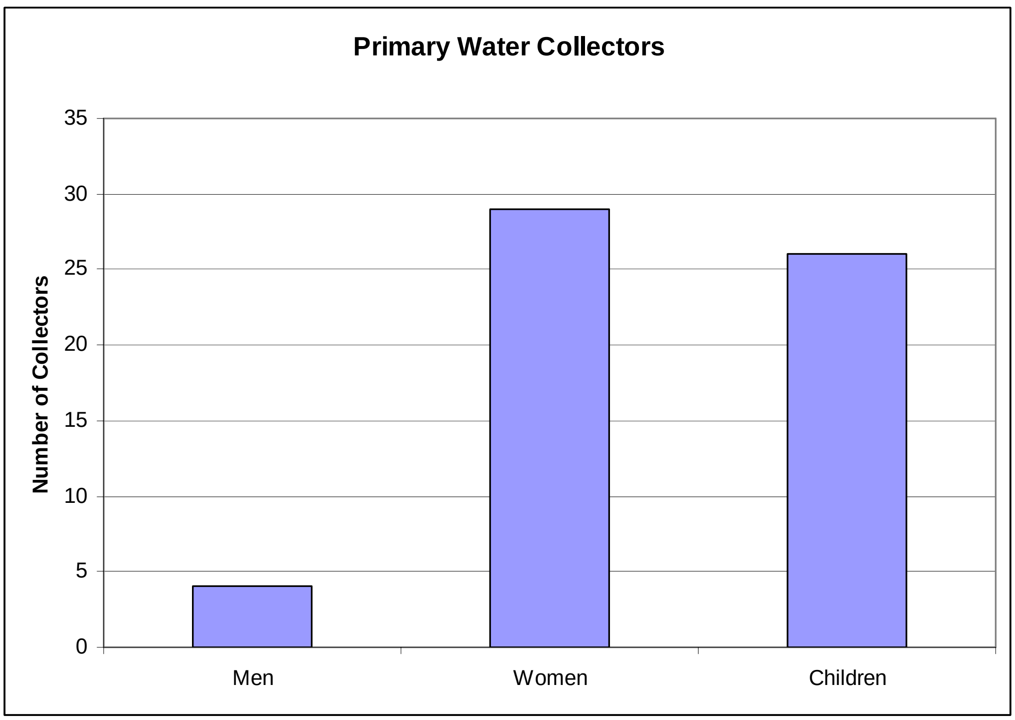


Figure 13: Primary water collectors in traditional households.

Water Sources When away from Home

When away from home, many respondents drink any water that is available to them, and some specify that they drink anything as long as it is cloth filtered. Factory-produced sachet water and hand-tied sachet water, shown below in Figure 14, are popular. Teshamulwa Okioga (2007) analyzed the use of sachet water in the Northern Region of Ghana, and readers are referred to her work for more information.

Figure 14: Factory-produced sachet water (left) and hand-tied sachet water (right) are commonly drunk by people when they are away from home.
Photo credit: Teshamulwa Okioga

Storage Containers

Many containers were used to store drinking water in households. In households that used the ceramic water filter, it ranked the highest as a storage container. More than half of the households stored water in ceramic vessels, pictured in Figure 15. Jerry cans, metal drums, plastic bottles, and cooking pots were also used. Households were considered to practice proper storage if the containers were always covered and if respondents accessed the water by pouring it, using a spigot, or using a cup with a handle. Cups without handles, such as metal cans, allow users' hands to touch the water, which could introduce contamination. One such cup is pictured in Figure 15 resting on the ceramic storage vessels. Forty-four percent of households were found to practice proper storage. However, even if the containers are covered and used correctly, they could still be contaminated if they are not cleaned properly.

Figure 15: Ceramic vessels commonly used to store water in traditional households. A cup without a handle rests on the vessels, and the vessel in the front has a cloth filter over it.

5.1.6 Household Water Treatment

Only 2 out of 41 households believed their water was safe to drink without treatment, and all households reported using some type of treatment. Eighty percent (33/41) of households surveyed treated their water with cloth filters, and 61% (25/41) of households used ceramic filters. The Guinea Worm Eradication Campaign has widely promoted the use of cloth filters to remove the copepods that carry the guinea worm vector. All but two of the 19 traditional households with ceramic filters reported using cloth filters as a preliminary step before using the ceramic filter.

5.1.7 Filter Awareness, Acceptability, and Maintenance

Non-filter users were asked several questions about their interest in using a ceramic filter, and filter users were asked about the filter's acceptability and maintenance requirements. These results are analyzed in Chapter 8.0.

Table 3: Survey Results from All Households

Communities surveyed	Traditional	35/41 = 85%	
	Shenshegu	4/41 = 9.8%	
	Taha	6/41 = 15%	
	Gbalahi	6/41 = 15%	
	Chenshegu	6/41 = 15%	
	Gbanyamni	8/41 = 20%	
	Kalariga	5/41 = 12%	
	Modern	6/41 = 15%	
	Vitin Estates	3/41 = 7.3%	
	Kamina Barracks	3/41 = 7.3%	
Household Information	Average number of people in household	12 people (STDV = 6.7)	
	Average number of children under 5	2 children (STDV=1.8)	
	Average age of respondent	39 years old (STDV=13)	
	Average number of years of education of respondent	1.7 years (STDV=4.4)	
	Average expenses per person per month	78,000 cedis (US $8.60) (STDV=53,000 (US $5.90))	
	Types of Energy Used		
	Electricity	9/41 = 22%	
	Gas	4/41 = 9.8%	
	Charcoal	30/41 = 73%	
	Firewood	36/41 = 88%	
Diarrheal Prevalence and Knowledge	Diarrheal Prevalence (people)	21/474 = 4.4%	
	Diarrheal Prevalence (households)	15/41 = 37%	
	Diarrheal Prevalence for children under 5	13/80 = 16%	
	Knowledgeable about diarrheal causes	39/41 = 95%	
Hygiene and Sanitation	Appropriate Hand-washing	14/41 = 34%	
	Adequate sanitation facility	6/41 = 15%	
	Average time to sanitation facility	3.8 minutes (STDV=3.0)	
Water Access	Primary Water source	Dry Season	Wet Season
	Household Tap	6/41 = 15%	5/41 = 12%
	Standpipe	2/41 = 4.9%	1/41 = 2.4%
	Rainwater Collection	0/41 = 0%	3/41 = 7.3%
	Dam	31/41 = 76%	20/41 = 49%
	Unprotected Well	1/41 = 2.4%	11/41 = 27%
	Tanker Truck	1/41 = 2.4%	1/41 = 2.4%
	Always using Improved Water Source	5/41 = 12%	
	Average time to Collect Water		
	Dry season	70 minutes (STDV = 66)	
	Wet season	14 minutes (STDV = 12)	
	Number of Trips to Collect Water		
	Dry Season	3.7 trips (STDV=2.3)	
	Wet Season	4.2 trips (STDV=2.7)	
	Primary water sources while traveling	Any Available, Sachet, Tied	
Water Storage	Storage containers		
	Ceramic vessels	21/41 = 51%	
	CT Filter Receptacle	22/41 = 54%	
	Jerry can	3/41 = 7.3%	
	Metal tank/drum	2/41 = 4.9%	
	Plastic bottles	2/41 = 4.9%	
	Cooking Pots	1/41 = 2.4%	
	Proper Storage	18/41 = 44%	
Water Quality Perception and Household Water Treatment	Believe water is safe without treatment	2/41 = 4.9%	
	Treatment method: some type	41/41 = 100%	
	Tamakloe	25/41 = 61%	
	Cloth	33/41 = 80%	

5.2 Comparisons using January 2007 Data

5.2.1 Comparison of Traditional and Modern Communities

Traditional and modern communities differ significantly on the surface, and the survey responses quantified these differences and highlighted less obvious ones.

Traditional households averaged thirteen people, while modern households were smaller at an average of six people. Only one respondent from a traditional household had received any education. Respondents from modern communities average ten years of education per person. The average expenses per person per month were about five times higher in modern households. Lastly, modern households had much greater access to gas and electricity than traditional households.

The small sample size of only six modern households may have affected the diarrheal prevalence results. The modern households had a higher diarrheal prevalence for households, individuals, and children over five. One respondent from a modern household noted that she and her husband had diarrhea from food poisoning, which increased the numbers significantly. Respondents from both modern and traditional communities were found to be knowledgeable about diarrhea causes.

In traditional households, 29% of respondents practiced appropriate hand-washing, compared to 67% of respondents in modern households. All modern households had adequate sanitation facilities, while none of the traditional households did.

All modern households either had a household tap or a nearby standpipe for their water source, and 83% were found to always use an improved water source. However, as previously mentioned, several taps in modern households only provided water one to two days per week. Dams were the most common water source for traditional households in both wet and dry seasons. During the wet season, unprotected wells were also common. None of the traditional households always used an improved water source. Traditional households spent a significant amount of time collecting water. During the dry season, traditional households averaged 82 minutes per trip and took an average of 4 trips per day. In the wet season, trips were shorter at an average of 16 minutes but more frequent at an average of 4.6 trips per day.

Table 4: Comparison of Traditional and Modern Communities

		Modern		Traditional	
Communities surveyed	Traditional	-		35/35 = 100%	
	Shenshegu	-		4/35 = 11%	
	Taha	-		6/35 = 17%	
	Gbalahi	-		6/35 = 17%	
	Chenshegu	-		6/35 = 17%	
	Gbanyamni	-		8/35 = 23%	
	Kalariga	-		5/35 = 14%	
	Modern	6/6 = 100%		-	
	Vitin Estates	3/6 = 50%		-	
	Kamina Barracks	3/6 = 50%		-	
	Average number of children under 5	0.67 children (STDV=0.52)		2.2 children (STDV=1.8)	
	Average age of respondent	28 years old (STDV=8)		42 years old (STDV=14)	
	Average number of years of education of respondent	10 years (STDV=6.4)		0.2 years (STDV=1.4)	
	Average expenses per person per month	270,000 cedis (US $30) (STDV=85,000 (US$ 9.40))		57,000 cedis (US $6.30) (STDV=42,000 (US$ 4.70))	
	Types of Energy Used				
	Electricity	6/6= 100%		3/35 = 8.6%	
	Gas	4/6 = 67%		0/35 = 0%	
	Charcoal	4/6 = 67%		9/35 = 26%	
	Firewood	1/6 = 17%		35/35 = 100%	
Diarrheal Prevalence and Knowledge	Diarrheal Prevalence (people)	5/36 = 14%		16/438 = 3.7%	
	Diarrheal Prevalence (households)	4/6 = 67%		11/35 = 31%	
	Diarrheal Prevalence for children under 5	1/4 = 25%		12/76 = 16%	
	Knowledgeable about diarrheal causes	6/6 = 100%		33/35 = 94%	
Hygiene and Sanitation	Appropriate Hand-washing	4/6 = 67%		10/35 = 29%	
	Adequate sanitation facility	6/6 = 100%		0/35 = 0%	
	Average time to sanitation facility	0.33 minutes (STDV=0.82)		4.4 minutes (STDV=2.8)	
Water Access	Primary Water source	Dry Season	Wet Season	Dry Season	Wet Season
	Household Tap	5/6 = 83%	5/6 =83%	1/35 = 2.8%	0/35 = 0%
	Standpipe	1/6 = 17%	1/6 =17%	1/35 = 2.8%	0/35 = 0%
	Rainwater Collection	0/6 = 0%	0/6 = 0%	0/35 = 0%	3/35 = 8.6%
	Dam	0/6 = 0%	0/6 = 0%	31/35 = 89%	20/35= 57%
	Unprotected Well	0/6 = 0%	0/6 = 0%	1/35 = 2.8%	11/35= 31%
	Tanker Truck	0/6 = 0%	0/6 = 0%	1/35 = 2.8%	1/35 = 2.8%
	Always using Improved Water Source	5/6 = 83%		0/35 = 0%	
	Average time to Collect Water				
	Dry season	1 minute (STDV=1.7)		82 minutes (STDV=64)	
	Wet season	1 minute (STDV=1.7)		16 minutes (STDV=11)	
	Number of Trips to Collect Water				
	Dry Season	1.7 trips (STDV=4.1)		4.0 trips (STDV=1.8)	
	Wet Season	1.7 trips (STDV=4.1)		4.6 trips (STDV=2.2)	
	Primary water sources while traveling	Sachet		Any Available, Tied, Sachet	
Water Storage	Storage containers				
	Ceramic vessels	0%		21/35 = 60%	
	CT Filter Receptacle	5/6 = 83%		17/35 = 49%	
	Jerry can	0%		3/35 = 8.6%	
	Metal tank/drum	0%		2/35 = 5.7%	
	Plastic bottles	2/6 = 33%		0%	
	Cooking Pots	0%		1/35 = 2.9%	
	Proper Storage	6/6 = 100%		12/35 = 34%	
Water Quality Perception and Treatment	Believe water is safe without treatment	0/6 = 0%		2/35 = 5.7%	
	Treatment method: some type	6/6 = 100%		35/35 = 100%	
	Tamakloe	6/6 = 100%		19/35 = 54%	
	Cloth	0/6 = 0%		33/35 = 94%	

5.2.2 Comparison of Traditional Households with and without Ceramic Filters

Traditional households with ceramic filters were compared to those without. Because all modern households had ceramic filters and because only six modern households were surveyed, they were not included in this comparison. Nineteen traditional households with filters are compared to 16 households without filters, and Table 5 displays the results.

The household information for families with and without filters was fairly similar. Household size, years of education, and respondent age were all comparable. Because the majority of the households with a filter purchased it, it might be expected that filter households would be wealthier and report higher monthly expenses. However, the average expenses per person per month were greater for households without a filter. The expense estimates were crude, but the numbers indicate that people living on less than US $1 per day are able to purchase the filters at PHW's rate.

The diarrheal prevalence for households, people, and children under five were all lower in houses with filters. Only 1.8% of people in households with filters had diarrhea, compared to 5.6% of people in households without filters.

Homes without filters were found to be slightly more knowledgeable about appropriate hand-washing. However, by conducting a chi-square test as described in Section 6.1.2, the results are not statistically significant at the 0.05 level. Both categories of households obtained water from similar sources and spent comparable amounts of time collecting water. The respondents with ceramic filters were more likely to drink factory-produced sachet water, as opposed to cheaper hand-tied sachet water, when away from home. This could indicate that respondents in households with filters are willing to pay more for higher-quality water.

Table 5: Comparison of Traditional Households with and without Ceramic Filters

		With Ceramic Filter		Without Ceramic Filter	
Communities surveyed	Traditional	19/35 = 54%		16/35 = 46%	
	Shenshegu	3/4 = 75%		1/4 = 25%	
	Taha	3/6 = 50%		3/6 = 50%	
	Gbalahi	3/6 = 50%		3/6 = 50%	
	Chenshegu	3/6 = 50%		3/6 = 50%	
	Gbanyamni	4/8 = 50%		4/8 = 50%	
	Kalariga	3/5 = 60%		2/5 = 40%	
Household Information	Average number of people in household	12 people (STDV=7.6)		13 people (STDV=5.6)	
	Average number of children under 5	1.7 children (STDV=1.6)		2.8 children (STDV=2.0)	
	Average age of respondent	44 years old (STDV=12)		38 years old (STDV=15)	
	Average number of years of education of respondent	0 years (STDV=0)		0.5 years (STDV=2)	
	Average expenses per person per month	50,000 cedis (US $5.50) (STDV=41,000 (US$ 4.50))		68,000 cedis (US $7.60) (STDV=40,000 (US$ 4.50))	
	Types of Energy Used				
	Electricity	3/19 = 16%		0/0 = 0%	
	Gas	0/0 = 0%		0/0 = 0%	
	Charcoal	14/19 = 74%		12/16 = 75%	
	Firewood	19/19 = 100%		16/16 = 100%	
Diarrheal Prevalence and Knowledge	Diarrheal Prevalence (people)	4/223 = 1.8%		12/215 = 5.6%	
	Diarrheal Prevalence (households)	4/19 = 21%		7/16 = 37%	
	Diarrheal Prevalence for children under 5	4/32 = 13%		8/44 = 18%	
	Knowledgeable about diarrheal causes	18/19 = 95%		15/16 = 94%	
Hygiene and Sanitation	Appropriate Hand-washing	4/19 = 21%		6/16 = 38%	
	Adequate sanitation facility	0/19 = 0%		0/16 = 0%	
	Average time to sanitation facility	3.8 minutes (STDV=1.8)		5.2 minutes (STDV=3.6)	
Water Access	Primary Water source	Dry Season	Wet Season	Dry Season	Wet Season
	Household Tap	0%	0%	1/16 = 6.3%	0%
	Standpipe	1/19 = 5.3%	0%	0%	0%
	Rainwater Collection	0%	2/19 = 11%	0%	1/16 = 6.3%
	Dam	16/19 = 85%	10/19 = 53%	15/16 = 94%	10/16 = 63%
	Unprotected Well	1/19 = 5.3%	6/19 = 32%	0%	5/16 = 31%
	Tanker Truck	1/19 = 5.3%	1/19 = 5.3%	0%	0%
	Always using Improved Water Source	0/19 = 0%		0/16 = 0%	
	Average time to Collect Water				
	Dry season	93 minutes (STDV=75)		70 minutes (STDV=48)	
	Wet season	18 minutes (STDV=10)		14 minutes (STDV=13)	
	Number of Trips to Collect Water				
	Dry Season	4.0 trips (STDV=2.0)		4.0 trips (STDV=1.5)	
	Wet Season	4.1 trips (STDV=2.2)		5.3 trips (STDV=2.2)	
	Primary water sources while traveling	Tied, Sachet		Tied, Any Available	
Water Storage	Storage containers				
	Ceramic vessels	5/19 = 26%		16/16 = 100%	
	CT Filter Receptacle	17/19 = 89%		0/16 = 0%	
	Jerry can	3/19 = 16%		1/16 = 6.3%	
	Metal tank/drum	2/19 = 11%		0/16 = 0%	
	Plastic bottles	0/19 = 0%		0/16 = 0%	
	Cooking Pots	0/19 = 0%		1/16 = 6.3%	
	Proper Storage	12/19 = 63%		0/16 = 0%	
Water Quality Perception and Treatment	Believe water is safe without treatment	0/19 = 0%		2/16 = 13%	
	Treatment method: some type	19/19 = 100%		16/16 = 100%	
	Tamakloe	19/19 = 100%		0/16 = 0%	
	Cloth	17/19 = 89%		16/16 = 100%	

5.3 Comparisons Using Peletz's Data

5.3.1 Comparison of Modern Communities interviewed by both Peletz and Johnson

Households with ceramic filters visited by Peletz in January 2006 were revisited in January 2007. All of these households were in modern communities, and in two cases a family member was interviewed instead of the original respondent. Although most results were similar, a few were significantly different. The average expenses per person per month were much higher in Peletz's results. In 2007, respondents were asked for an estimate of monthly expenses, whereas Peletz asked for expenses for several different categories, like transportation and food, and then summed them together. Her method was likely more precise. Also, the diarrhea prevalence was much higher in 2007. Fourteen percent of all people in the households had diarrhea in 2007, compared to 5.6% in 2006. The small sample size allows these large variations. Households reported much higher water collection times to Peletz than to Johnson.

Table 6: Comparison of 6 Modern Communities Interviewed by Peletz (2006) and Johnson (2007)

	Johnson		Peletz	
Modern	6/6 = 100%		6/6 = 100%	
Vitin Estates	3/6 = 50%		3/6 = 50%	
Kamina Barracks	3/6 = 50%		3/6 = 50%	
Average number of people in household	6 people		6 people	
Average number of children under 5	0.67 children		1.2 children	
Average age of respondent	28 years old		32 years old	
Average number of years of education of respondent	10 years		11 years	
Average expenses per person per month	270,000 cedis (US $30)		470,000 (US $52)	
Diarrheal Prevalence (people)	5/36 = 14%		2/36 = 5.6%	
Diarrheal Prevalence (households)	4/6 = 67%		2/6 = 33%	
Diarrheal Prevalence for children under 5	1/4 = 35%		1/7 = 14%	
Knowledgeable about diarrheal causes	6/6 = 100%		4/6 = 67%	
Appropriate Hand-washing	4/6 = 67%		5/6 = 83%	
Adequate sanitation facility	6/6 = 100%		6/6 = 100%	
Average time to sanitation facility	0.33 minutes		0 minutes	
Primary Water source	Dry Season	Wet Season	Dry Season	Wet Season
Household Tap	5/6 = 83%	5/6 = 83%	6/6 = 100%	6/6 = 100%
Standpipe	1/6 = 17%	1/6 = 17%	-	-
Always using Improved Water Source	5/6 = 83%		4/6 = 67%	
Average time to Collect Water				
Dry season	1 minute		38 minutes	
Wet season	1 minute		15 minutes	
Primary water sources while traveling	Sachet		Sachet	
Proper Storage	6/6 = 100%		6/6 = 100%	
Believe water is safe without treatment	0/6 = 0%		1/6 = 17%	
Treatment method: some type	6/6 = 100%		6/6 = 100%	
Tamakloe	6/6 = 100%		6/6 = 100%	

5.3.2 Comparison of Traditional and Modern Communities

In Section 5.2.1, the author's data was used to compare traditional and modern communities. Table 7 below makes the same comparison with Peletz's data included. The author's data for modern households was not included to avoid including the same households twice. Twenty-two modern households are compared to 63 traditional households.

Traditional households were much larger at an average of 17 people compared to five people in modern households. Only one respondent out of 63 traditional households had received any education. Respondents in modern households averaged 12 years of education. The expenses per person per month were eight times greater in modern households than traditional households.

Diarrhea prevalence was much greater in traditional households, as shown in Figure 16 and Figure 17. Only 5% of modern households reported at least one member with diarrhea, while 46% of traditional household did. A higher percentage of traditional households were deemed knowledgeable about diarrheal causes (95% versus 68%, respectively). However, more modern households were considered to practice adequate hand-washing (86% versus 54%, respectively). Much higher percentages of modern households had adequate sanitation and access improved water supplies. Traditional households spent much more time collecting water and were more likely to drink unsafe water when away from home.

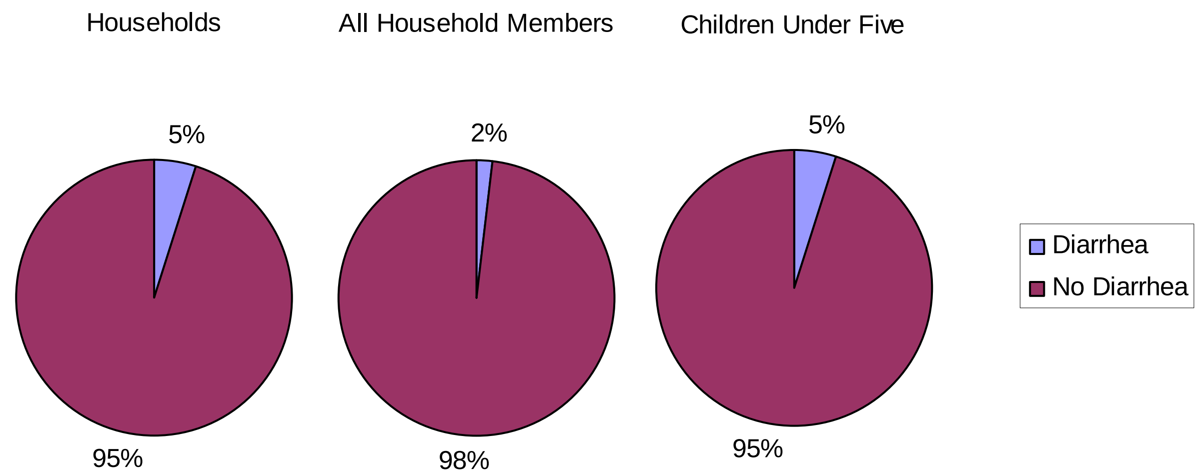


Figure 16: Diarrheal Prevalence for Modern Households

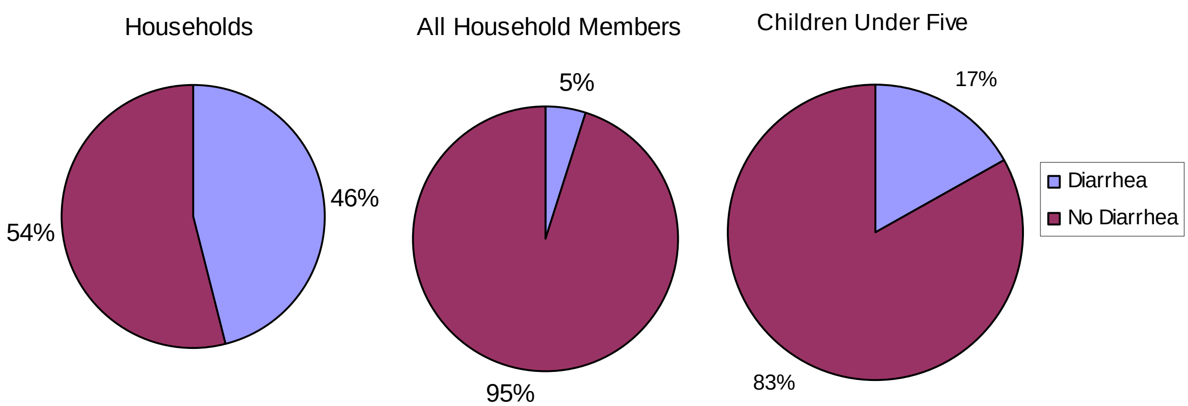


Figure 17: Diarrheal Prevalence for Traditional Households.

Table 7: Comparison of Modern and Traditional Communities

		Modern	Traditional
Communities surveyed	Traditional	-	63/63 = 100%
	Shenshegu	-	4/63 = 6.3%
	Taha	-	6/63 = 9.5%
	Gbalahi	-	6/63 = 9.5%
	Chenshegu	-	6/63 = 9.5%
	Gbanyamni	-	6/63 = 9.5%
	Kalariga	-	12/63 = 19%
	Diare		7/63 = 11%
	Bunglung		7/63 = 11%
	Libga		8/63 = 13%
	Modern	22/22 = 100%	-
	Vitin Estates	6/22 = 27%	-
	Kamina Barracks	10/22 = 45%	-
	Jisonayili	6/22 = 27%	
Household Information	Average number of people in household	5 people	17 people
	Average number of children under 5	1 child	2.6 children
	Average age of respondent	32 years old	40 years old
	Average number of years of education of respondent	12 years	0.1 years
	Average expenses per person per month	500,000 cedis (US $56)	63,000 cedis (US $7)
Diarrheal Prevalence and Knowledge	Diarrheal Prevalence (people)	2/119 = 2%	53/1043 = 5.1%
	Diarrheal Prevalence (households)	1/22 = 5%	29/63 = 46%
	Diarrheal Prevalence for children under 5	1/21 = 5%	28/164 = 17%
	Knowledgeable about diarrheal causes	15/22 = 68%	60/63 = 95%
Hygiene and Sanitation	Appropriate Hand-washing	19/22 = 86%	34/63 = 54%
	Adequate sanitation facility	21/22 = 95%	2/63 = 3.2%
	Average time to sanitation facility	Under 1 minute	5.6 minutes
Water Use Practices	Always using Improved Water Source	18/22 = 82%	14/63 = 22%
	Average time to Collect Water		
	Dry season	13 minutes	62 minutes
	Wet season	5 minutes	15 minutes
	Primary water sources while traveling	Sachet	Any Available, Tied
Water Storage	Proper Storage	21/22 = 95%	23/63 = 37%
Water Quality Perception and Household Water Treatment	Believe water is safe without treatment	10/22 = 45%	30/63 = 48%
	Treatment method: some type	15/22 = 68%	61/63 = 97%
	Tamakloe	8/22 = 36%	19/63 = 30%
	Nnsupa	3/22 = 14%	0/63 = 0%
	Cloth	3/22 = 14%	58/63 = 92%
	Boiling	0/22 = 0%	1/63 = 1.6%
	Settling	4/22 = 18%	1/63 = 1.6%
	Glucose	1/22 = 5%	0/63 = 0%
	Alum	0/22 = 0%	1/63 = 1.6%

5.3.3 Comparison of Households with and without Diarrheal Illness

A comparison between households with and without diarrheal illness was done using Peletz's data on traditional and modern households and the author's data on traditional households. The author's data on modern households was excluded to avoid double-counting the same households. Thirty households with diarrhea are compared to 55 households without diarrhea in Table 8.

Most of the households with diarrheal illness were traditional ones. The family size and number of children under five were much higher in households with diarrhea compared to households without diarrhea. Both groups, those with and without diarrhea, were similar in their knowledge about diarrheal causes and the practice of adequate hand-washing. The households with diarrheal illness were much less likely to use an improved water source or to have an adequate sanitation facility.

Table 8: Comparison of Households with and without Diarrheal Illness

		Diarrheal Illness	No Diarrheal Illness
Communities surveyed	Traditional	29/30 = 97%	34/55 = 62%
	Shenshegu	2/30 = 6.7%	2/55 = 3.6%
	Taha	4/30 =13%	2/55 = 3.6%
	Gbalahi	3/30 = 10%	3/55 = 5.5%
	Chenshegu	0/30 = 0%	6/55 = 11%
	Gbanyamni	1/30 = 3.3%	7/55 = 13%
	Kalariga	5/30 = 17%	6/55 = 11%
	Diare	4/30 = 13%	3/55 = 5.5%
	Bunglung	4/30 = 13%	3/55 = 5.5%
	Libga	6/30 = 20%	2/55 = 3.6%
	Modern	1/30 = 3.3%	21/55 = 38%
	Vitin Estates	0/30 = 0%	6/55 = 11%
	Kamina Barracks	1/30 = 3.3%	9/55 = 16%
	Jisonayili	0/30 = 0%	6/55 = 11%
Household Information	Average number of people in household	18 people	12 people
	Average number of children under 5	2.9 children	1.4 children
	Average age of respondent	39 years old	37 years old
	Average number of years of education of respondent	0.6 years	4.5 years
	Average expenses per person per month	79,000 cedis (US $8.80)	230,000 (US $25)
Diarrheal Prevalence and Knowledge	Diarrheal Prevalence (people)	55/538 = 10%	0/624 = 0%
	Diarrheal Prevalence (households)	30/30 = 100%	0/55 = 0%
	Diarrheal Prevalence for children under 5	29/95 = 31%	0/90 = 0%
	Knowledgeable about diarrheal causes	26/30 = 87%	49/55 = 89%
Hygiene and Sanitation	Appropriate Hand-washing	19/30 = 63%	34/55 = 62%
	Adequate sanitation facility	2/30 = 6.7%	21/55 = 38%
	Average time to sanitation facility	6.4 minutes	3.4 minutes
Water Use Practices	Always using Improved Water Source	9/30 = 30%	23/55 = 42%
	Average time to Collect Water		
	Dry season	44 minutes	52 minutes
	Wet season	12 minutes	13 minutes
	Primary water sources while traveling	Tied, Any Available	Sachet, Tied, Any Available
Water Storage	Proper Storage	9/30 = 30%	35/55 = 64%
Water Quality Perception and Household Water Treatment	Believe water is safe without treatment	21/30 = 70%	19/55 = 35%
	Treatment method: some type	27/30 = 90%	48/55 = 87%
	Tamakloe	5/30 = 17%	22/55 = 40%
	Nnsupa	0/30 = 0%	3/55 = 5.5%
	Cloth	25/30 = 83%	35/55 = 64%
	Boiling	1/30 = 3.3%	0/55 = 0%
	Settling	1/30 = 3.3%	4/55 = 7.3%
	Glucose	0/30 = 0%	1/55 = 1.8%
	Alum	1/30 = 3.3%	0/55 = 0%

5.3.4 Comparison of Peletz and Johnson Data to Ghana Statistical Service Data

Peletz (2006) created the following table to compare her survey data to that of the Ghana Statistical Service (GSS), and the author's data has been added for further comparison. The difference in the types of communities surveyed partly accounts for the differences. For instance, because Johnson's survey pool was mostly traditional households, her average household size was larger. Variations in definitions of the factors also led to the differences. For instance, to determine if households practice appropriate hand-washing, the GSS confirms that households have soap. Peletz and Johnson, however, asked if respondents washed their hands at appropriate times and if they had soap, but they did not confirm that soap was actually in the household. Also, the GSS defines diarrheal prevalence by the number of people with diarrhea in the two weeks preceding the survey, while Johnson and Peletz defined it as the number of people with diarrhea in one week preceding the survey.

Table 9: Comparison of Peletz and Johnson Data to Ghana Statistical Service Data

		Tamale			Northern Region
		Peletz Survey Data	Johnson Survey Data	GSS Data*	GSS Data*
Communities Surveyed	Traditional/Rural	21%	85%	33%	
	Modern/Urban	79%	15%	67%	
Household Information	Average household size	7 people	12 people	6.5 people	
	Female population with no education	21%	88%	59%	
Diarrheal Prevalence	Diarrheal Prevalence for children under 5	13%	16%		15.30%**
Hygiene and Sanitation	Appropriate Hand-washing	86%	34%		37.6%***
	Adequate sanitation facility	79%	15%	64.4% have facilities, 13.6% have improved facilities	
Water Use Practices	Tap	79%	15%	33.20%	
	Standpipe	21%	5%	45.60%	
	Borehole	0%	0%	0.60%	
	Dam/surface	0%	76%	14.10%	
	Tanker	0%	2%	3.90%	
	Well	0%	2%	1.70%	
	Spring/rain	0%	0%	0.20%	
	Always Using Improved Water Source	64%	12%	79.60%	

* Ghana Statistical Service, 2005
** Diarrhea prevalence within 2 weeks of the survey
***Have hand-washing materials available

6.0 Analysis of Epidemiology Survey Results

6.1 Analysis Methodology

Peletz (2006) conducted a relative risk analysis using her epidemiological survey data and her water quality data in order to understand connections between certain exposures and outcomes. Diarrheal illness was used for the outcome, and exposure factors included use of PHW products, type of community, sanitation access, and drinking water quality. For each analysis, she calculated an odds ratio and used the chi-square test to determine statistical significance. This same procedure was conducted by the author so that Peletz's results could be combined and compared with those in this thesis. Peletz organized the observed data in tables, as shown in Table 10, in order to calculate the odds ratio and the chi-square value.

Table 10: Observed data tabulated for the analysis.

	Disease	No Disease
Exposure	a	b
No Exposure	c	d

6.1.1 Odds Ratio

An odds ratio (OR) compares the odds of an event occurring in one group to the odds of occurrence in a second group. If the odds ratio equals one, then the outcome is just as likely in both groups. The event is more likely in the first group if the odds ratio is greater than 1 and is less likely in the first group if the odds ratio is less than one. The odds ratio was used to determine the relationship between diarrheal illness and various exposure factors. It is defined as:

$$OR = \frac{(a \times d)}{(c \times b)}$$

6.1.2 Chi-Square Test

The chi-square test was used to determine if the two factors analyzed had significantly different outcomes or not. The chi-square value was determined using the following equation:

$$X^2 = \sum \frac{(O-E)^2}{E}$$

where O is the observed outcome and E is the expected outcome. The expected outcome was found by multiplying a cell's row total by the cell's column total and then dividing by the total of all observations, as shown in Table 11 below. For the chi-square test to be valid, the expected outcome in a 2x2 table should not be less than five. Because of this restriction, it was not possible to look at modern households alone using just the author's data from 2007. Chi-square values from each outcome and exposure pair were then summed.

Table 11: Expected Outcome Calculation Method

	Disease	No Disease
Exposure	(a+b)(a+c)/(a+b+c+d)	(a+b)(b+d)/(a+b+c+d)
No Exposure	(c+d)(a+c)/(a+b+c+d)	(c+d)(b+d)/(a+b+c+d)

Once the chi-square value was obtained, the p-value was found to see if the results were significant enough to allow for the rejection of the null hypothesis. To do this, first the degrees of freedom were determined. A table's degrees of freedom (df) equals:

$$df = (r-1)(c-1)$$

where r is the number of rows and c is the number of columns in the table. All tables in this section are 2x2, so df = (2-1)(2-1) = 1. Then a chart was used to pinpoint a p-value based on the chi-square test and the degree of freedom. Significance is more likely if the relationship is strong and if the data set is large. For one degree of freedom, typical p-values and chi-square values are shown below. Results were considered statistically significant if the p-value was less than 0.05, which corresponds to a chi-square value of 3.84.

Table 12: Correlation of chi-square values and p-values for a table with 1 degree of freedom (Fischer 1974).

Chi-square value	p-value
0.004	0.95
0.02	0.9
0.06	0.8
0.15	0.7
0.46	0.5
1.07	0.3
1.64	0.2
2.71	0.1
3.84	0.05
6.64	0.01
10.83	0.001

6.2 Relationship between Exposure Factors and Diarrheal Illness

The subsequent sections determine the relative risk relationship between various exposure factors and diarrheal illness. First the analyses use data from traditional households visited by the author in January 2007, and then comparisons are made using Peletz's data from 2006. If Peletz did not conduct the same analysis, then a comparison was not made. The data from Peletz includes both modern and traditional households, and some households used filters other than the *Kosim* filter. Two of the comparisons between filter use and diarrheal prevalence were found to be statistically significant; however, other results were not found to be statistically significant, which is due, in part, to the small sample size.

6.2.1 Filters and Diarrheal Illness in Traditional Households

Johnson's Data

The relationship between household diarrhea prevalence and household filter ownership was examined for the traditional households. The odds ratio in this case is (4x9)/(7x15) = 0.34. Households without the filter are only 34% as likely (or 66% less likely) to have diarrheal illness as households without the filters. However, a chi-square value of 2.08 gives a p-value of 0.15.

These results **are not statistically significant** at the 0.05 level since 15% of the time this relationship occurs by chance.

Table 13: Filters and Household Diarrheal Prevalence (Johnson data)

	Diarrhea	No Diarrhea
Filter	4	15
No Filter	7	9

OR = 34%
$X^2 = 2.08$
p-value = 0.15

Peletz and Johnson's Data
With the data combined, there is a stronger connection between filter use and household diarrheal prevalence. Households with filters are 76% less likely to have a member with diarrhea than households without a filter. The p-value is 0.008 which indicates that the relationship **is statistically significant**. This increased difference in diarrheal prevalence may be caused in part by the fact that all of Peletz's filter users were from modern households, which typically have fewer exposure factors than traditional households. The larger data set also helps make the results more statistically significant.

Table 14: Filters and Household Diarrheal Prevalence (Combined Data)

	Diarrhea	No Diarrhea
Filter	5	25
No Filter	25	30

OR = 24%
$X^2 = 7.04$
p-value = 0.008

6.2.2 Filters and Diarrheal Illness for All People in Traditional Households.

Johnson's Data
Another analysis was done to find the relationship between filters and diarrheal illness for all people in the traditional households. The odds ratio (OR) was 31%, which indicates that people living in households without the filters are about three times as likely to have diarrhea as those living in households with the filters. With a chi-squared value of 4.46, the p-value is 0.035. Therefore, the results **are statistically significant** at the 0.05 level.

Table 15: Filters and Diarrheal Prevalence for All People

	Diarrhea	No Diarrhea
Filter	4	219
No Filter	12	203

OR = 31%
$X^2 = 4.46$
p-value = 0.035

6.2.3 Filters and Diarrheal Illness in Children under Five in Traditional Households

Johnson's Data

The relationship between diarrheal illness in children under 5 and household filter ownership is examined. The odds ratio (OR) is 64%, which means that children in households with the filters are 36% less likely to have diarrhea than children in households without filters. The chi-square value of 0.450 gives a p-value of 0.50, which indicates that the results **are not statistically significant**. Half of the time chance accounts for the difference in diarrhea prevalence for children in households with and without the filters.

Table 16: Filters and Diarrheal Prevalence for Children Under 5

	Diarrhea	No Diarrhea
Filters	4	28
No Filters	8	36

OR = 64%

$X^2 = 0.450$

p-value = 0.50

Peletz and Johnson's Data

The odds ratio with the data combined is 67%, so children in households with the filters are 33% less likely to have diarrhea than children in households without filters. However, with a p-value of 44%, this result **is not statistically significant**.

Table 17: Filters and Diarrheal Prevalence for Children Under 5

	Diarrhea	No Diarrhea
Filters	5	37
No Filters	24	119

OR = 67%

$X^2 = 0.585$

p-value = 0.44

6.3 Diarrheal Illness and Water Testing Results

Johnson's Data

The relationship between household diarrheal illness and water quality was analyzed using data from both traditional and modern households. The following table uses January 2007 data and displays the frequency of diarrhea for households with and without H_2S bacteria in their drinking water sample. Households that tested positive for the presence of H_2S bacteria were 1.6 times as likely to have diarrhea. However, with a chi-square value of 0.504, the p-value is 0.48 which means the results **are not statistically significant** at the 0.05 level.

Table 18: H_2S Bacteria and Household Diarrheal Prevalence (2007 data)

	Diarrhea	No Diarrhea
H_2S Bacteria Present	7	10
H_2S Bacteria Not Present	6	14

OR = 160%
$X^2 = 0.504$
p-value = 0.48

Peletz and Johnson's Data

These numbers were combined with those from Peletz's 2006 results to create Table 19 below. The odds ratio (OR) was 179%, indicating that households with H_2S bacteria in their drinking water were 1.8 times as likely to have diarrhea than households without H_2S bacteria in their drinking water. However, the chi-square value was 1.71, which gives a p-value of 0.19. These results **are not statistically significant** since 19% of the time the difference occurs because of chance alone.

Table 19: H2S Bacteria and Household Diarrheal Prevalence (2006 and 2007 data)

	Diarrhea	No Diarrhea
H_2S Bacteria Present	17	19
H_2S Bacteria Not Present	17	34

OR = 180%
$X^2 = 1.71$
p-value = 0.19

7.0 Water Quality Results and Analysis

7.1 Summary of Results

Water quality tests were conducted to assess the effectiveness of the ceramic pot filters in the field. Source water samples and filtered samples were collected and tested for total coliforms, *E. coli*, hydrogen sulfide-producing bacteria, and turbidity. The results for three bacterial tests and for turbidity are summarized below in Table 20 for traditional and modern communities.

Table 20: Summary of Water Quality Test Results

Traditional Communities		Source Water	Filtered Water	Percent Removal for Paired Samples
Membrane Filtration	Average *E. Coli* CFU/100mL	690	2.5	99.70%
	Average Total Coliform CFU/100mL	23,000	170	99.40%
3M Petrifilm (25 samples)	Average *E. Coli* CFU/100mL	330	0	100%
	Average Total Coliform CFU/100mL	5700	180 or 810*	94%
Hydrogen Sulfide Bacteria Presence/Absence	Positive for H2S Bacteria	97% (30/31)	13% (2/16)	85% (13/15)
	Negative for H2S Bacteria	3.2% (1/31)	88% (14/16)	
Turbidity	Average NTUs	190 (33 samples)	11 (19 samples)	92%

Modern Communities		Source Water	Filtered Water	Percent Removal for Paired Samples
Membrane Filtration	Average *E. Coli* CFU/100mL	1.4	0.21	85%
	Average Total Coliform CFU/100mL	1500	150	90%
3M Petrifilm (7 samples)	Average *E. Coli* CFU/100mL	0	0	n/a
	Average Total Coliform CFU/100mL	440	57	78%
Hydrogen Sulfide Bacteria Presence/Absence	Positive for H2S Bacteria	29% (2/7)	0% (0/7)	100% (1/1)
	Negative for H2S Bacteria	71% (5/7)	100% (7/7)	
Turbidity	Average NTUs	4.5 (7 samples)	1.4 (7 samples)	68%

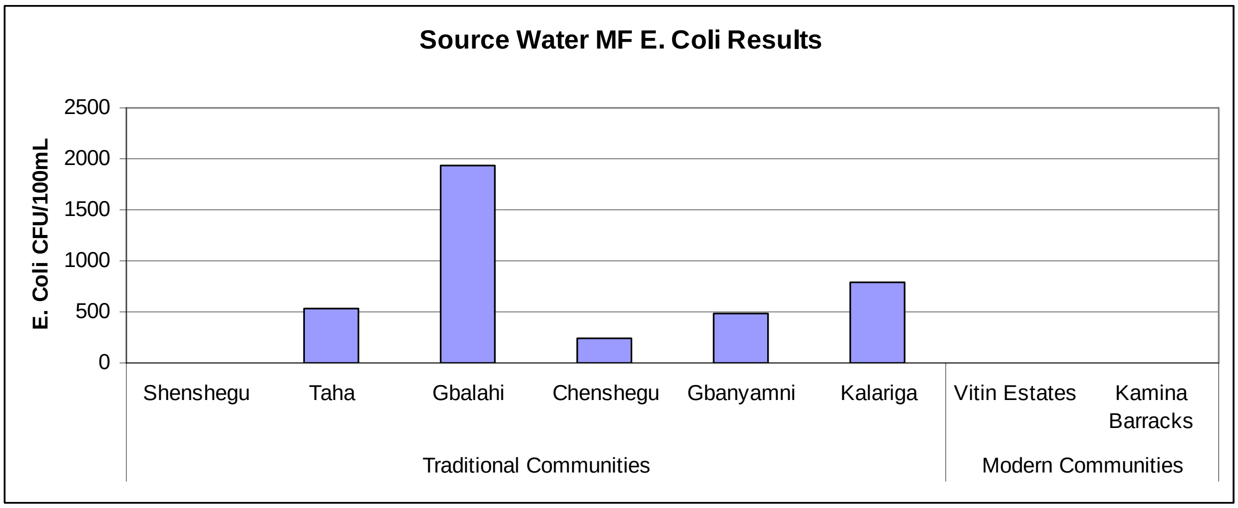
*The 180 average excludes one anomaly that may have been due to sample mislabeling.

7.2 Membrane Filtration Test Results

Membrane filtration tests were conducted on each surveyed household's source water and filtered water samples. According to Millipore's *Water Microbiology: Laboratory and Field Procedures* manual, the target number of total coliforms is 20-80 per plate, and the total number of organisms must not exceed 200 CFU per plate. The target number was not always achieved, and the following results do not include data where the total coliform CFU counts exceeded 200 per plate.

7.2.1 Source Water Membrane Filtration Results

The quality of source water varied greatly. Average *E. coli* and total coliform counts for each community are shown below in Figure 18 and Figure 19. Shenshegu, Vitin Estates, and Kamina Barracks had the highest-quality source water.



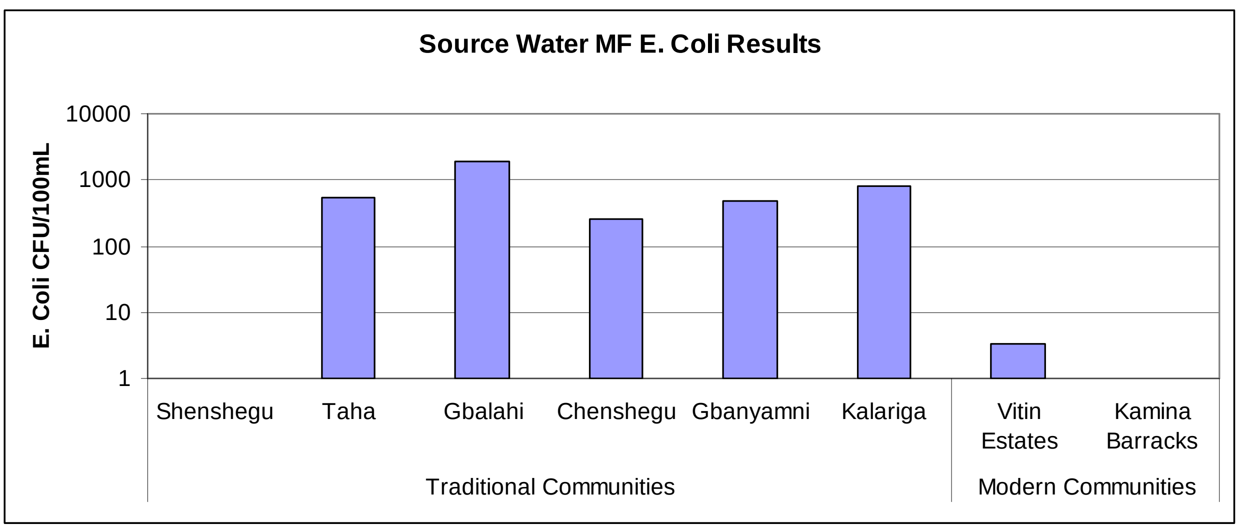


Figure 18: Average *E. coli* counts for source water in each community. The graphs show the same data, but the y-axis is log-scale in the bottom graph.

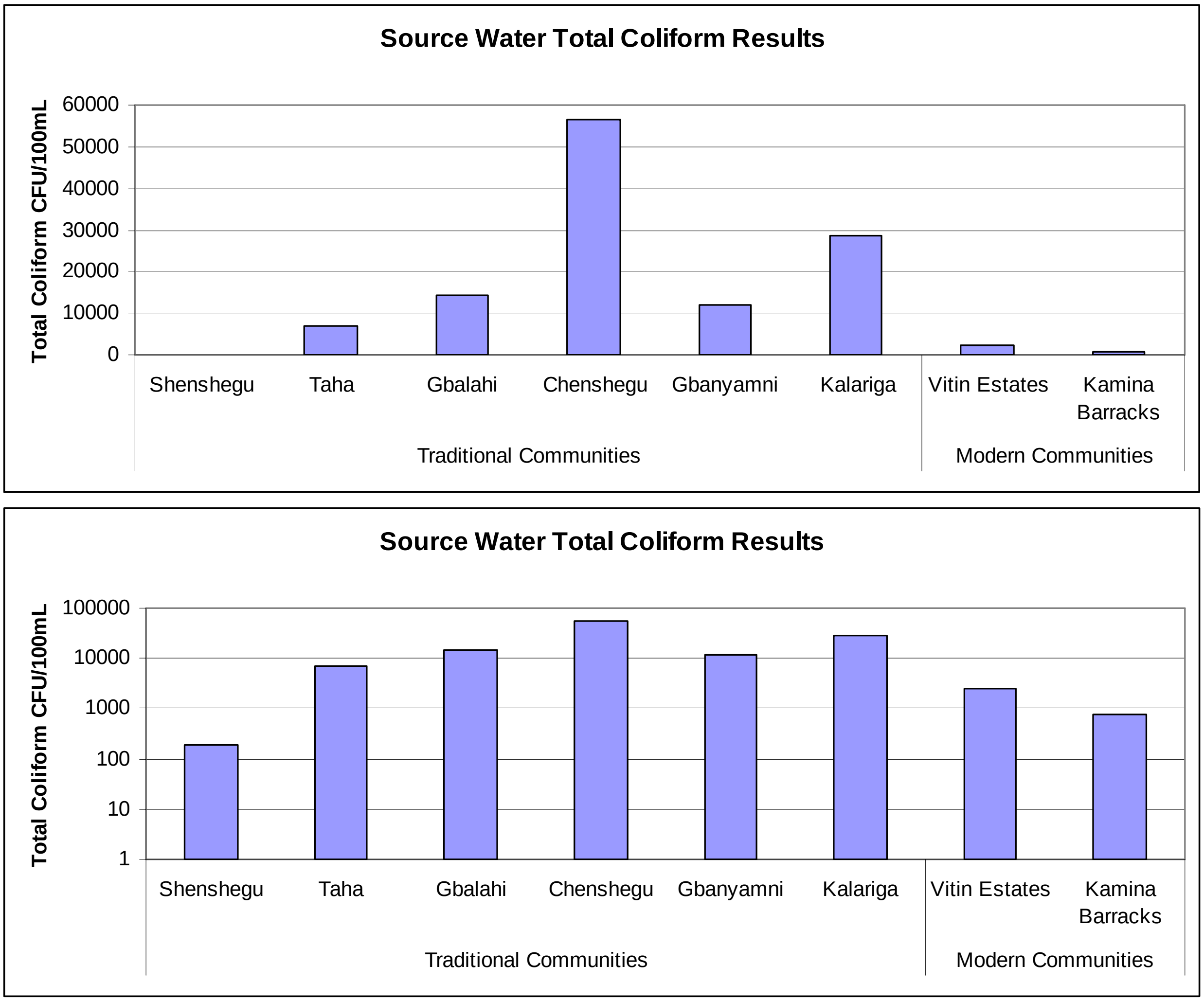


Figure 19: Average total coliform counts for source water in each community. The graphs show the same data, but the y-axis is log-scale in the bottom graph.

7.2.2 Filtered Water Membrane Filtration Results

Overall, filtered water had much lower *E. coli* and total coliform counts than source water, and the results are shown below in Figure 20 and Figure 21.

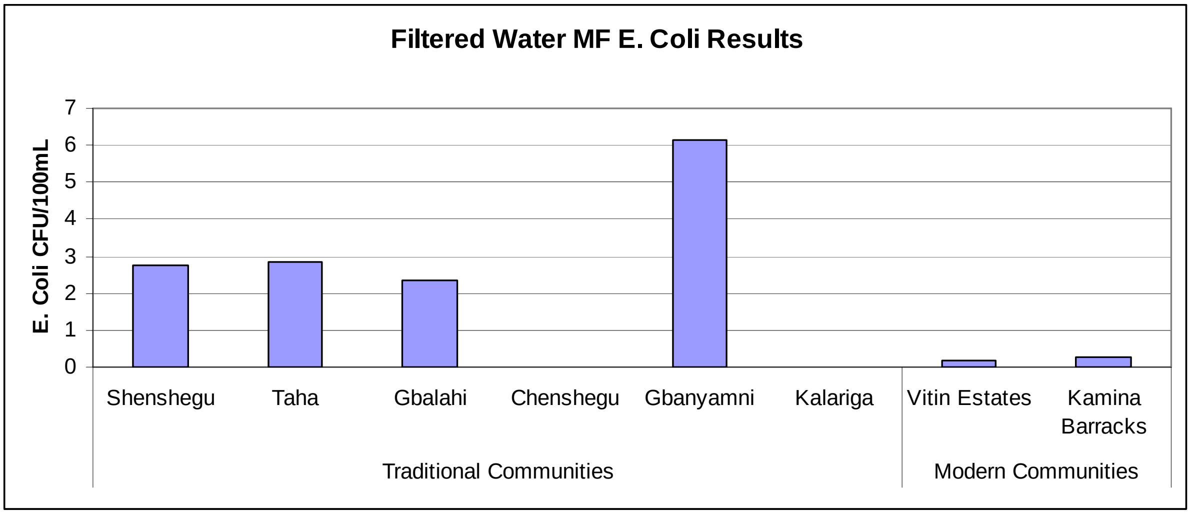
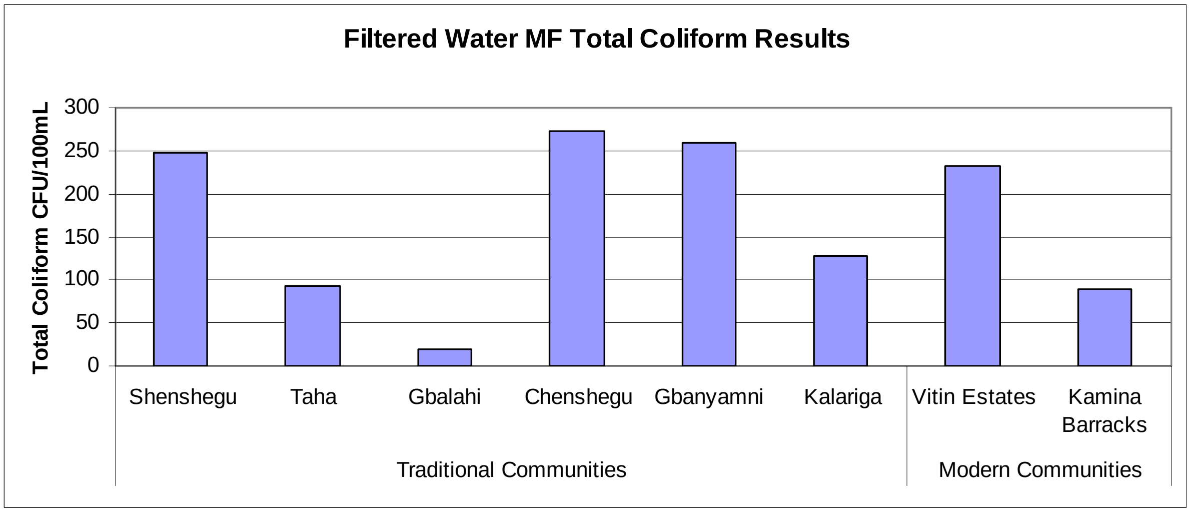


Figure 20: Average *E. coli* counts in filtered water for each community.



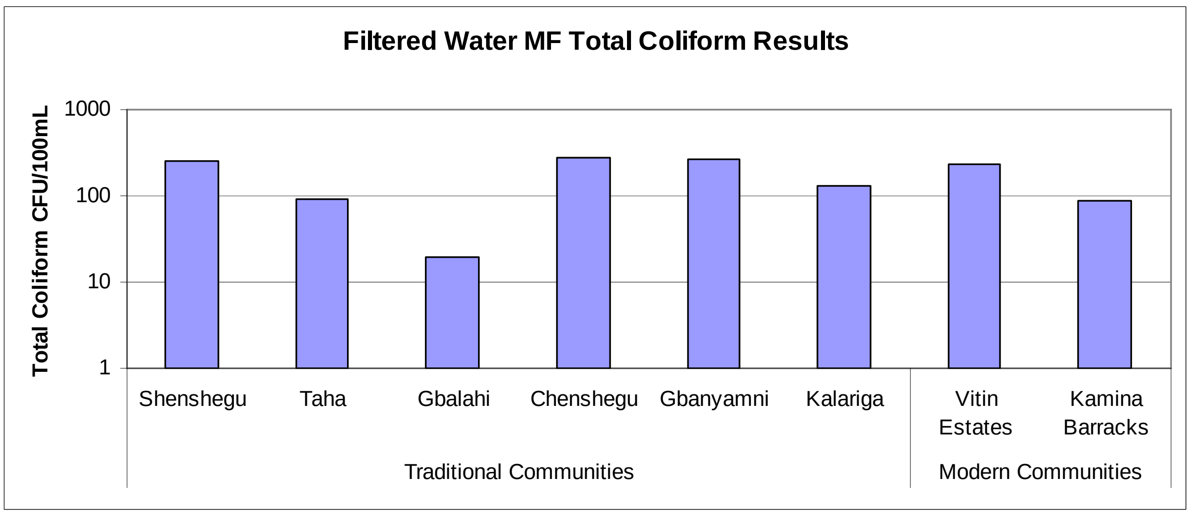


Figure 21: Average total coliform counts for filtered water in each community. The graphs show the same data, but the y-axis is log-scale in the bottom graph.

In traditional households the average percent removal for paired samples was 99.7% for *E. coli* and 99.4% for total coliform. In modern households, removal rates were 85% for *E. coli* and 90% for total coliform. Figure 22 and Figure 23 show *E. coli* and total coliform averages for paired samples for each community.

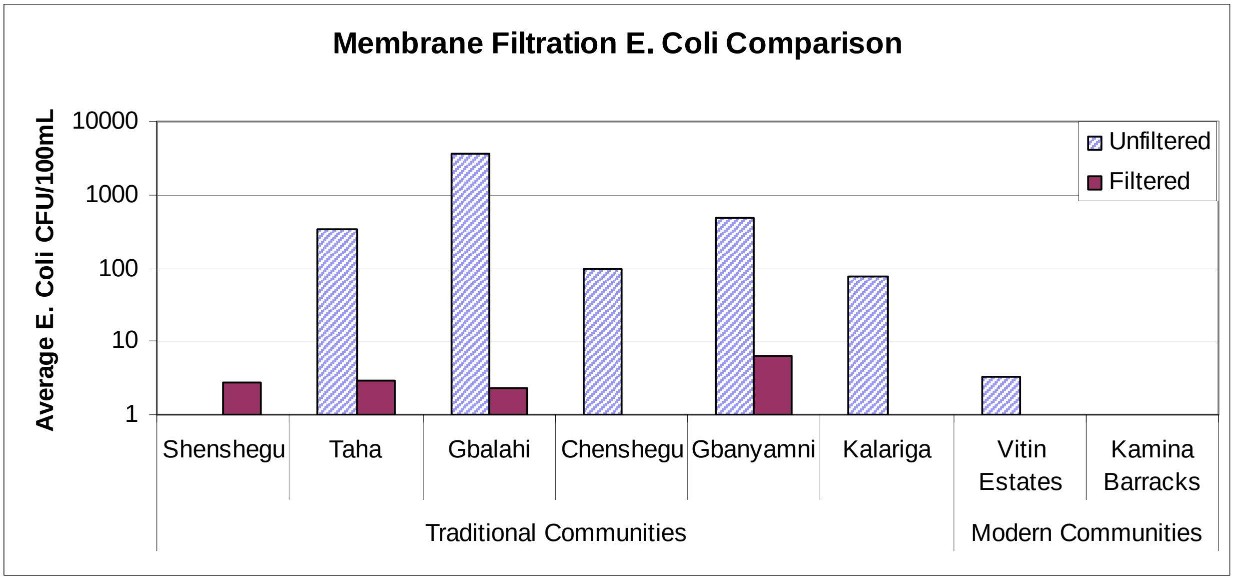
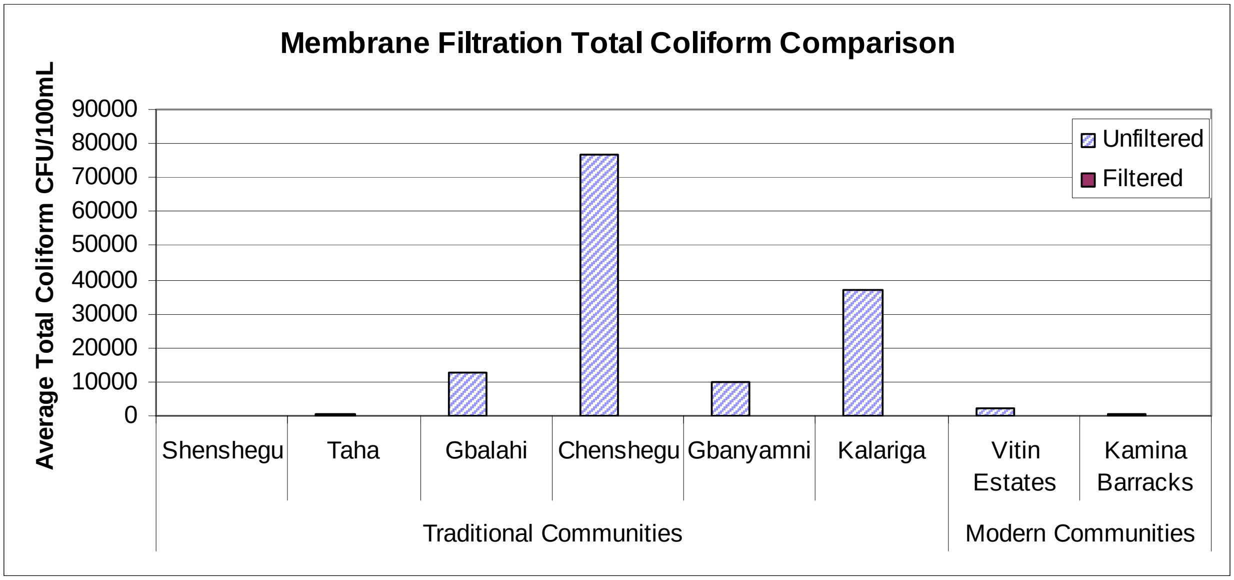


Figure 22: Average *E. coli* counts for paired source and filtered water samples for each community.



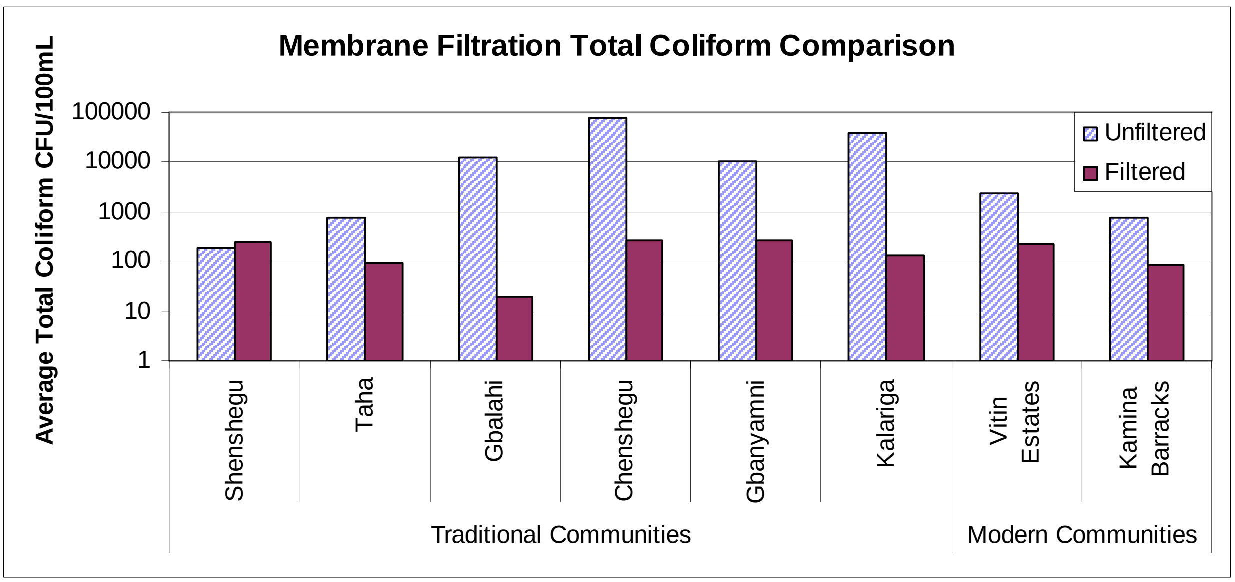


Figure 23: Average total coliform counts for paired unfiltered and filtered samples for each community. The two graphs show the same data, but the one of the bottom is on log-scale.

7.3 3M™ Petrifilm™ Test Results

3M™ Petrifilm™ tests were conducted on 55 out of 68 samples. Because testing materials were limited, 3M™ Petrifilm™ tests were not performed for the source water samples from Shenshegu or on any of the samples from Taha.

7.3.1 Source Water 3M™ Petrifilm™ Results

Total coliform and *E. coli* counts varied greatly between the traditional and modern communities. Twenty-five source water samples from traditional communities averaged 330 *E. coli* per 100mL. All seven of the source water samples from modern communities had 0 *E. coli* per 100mL. For total coliform counts, traditional communities averaged 5,700 per 100mL in their source water, while modern communities averaged 440 per 100mL.

Figure 24 shows the average *E. coli* results for each community, and Figure 25 shows the average total coliform results.

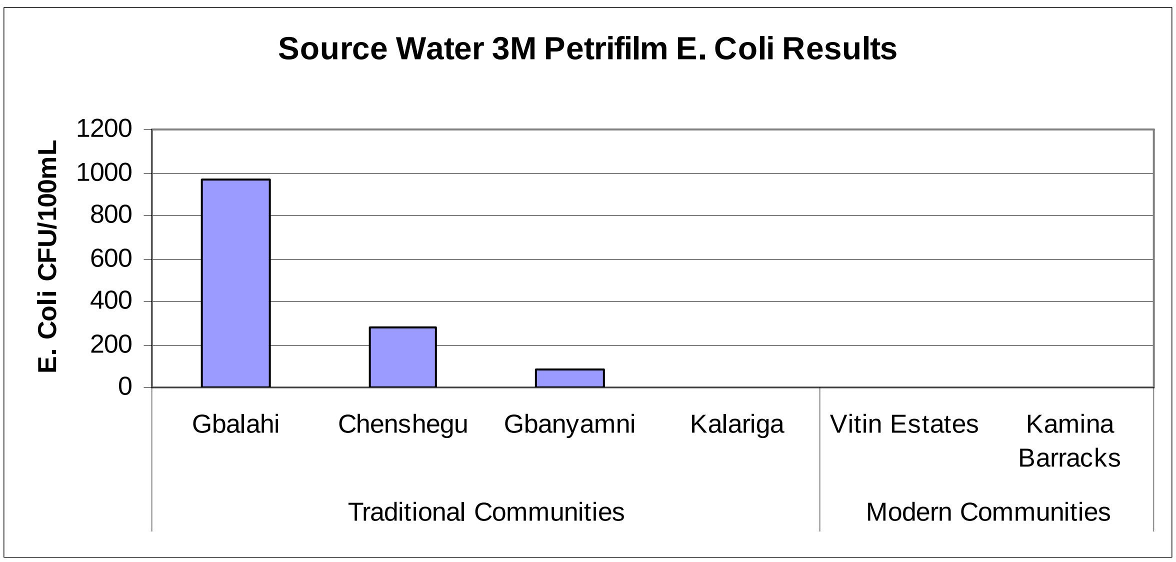


Figure 24: Average *E. coli* counts for source water samples from each community. Kalariga, Vitin Estates, and Kamina Barracks had 0 *E. coli* CFU/100mL in their source water.

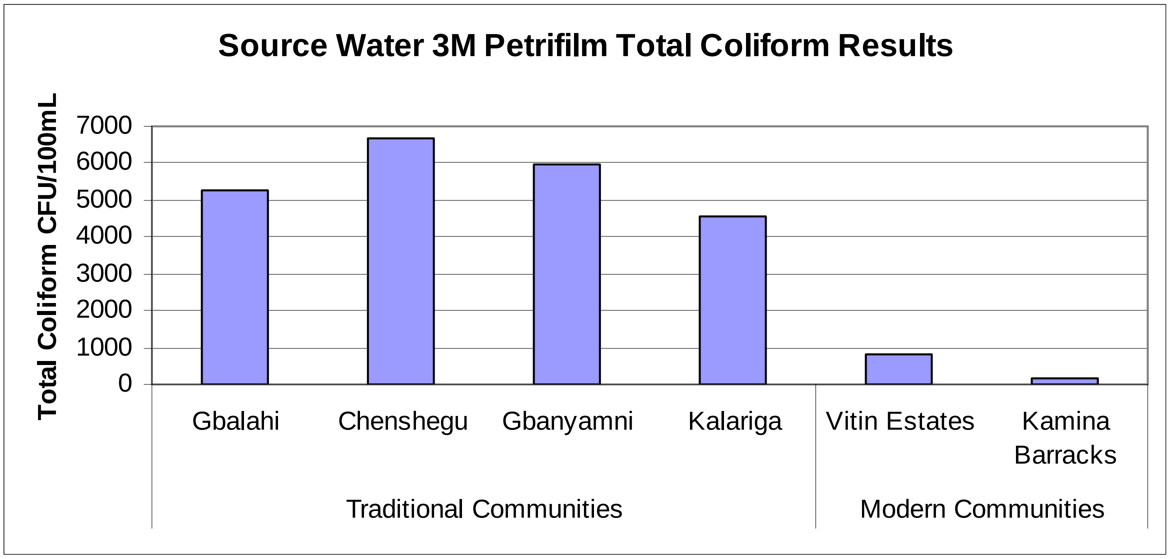


Figure 25: Average total coliform counts for source water samples from each community. The modern communities, Vitin Estates and Kamina Barracks, had much lower total coliform counts.

7.3.2 Filtered Water 3M™ Petrifilm™ Results

Overall, the 23 filtered water samples had significantly lower *E. coli* and total coliform counts than the source water. In one case, however, the total coliform count was 10 times higher in the filtered sample than in the unfiltered sample. There is a chance that the samples were inadvertently switched since the membrane filtration test did not find a similar relationship. Because this could have been due to mislabeling the samples, numbers below are given with and without that value included.

In traditional and modern communities, no *E. coli* were detected in the filtered water. Although most samples had zero counts of total coliforms also, the 16 samples from traditional communities averaged 810 total coliform CFU/100mL. The average total coliform CFU count lowers to 180 per 100mL without including the one outlier described previously. The 7 filtered samples from modern communities averaged 57 total coliform CFU/100mL. The total coliform averages for the traditional and modern communities are shown below in Figure 26. Standard deviations were high for both averages graphed because most samples had zero total coliforms. For traditional communities, the standard deviation was 480, and in modern communities it was 150.

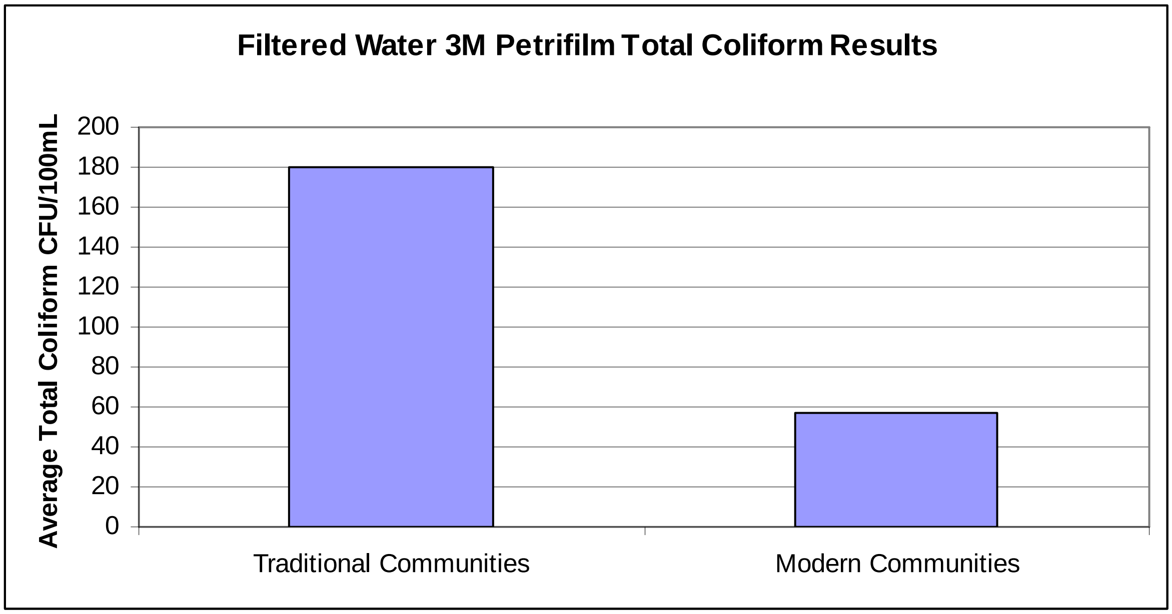


Figure 26: 3M Petrifilm results for filtered water from traditional and modern communities. The traditional average does not include the outlier discussed above.

Compared to the source water, the filtered water had a 100% reduction in *E. coli* counts. Ignoring the one test that showed a ten-fold increase in filtered counts, the average total coliform reduction between source and filtered water was 94% for 15 samples from traditional communities. For the three modern communities that had total coliform in the source water, the average reduction in the filtered samples was 78%. The overall total coliform reduction for all communities was 91%. Figure 27 shows a typical comparison between an unfiltered and a filtered sample in 3M Petrifilm.

Figure 27: Comparison between source water (left) and filtered water (right) for samples taken from Gbanyamni. The red and blue colonies surrounded by air bubbles in the sample on the left indicate total coliform and *E. coli.*

7.4 Hydrogen Sulfide Bacteria Test Results

Hydrogen sulfide (H_2S) presence/absence tests were done for 61 out of 68 water samples. During the first day of testing, not enough water was collected to conduct the H_2S tests, and therefore, no results for Shenshegu are shown.

7.4.1 Source Water H_2S Results

For source samples from traditional communities, 97% (30/31) tested positive for H_2S bacteria. For modern communities, five source water samples tested negative, and 2 source water samples from Vitin Estates tested positive. Figure 28 shows these results broken down by each community.

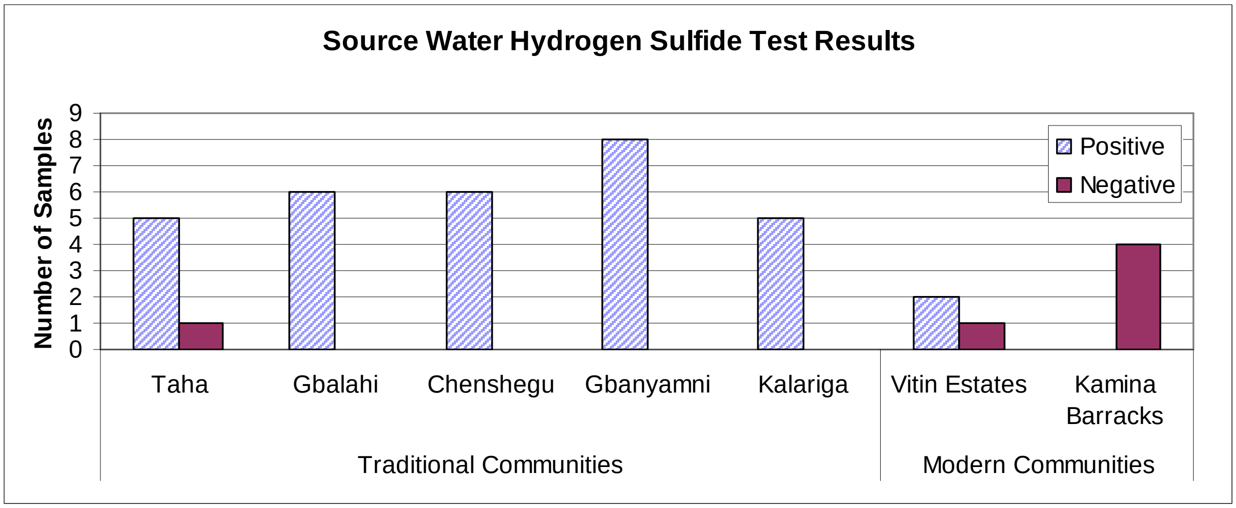


Figure 28: H_2S test results by community. Positive indicates the presence of H_2S bacteria, while negative indicates its absence.

7.4.2 Filtered Water H_2S Results

Only 2 out of 23 filtered water samples tested positive for H_2S-producing bacteria. Of these 23 filtered samples, 16 of their corresponding source water samples tested positive for H_2S bacteria. Only including paired samples with positive source water samples, removal rates were 85% (13/15) for traditional households and 100% (1/1) for modern households. Results for each community are shown below in Figure 29. The test results from Gbanyamni, where all source samples were H_2S positive and all filtered samples were H_2S negative, are pictured in Figure 30.

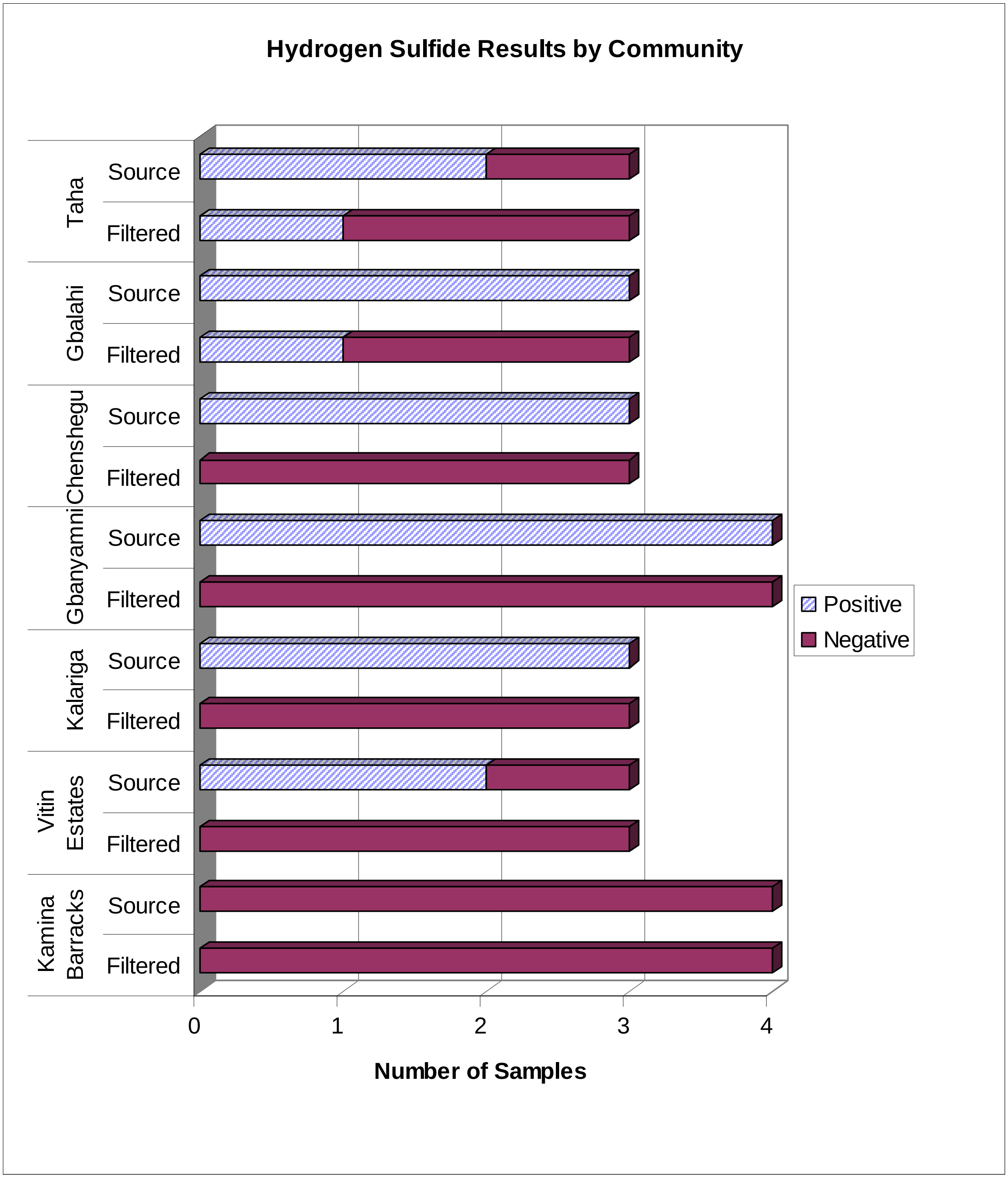


Figure 29: H_2S test results for source water and filtered water samples for each community.

Figure 30: H_2S test results from Gbanyamni samples. All source water tested positive for H_2S-producing bacteria, while all filtered samples tested negative.

7.5 Turbidity Results

Sixty-six out of 68 water samples were tested for turbidity. During the first day of testing, not enough source water was collected from two households, and therefore turbidity could not be tested.

7.5.1 Source Water Turbidity Results

Most households in traditional communities used dam water, and the turbidity was high in these samples. The average source water turbidity for 33 samples from traditional communities was 190 NTU, while the average for seven samples from modern communities was 4.5 NTU.

Figure 31 shows average turbidity for each community. Shenshegu, a traditional community, had a lower average turbidity than other traditional households because some of the households in Shenshegu obtain drinking water from standpipes or tanker trucks. The modern communities Vitin Estates and Kamina Barracks had lower averages because all households obtain water from household taps or standpipes.

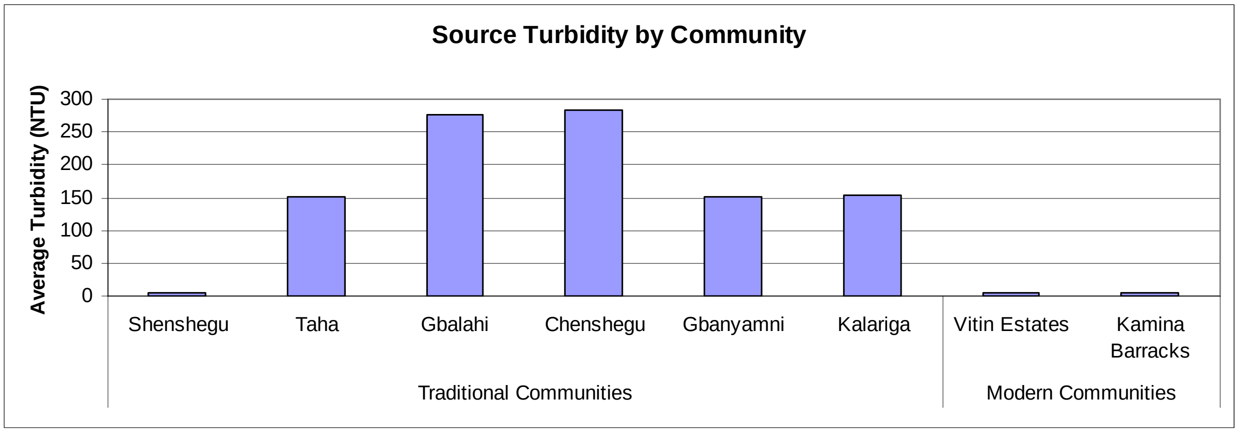


Figure 31: Average source turbidity by community.

7.5.2 Filtered Water Turbidity Results

All filtered samples were tested for turbidity. Each filtered sample had a lower turbidity than its corresponding unfiltered sample, and all households averaged an 85% reduction in turbidity. In traditional communities, the 19 filtered samples averaged 92% lower turbidity than their respective unfiltered samples. In modern communities, with their significantly lower source water turbidity, the difference between filtered and source water was smaller; seven filtered samples were 68% lower than their corresponding unfiltered samples. Figure 32 shows paired values of unfiltered and filtered samples for each household. One household could not be graphed because its unfiltered water was not tested.

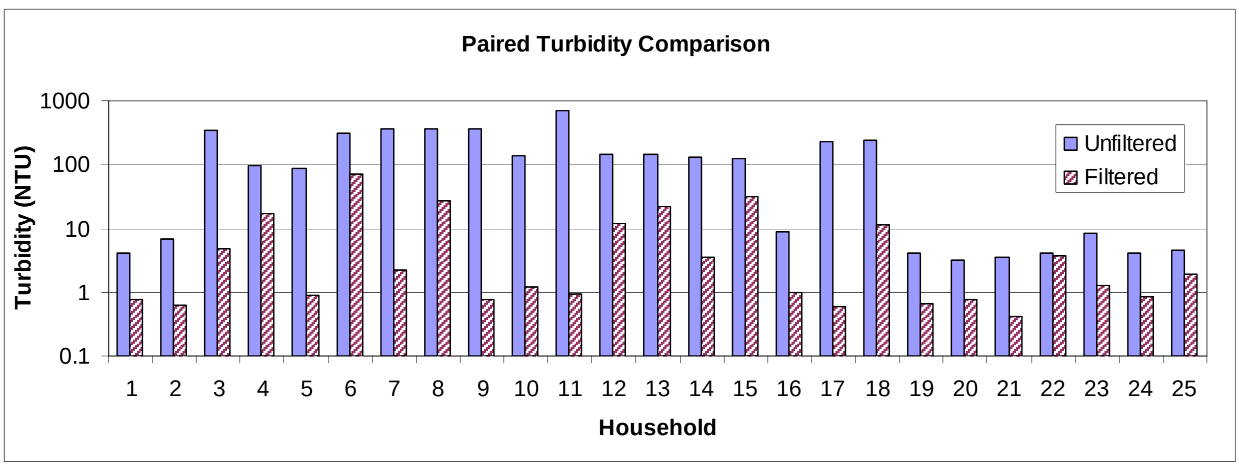


Figure 32: Paired turbidity results for unfiltered and filtered households. Note the log-scale for the turbidity values.

8.0 Business Survey Results and Assessment

8.1 Summary

Table 21 and Table 22 summarize the survey results of consumer perceptions, attitudes, knowledge, and practices related to water treatment using ceramic water filters. The subsequent sections analyze these results within the 4P's framework.

Table 21: Survey Results for Filter Users

	Filter Users	
Filter Awareness and Decision to Purchase	Attended PHW Presentation*	13/15 = 87%
	Source for Learning about the Filter*	
	PHW Presentation	1/16 = 6.3%
	Family Member	3/16 = 19%
	Community Liaison	3/16 = 19%
	Neighbors	1/16 = 6.3%
	Member of PHW Marketing Program**	5/16 = 31%
	Member of Alioune Dia's Research Study	3/16 = 19%
	Family Member Who Decided to Purchase Filter	
	Father	9/25 = 36%
	Mother	4/25 = 16%
	Father and Mother	4/25 = 16%
	n/a since given for free	8/25 = 32%
Filter Use and Acceptability	Average Days/Week Filter is Used	7 days
	Treat all Water Family Drinks	22/25 = 88%
	Noticeable Improvements in Family Health	25/25 = 100%
	Happy with Technology	25/25 = 100%
	Technology is Easy to Use	25/25 = 100%
	Problems with Filter	
	Spigot Problems	3/25 = 12%
	Flow is too Slow	4/25 = 16%
	Need Brush to Clean It	2/25 = 8%
	Cracked Receptacle	1/25 = 4%
	Incorrect Use	1/25 = 4%
	Would Recommend Filter to a Friend	25/25 = 100%
Willingness to Pay	Willingness to Pay for Filter	
	Traditional Households	US $6.40 (GHC 57,000)
	Modern Households	US $11.40 (GHC 103,000)
	Neighbors Would Pay this Price	
	Yes	21/25 = 84%
	No	1/25 = 4%
	Maybe	3/25 = 12%

*Not all households were asked
**Member of community liaison or chief's household

Table 22: Survey Results for Non Filter Users

Non Filter Users	
Want to Treat Water	16/16 = 100%
Family Decision Maker	
Father	9/16 = 56%
Mother	1/16 = 6.3%
Father and Mother	3/16 = 19%
Oldest Family Members	2/16 = 13%
Young Males	1/16 = 6.3%
Aware of Ceramic Filter in Village	15/16 = 94%
Has Drunk Water from a Filter	5/16 = 31%
Attended PHW Presentation*	3/9 = 33%
Willingness to Pay for Filter	US $4.40 (GHC 39,000)

*Not all households were asked

8.2 4 P's Analysis

8.2.1 Product

PHW's primary product, the *Kosim* filter, was evaluated through the household surveys and water quality tests described in earlier sections. Overall, filter owners seemed to be very satisfied with the product. All households (25/25) said that the filter is used seven days a week. Also, 88% (22/25) claimed that they treat all the water that the family uses for drinking. Three out of 25 families do not treat all water because sometimes untreated water is more convenient, and sometimes the filter does not provide enough water for all family members. It is probable that more people drink unfiltered water than was reported since family members at several households were observed drinking from vessels containing unfiltered water.

Several questions were asked about how acceptable the ceramic filter is to the users. One hundred percent of users (25/25) said that they are happy with the technology, that it is easy to use, and that they would recommend it to others. One respondent had recommended the filter to several people who then bought the product for their households. All respondents (25/25) said they would replace their filter if it broke. Some problems were cited, including a few broken spigots in the filters in use for over one year, slow flow rates, and one broken receptacle. It is recommended that PHW give families an option to pay more for a metal spigot instead of the plastic spigot that is provided. Although the metal spigots do not turn off automatically and are more expensive, they are much more durable. Also, a couple of households needed the brush that is supposed to come as part of a filter purchase. Respondents with turbid water reported cleaning their filter several times each week, while others said they clean it a couple of times each month, as necessary. Because households are typically large in this region, PHW could suggest that families buy multiple units if possible. One family interviewed had two filters, and it is likely that many of the larger families could better meet their needs with a second filter.

8.2.2 Price

As described previously, PHW has changed its pricing scheme. Since PHW changed the price charged to traditional households in Year 2 to US$ 6.70 (GHC 60,000), the demand has increased, indicating that the price is within reach of most people in traditional communities. Filter users were asked what they would pay to replace their filter if it broke, and most said that they would pay the price at which they purchased it. The average response in traditional households was US $6.40 (GHC 57,000), and modern households averaged higher at US $11.40 (GHC 103,000). Filter users were asked if their neighbors would buy one at the price they gave in the previous answer, and 84% (21/25) said "yes." Non-users from traditional households were also asked what they would pay for a ceramic filter unit, and their average response was a little lower at US$ 4.40 (GHC 39,000). Figure 33 shows the willingness to pay for *Kosim* filters for both non-users and users from all households.

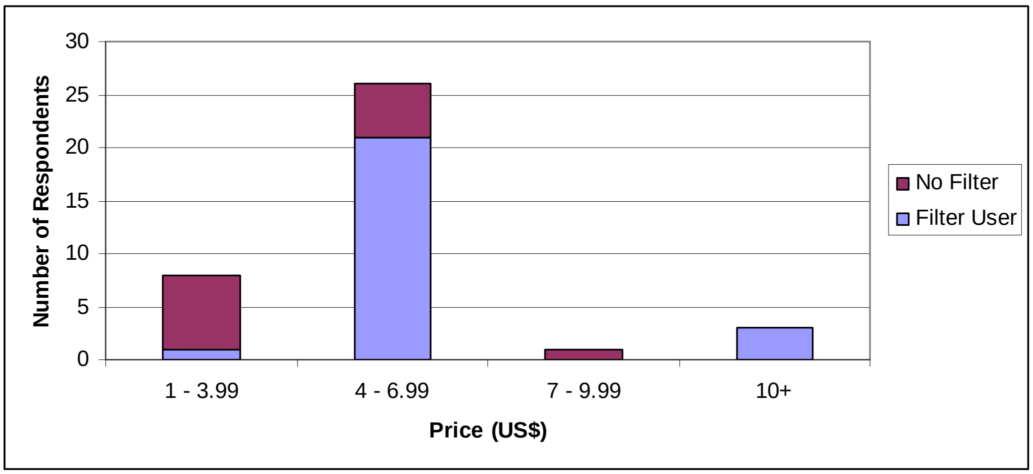


Figure 33: Willingness to pay for a ceramic water filter for households with and without a filter unit.

8.2.3 Place

Place is analyzed in two respects, both the target communities PHW is reaching and the marketing channels by which they are doing so.

The household surveys determined that PHW is reaching people in greatest need for the ceramic filters. Whereas PHW's Year 1 strategy mostly reached people from modern communities in the urban areas and outskirts of Tamale that have access to improved water and sanitation, Year 2's strategy has made it possible to reach poorer people in rural communities. Zero percent (19/19) of the filter users from the rural communities have year-round access to an improved water supply or improved sanitation, and only one of the rural filter users had attended school.

PHW's marketing channels also seem effective. Community liaisons in each village are accessible for people who want to buy filters or who have questions about them. Although these marketing channels have reached low-income rural people and generated demand, there have been delivery delays from the factory in Accra. Hopefully PHW's assuming a new role in local ceramic manufacturing in the not-so-distant future will prevent these delays from occurring.

8.2.4 Promotion

The rural promotion efforts seem to be reaching many people in each village. Ninety-four percent (15/16) of non-users were aware of the ceramic filters in their village, and one third of the non-users (5/16) had had water from a filter. Many noted that the filtered water tasted very good and was clear. All sixteen non-users expressed an interest in treating their water. Most filter users first found out about the filters from a family member or from the community liaison. Respondents were also asked if they had attended the Pure Home Water village presentation, and the results are shown in Figure 34. The numbers indicate that presentation attendance might encourage people to buy the filters.

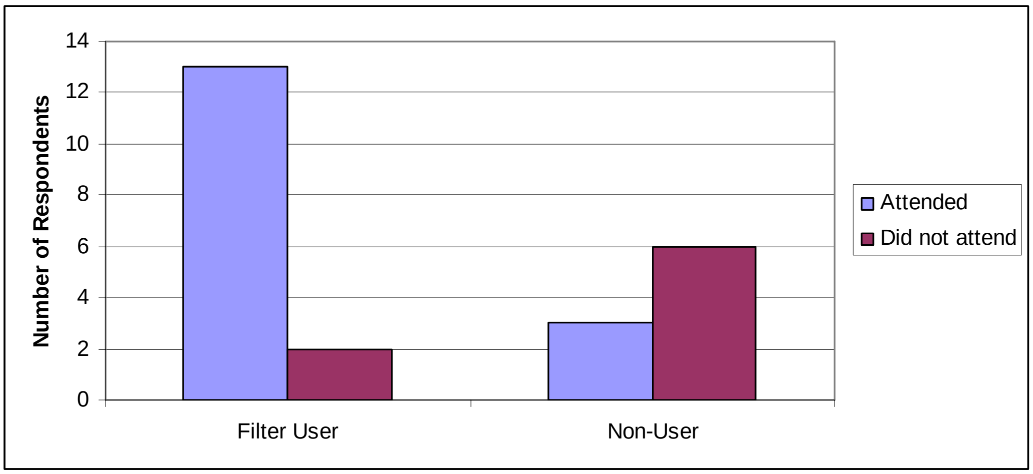


Figure 34: Attendance at Pure Home Water's village presentation for respondents with and without ceramic filters.

9.0 Conclusions and Recommendations

9.1 Conclusions

9.1.1 Key Findings

PHW is reaching communities that need the filter the most, and the filters are performing well and are acceptable to users. The following key findings support these conclusions:

- Whereas 83% of modern households surveyed always have access to an improved water source, and 100% of modern households surveyed have access to improved sanitation, 0% of traditional households surveyed always have access to improved water or sanitation. PHW is reaching these traditional communities.
- In membrane filtration testing, the filters reduced *E. coli* by 99.7% in traditional households and by 85% in modern households.
- The filters reduced total coliform by 99.4% in traditional households and by 90% in modern households according to membrane filtration testing.
- Turbidity was reduced by 92% in traditional households and by 68% in modern households.
- People living in traditional households with filters were 69% less likely to have diarrhea than people living in households without the filters.
- The filters are acceptable to users, and non-users are interested in treating their water with the filters.
- The pricing scheme works well for most traditional households.

9.1.2 Discussion of Findings

Baseline data for filter users and non users was collected in the household surveys conducted by the author in January 2007. For the first time, it was possible to gather data from filter users in traditional households because before all filter users were from modern communities. From the data on filter users in traditional communities, it is clear that Pure Home Water is reaching those with the greatest need for the ceramic water filter. Some points from the surveys are highlighted below:

- 29% of respondents from traditional households and 67% of respondents from modern households practice appropriate hand-washing.
- Traditional households spend an average of 82 minutes per trip to collect water during the dry season.
- Surprisingly, traditional households without the filters reported a higher income per person per month (US$ 7.60) than households with the filters (US $5.50). Even people who live on much less than $1 per day seem to be able to afford to buy the filter at PHW's price.

Although the filters are providing significantly cleaner water to users, the water provided by the filter may still not be safe. Traditional households averaged 170 total coliform CFUs/100mL in the filtered water, which is still not very good, even though it is a vast improvement upon the source water, which averaged 23,000 CFU/100mL. The problems could arise because the filter is unable to remove all bacterial contamination, or the problems could be due to improper filter use or manufacturing flaws.

According to the risk assessment analysis, households with filters were 76% less likely to have a member with diarrhea than non-filter households. Also, when comparing all people from traditional households, people in a household with a filter were 69% less likely to have diarrhea than people in a household without a filter. The diarrheal rates for children under five showed less contrast between filter and non-filter households. Children under five may be more likely to be exposed through additional contamination pathways.

The results from the business survey found that the filters are acceptable to users and that non-users were interested in treating their water with the filters. Users thought the filters performed well and were easy to use. The pricing scheme works well for most traditional households, and the community liaisons are providing an effective link between the communities and Pure Home Water. Many households that had been using the filter for over one year cited problems with the spigot, and Pure Home Water should offer households the opportunity to purchase a more durable metal spigot.

9.2 Recommendations to Improve PHW's Practices

PHW should take additional steps to ensure all filters provide safe water to users. To address possible improper filter use, PHW should ask its community liaisons to periodically check to ensure users understand how to use and maintain the filter. Until PHW begins its own manufacturing, additional quality control methods should be implemented to address possible manufacturing flaws. PHW already inspects each shipment from the manufacturer and rejects many of the filters, and an inspection checklist could be made that included current criteria and some additional tests. An inspection checklist could include:

- A check to ensure the filter fits correctly in the receptacle so water does not leak around the sides.
- A knocking audio test and visual inspection to check for cracks.
- A flow rate retest to ensure a flow of approximately $2m^3/s$.
- Bacterial tests to ensure over 99% of bacteria are being removed.

Because the flow rate test and bacterial tests would require significant time commitments, PHW could test a percentage of filters from each shipment from the manufacturer. The bacterial tests could include membrane filtration if time allowed, but 3M™ Petrifilm™ and hydrogen sulfide tests may be better screening options since they are less expensive and much quicker to perform. The source water samples should include a range of turbidities and bacterial concentrations.

Future studies could continue to monitor filter use through epidemiological studies and water quality testing. Spigot problems were cited for households using the filter for over one year, and additional problems may arise with further use. Long-term studies of several years could help identify these problems. A more comprehensive epidemiological study with a survey size of several hundred households could determine better relationships between diarrheal rates for people drinking filtered water compared to those not drinking filtered water. Although results from a larger scale health impact study would be interesting for the field of HWTS technologies, they would not be critical to PHW's operation.

PHW will need to monitor its rural outreach strategy to ensure that the most effective opinion leaders in each community are being chosen to promote the filters. A study could be done to assess the effects of opinion leaders in each community. For instance, households could be surveyed on their thoughts about the opinion leaders and whether or not their actions are actually influential. Chiefs of communities may in fact not be the best opinion leaders. Also, future studies could assess the school and hospital outreach programs through both surveys and water quality testing.

When PHW begins its own filter manufacturing facility in the Northern Region, flow rate tests, bacterial tests, and turbidity tests will be necessary to ensure that the filters are performing well. If chemical contamination in drinking water sources becomes an identified concern, PHW will need to test the filters' removal ability for the contaminants. After several months of operation, only flow rate tests will be required for every filter, while turbidity and bacterial tests should be done for a percentage of filters produced each week. Students could try to change clay/sawdust mix ratios to optimize flow rates without sacrificing performance. Another project could focus on strengthening the lip of the filter.

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11.0 Appendices

Appendix A: Survey from Peletz (2006)

Ghana Household Questionnaire for Safe Household Water Implementation Project
Cross-sectional study

Hello, my name is Sophie Johnson, and I am student from MIT in the United States. We are conducting a household survey on water and sanitation in Ghana. We would like to talk with a woman of the household for about 30 minutes. Participation is voluntary; you may decline to answer any or all of the questions, and you may end the questionnaire early if you wish. All information will be kept confidential. Do you understand? Will you be willing to participate?

Yes	
No	

(If no, thank and close)

Interview background

Survey Number	
Surveyor	
HWTS Technology	
Name	
District	
Community	
Address	

Date	
Start Time	
End Time	
Water test #	
GPS number	
GPS coordinates	
Photo Description	

1. Household Information

1.1 Respondent's status

Mother	
Grandmother	

1.2 How many people live in the household? What are their ages?

Total Number in household	
Respondent's Age	

Age	Number of Members (including respondent)
≤ 5 years old	
6-15 years old	
16-59 years old	
≥ 60 years old	

1.3 Have you ever attended school?

Yes	
If so, how many years?	
No	

1.4 What are your average expenses each month?

1.5 Do you have ________?

Electricity	
Firewood	
Charcoal	
Gas	

1.6 OBSERVATIONS (socioeconomic)

House Type	
Floor Type	

1.7 How do you get your information (about events, news)? Information about water?

	General	Water
Meetings/presentation		
Radio		
Market		
Television		
Newspaper		
Other (specify):		

2. Diarrhea Knowledge

2.1 Has anyone in the household had diarrhea in the last week?

Yes	
No	

	Number that have had diarrhea	Number of days (list for each person)
≤ 5 years old		
5-15 years old		
16-59 years old		
≥ 60 years old		

2.2 What do you think is the main cause of diarrhea? Do you think ________ is a cause?
(First just ask what causes it, and then after response, read the list)

	Main cause	Probed response
Dirty water		
Dirty food		
Flies/insects		
Poor hygiene/ Environment		
Other(Specify):		
Unsure		

2.3 What do you do to treat diarrhea? How much does it cost?

	Treatment
Hospital	
ORS (oral rehydration salt)	
Salt/sugar solution	
Medicines	
Rice water	
Mashed Kenkey	
Bread	
Other (specify):	

2.4 If someone gets sick with diarrhea, who takes care of them? (CHECK, DON'T READ)

Mother	
Father	
Grandmother	
Grandfather	
Male child	
Female child	
Other(Specify):	

3. Household Hygiene and Sanitation

3.1 When do you wash your hands? Do you wash your hands __________?

	Yes	No
After the toilet		
Before eating		
Before cooking		
Other(Specify):		

3.2 Do you use soap when washing your hands? Do you have soap right now?

	Use	Have
Yes		
No		

3.3 What type of toilet facility do you use? (DON'T READ THE LIST)

	Check	Always available?	Public/Private/Shared
Flush toilet/WC			
KVIP Latrine			
Pit/Pan latrine			
Free range			
Other(specify):			

3.4 How far away is the toilet facility? (CHECK AND WRITE THE TIME)

In House	
Time to facility	

3.5 Is hand-washing facility available where you go to the toilet?

Yes	
No	

4. Water Use Practices

Source collection

4.1 Where do you get your drinking water during the DRY season?   (Is another source used if first is unavailable?)

Improved Source	Always	Sometimes	**Unimproved Source**	Always	Sometimes
Household tap			Surface (lake/river)		
Protected Well			Unprotected well		
Protected Spring			Unprotected spring		
Borehole			Tanker truck water		
Rainwater collection			Water vendor: bottled (cost)		
Public standpipe			Water vendor: Sachet (cost)		
Other (specify):			Other (specify):		

Where do you get your drinking water during the WET season? (Is another source used if first is unavailable?)

Improved Source	Always	Sometimes	**Unimproved Source**	Always	Sometimes
Household tap			Surface (lake/river)		
Protected Well			Unprotected well		
Protected Spring			Unprotected spring		
Borehole			Tanker truck water		
Rainwater collection			Water vendor: bottled (cost)		
Public standpipe			Water vendor: Sachet (Pure or Ice, cost)		
Other (specify):			Other (specify):		

4.2 If you are getting water from a pump, have there been more than 10 days without operation in the last year (in 2006)?

N/A	
Yes	
No	

If you are getting water from a tap, how many days a week is the water flowing?

Number of days	

IF WATER IS FROM A TAP INSIDE THE HOME, GO TO QUESTION 4.6

4.3 Who collects the water?

Mother	
Father	
Grandmother	
Male Child	
Female Child	
Other(specify):	

4.4 How many times each day do you collect water?

Dry season	
Wet season	

4.5 How long does it take to collect water, including going, filling, and returning? (TIME)

	Under 30 min	Over 30 min
Wet Season		
Dry Season		

4.6 When not at home, from what source do you drink?

Improved Source	Always	Sometimes	Never	**Unimproved Source**	Always	Sometimes	Never
Household tap				Surface (lake/river)			
Protected Well				Unprotected well			
Protected Spring				Unprotected spring			
Borehole				Tanker truck water			
Rainwater collection				Water vendor: bottled (cost)			
Public standpipe				Water vendor: Sachet (Pure or Ice, cost)			
Other (specify):				Other (specify):			

Water Storage

4.7 Where do you store your drinking water (before drinking, after filtering or collecting)?

	Number	Narrow mouthed?
Ceramic vessels		
Metal buckets		
Plastic buckets		
Jerry can		
Small pans		
Cooking pots		
Plastic bottles		
Other(specify):		

4.8 Are your storage vessels always covered?

Yes	
No	

4.9 Do you use the stored water for any other purposes besides drinking water?

Yes	
No	

What purposes? Do you use it for _______________?

Everything	
Cooking	
Bathing	
Cleaning	
Washing	
Other(specify):	

4.10 How do you take water from the containers?

Pour directly	
Draw with cup/scoop **with handle**	
Draw with cup/scoop **without handle**	
Spigot on container	
Other(specify):	

Water Quality Perception

4.11 Do you think the water is safe to drink without treatment?

Yes	
No	

If not, why? (DO NOT READ LIST)

Dirty/turbid	
Microbial contamination	
Larvae/worms	
Causes malaria	
People get sick	
Other(specify)	
Unsure	

4.12 What system are you using to treat your water? Do you know about any other methods? (Follow up questions: What if water is cloudy at collection? What if family members are sick?)

	Always	Sometimes
Boil		
Chemicals (tablets/liquid)		
Filter:		
CT Tamakloe ceramic		
Nnsupa candle		
Biosand		
Cloth		
Other filter (specify):		
Settle		
Safe storage		
SODIS (solar)		
Other (specify)		

4.13 Why do you use this method?

5. Preparedness to use household treatment (WITHOUT technology)

5.1 Would you like to treat your water before drinking?

Yes	
No	

If not, why not?

Cost	
Not necessary, water is clean	
Afraid to change water (add chemicals, etc.)	
Need to discuss with guardian/spouse	

5.2 How much are you prepared to spend on the treatment of your water? How much can you afford?

5.3 Who in the family usually decides what is necessary to buy for the household?

Mother	
Father	
Grandfather	
Other(specify):	

5.4 Are you aware of ceramic filters in your village?

Yes	
No	
Unsure	

If so, have you had water from it?

Yes	
No	

What do you think about its performance and the quality of the water it produces?

5.5 Are you ready to learn how to produce any of the HWTS products?

Yes	
No	

OTHER COMMENTS/QUESTIONS:

REMEMBER

Mark end time
Photo
Water sample
GPS coordinates

WITH HWTS Technology

A. Type

Ceramic CT Filtron	
Ceramic candle Nnsupa filter	
Plastic safe storage container	

B. Why did you select this technology?

Cost	
Ease of Use	
Other:	

C. Did you attend a Pure Home Water presentation about the ceramic filter?

Yes	
No	

If not, where did you find out about it? (community liaison, relative, neighbor, school, etc.)

D. Who in the family decided to purchase the filter/technology?

Mother	
Father	
Other(specify):	

E. How many days a week do you use it?

Regular use (7 days)	
Irregular use (1-6 days)	
Non-users (0 days)	

F. Is the filtered/treated water better, worse or the same? (taste, odor)

Better	
Worse	
The Same	

G. Do you treat all of the water the family uses for drinking? If not, when not?

		When Not
Yes		
No		

H. Have you noticed any health improvement since you started using HWTS?

Yes	
No	

I. Who is responsible for treating the water?

Mother	
Father	
Grandmother	
Male Child	
Female Child	
Other(specify):	

HWTS Acceptability

A. Are you happy with the technology? Why or why not?

Yes		Why:
No		Why not:

B. Is it easy to use?

Yes	
No	

C. Would you recommend to others?

Yes	
No	

D. Have you had any problems with the technology? If so, what? How often?

		What	How often
Yes			
No			

HWTS Operation and Maintenance

A. Do you clean the technology? How often?

		How Often
Yes		
No		

B. Do you use another treatment method is the filter is not working well?

C. Do you think you have enough resources ($, info, skills) to keep the HTWS running?

Yes	
No	

D. If it was broken, would you buy a new one? How much are you willing to pay?

		Willing to pay? (Amount)
Yes		
No		

E. Do you think your neighbors would buy one for this price?

Yes	
No	

F. Are you ready to learn how to produce any of the HWTS products?

Yes	
No	

OTHER COMMENTS/QUESTIONS:

REMEMBER

Mark end time
Photo
Water sample
GPS coordinates

Appendix B: General Household Survey Data

Survey Responses: General, Households 1-3

Survey Details	Survey Number	1	2	3
	Community	Shenshegu	Shenshegu	Shenshegu
	Date of Interview	8-Jan-07	8-Jan-07	8-Jan-07
	GPS North	9.64438	9.40225	9.4031
	GPS West	0.19055	0.88243	0.88222
	Filter User	Yes	No	Yes
	Surveyors Present	Wahabu, Ali, Sophie	Wahabu, Ali, Sophie	Wahabu, Ali, Sophie
Household Information	Respondent's Age	Not Asked	Not Asked	Not Asked
	Total Household Members	5	23	33
	Members under 5	1	4	6
	Members Age 6-15	1	6	8
	Members Age 16-59	3	13	18
	Members over 60	0	0	1
	Years of Education	0	0	0
	Monthly Household Expenses (GHC)	350,000	1,000,000	2,000,000
	Energy Access	Electricity, Firewood, Charcoal	Firewood and Charcoal	Electricity, Firewood, Charcoal
	House Type	Traditional	Traditional	Traditional
	Source of Information	Friends, Relatives	Radio and Friends	Radio, Husband, Friends
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	1	3	0
	Members under 5 with Diarrhea	1	3	0
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	0	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	.	.
	Main Cause of Diarrhea	dirty food	unsure	dirt
	Dirty Water	No	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	No	Yes	Yes
	Poor Hygiene/Environment	No	Yes	Yes
	Treatment of Diarrhea	Medicines	Medicines	Hospital and Medicines
	Caregiver for Someone with Diarrhea	Mother	Mother and Father	Mother and Father
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	No	No	No
	Before Eating	Yes	Yes	Yes
	Before Cooking	Yes	Yes	No
	Use Soap When Washing Hands	No	Sometimes	Sometimes
	Has Soap Right Now	No	Yes	Yes
	Type of Toilet Facility	KVIP Latrine	KVIP Latrine	KVIP Latrine
	Public/Private/Shared	Public	Public	Public
	Time to Toilet Facility	5	4	5
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Standpipe	Dam	Unprotected Well
	Other Water Source in Dry Season	Dam	Standpipe, Unprotected Well	Dam - not for drinking though
	Main Water Source in Wet Season	Rainwater Collection	Rainwater Collection	Rainwater Collection
	Other Water Source in Dry Season	Standpipe	Dam and Unprotected Well	Unprotected Well
	Days Per Week Tap Flows	1	Sometimes doesn't for weeks	.
	Main Water Collectors	Mother and Female Children	Mothers	Mother and Female Children
	Daily Trips to Collect Water in Dry Season	4	4	5
	Daily Trips to Collect Water in Wet Season	0	2	3
	Total Trip Time in Dry Season	60	60	45
	Total Trip Time in Wet Season	3	60	45
	Water Source when not at Home	Tied (Ice)	Tied (Ice)	Any Available
	Water Storage Vessels	Ceramic Vessels, Ceramic Filter Receptacle	Ceramic Vessels	Ceramic Vessels, Metal Barrels, Ceramic Filter Receptacle
	Storage Vessels Always Covered	No	Yes	No
	Method of Taking Water from Containers	Spigot or Cup without Handle	Cup without Handle	Cup without Handle
	General Comments		Kids use free range sometimes for toilet	

Survey Responses: General, Households 4-6

Survey Details	Survey Number	4	5	6
	Community	Shenshegu	Taha	Taha
	Date of Interview	8-Jan-07	9-Jan-07	9-Jan-07
	GPS North	9.40292	9.4359	9.43547
	GPS West	0.88244	0.782	0.78462
	Filter User	Yes	Yes	Yes
	Surveyors Present	Wahabu, Ali, Sophie	Wahabu, Sophie	Wahabu, Sophie
Household Information	Respondent's Age	Not Asked	50	38
	Total Household Members	9	8	6
	Members under 5	0	1	1
	Members Age 6-15	0	2	2
	Members Age 16-59	9	4	3
	Members over 60	0	1	0
	Years of Education	0	0	0
	Monthly Household Expenses (GHC)	1,000,000	400,000	350,000
	Energy Access	Electricity, Firewood, Charcoal	Firewood and Charcoal	Firewood and Charcoal
	House Type	Traditional	Traditional	Traditional
	Source of Information	Radio, Children	Radio, Market	Radio
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	0	0	1
	Members under 5 with Diarrhea	0	0	1
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	0	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	.	5
	Main Cause of Diarrhea	dirty food, flies, hygiene	dirty food, flies, hygiene	dirty food, flies
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	Hospital and Medicines	Hospital and Medicines	Medicines
	Caregiver for Someone with Diarrhea	Mother and Father	Mother and Father	Mother
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	No	No	Yes
	Before Eating	Yes	Yes	Yes
	Before Cooking	Yes	Yes	Yes
	Use Soap When Washing Hands	Yes	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	KVIP Latrine	Free Range	Free Range
	Public/Private/Shared	Public		
	Time to Toilet Facility	5	10	5
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Tanker Truck	Dam	Dam
	Other Water Source in Dry Season	Dam when tank is empty		
	Main Water Source in Wet Season	Tanker Truck	Unprotected Well	Unprotected Well
	Other Water Source in Dry Season	Rainwater and dam		
	Days Per Week Tap Flows	.	.	.
	Main Water Collectors	Female Children	Mother and Female Children	Mothers
	Daily Trips to Collect Water in Dry Season	4	8	4
	Daily Trips to Collect Water in Wet Season	0	8	5
	Total Trip Time in Dry Season	30	30	45
	Total Trip Time in Wet Season	30	10	10
	Water Source when not at Home	Tied (Ice)	Tied (Ice), Any Available	Tied (Ice), Sachet (Pure)
	Water Storage Vessels	Ceramic Vessels, Metal Barrels, Ceramic Filter Receptacle	Ceramic Filter Receptacle	Ceramic Filter Receptacle
	Storage Vessels Always Covered	Yes	Yes	Yes
	Method of Taking Water from Containers	Cup without Handle	Spigot	Spigot
	General Comments			

Survey Responses: General, Households 7-9

Survey Details	Survey Number	7	8	9
	Community	Taha	Taha	Taha
	Date of Interview	9-Jan-07	9-Jan-07	9-Jan-07
	GPS North	9.43492	9.43591	9.43604
	GPS West	0.78602	0.78391	0.78422
	Filter User	Yes	No	No
	Surveyors Present	Wahabu, Sophie	Wahabu, Sophie	Wahabu, Sophie
Household Information	Respondent's Age	40	30	Not Asked
	Total Household Members	9	10	14
	Members under 5	2	1	3
	Members Age 6-15	4	3	3
	Members Age 16-59	3	4	6
	Members over 60	0	2	2
	Years of Education	0	0	8
	Monthly Household Expenses (GHC)	1,000,000	400,000	700,000
	Energy Access	Firewood and Charcoal	Firewood and Charcoal	Firewood and Charcoal
	House Type	Traditional	Traditional	Traditional
	Source of Information	Radio, Other People	Radio	Radio
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	1	0	2
	Members under 5 with Diarrhea	1	0	2
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	0	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	3	.	14
	Main Cause of Diarrhea	dirty food, from children defecating	hygiene, environment	children teething
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	Medicines	Hospital or Clinic	Hospital or Clinic
	Caregiver for Someone with Diarrhea	Mother and Father	Mother and Father	Mother
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	No	No	No
	Before Eating	Yes	Yes	Yes
	Before Cooking	No	Yes	No
	Use Soap When Washing Hands	Yes	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Free Range	Free Range	Free Range
	Public/Private/Shared			
	Time to Toilet Facility	5	5	5
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Dam	Dam	Dam
	Other Water Source in Dry Season			
	Main Water Source in Wet Season	Unprotected Well	Unprotected Well	Dam
	Other Water Source in Dry Season			
	Days Per Week Tap Flows	.	.	.
	Main Water Collectors	Mother and Female Children	Mothers	Mothers
	Daily Trips to Collect Water in Dry Season	4	6	6
	Daily Trips to Collect Water in Wet Season	6	4	6
	Total Trip Time in Dry Season	30	40	10
	Total Trip Time in Wet Season	9	10	10
	Water Source when not at Home	Tied (Ice), Any Available	Tied (Ice)	Tied (Ice)
	Water Storage Vessels	Ceramic Vessels, Ceramic Filter Receptacle	Ceramic Vessels	Ceramic Vessels
	Storage Vessels Always Covered	Yes	Yes	No
	Method of Taking Water from Containers	Spigot or Cup without Handle	Cup without Handle	Cup with Handle
	General Comments			

Survey Responses: General, Households 10-12

Survey Details	Survey Number	10	11	12
	Community	Taha	Gbalahi	Gbalahi
	Date of Interview	9-Jan-07	11-Jan-07	11-Jan-07
	GPS North	9.43569	9.43483	9.435
	GPS West	0.78303	0.76883	0.76762
	Filter User	No	No	No
	Surveyors Present	Wahabu, Sophie	Wahabu, Ali	Wahabu, Ali
Household Information	Respondent's Age	26	62	30
	Total Household Members	12	22	7
	Members under 5	3	5	2
	Members Age 6-15	3	2	2
	Members Age 16-59	5	12	3
	Members over 60	1	3	0
	Years of Education	0	0	0
	Monthly Household Expenses (GHC)	400,000	1,500,000	500,000
	Energy Access	Firewood	Firewood	Firewood
	House Type	Traditional	Traditional	Traditional
	Source of Information	Radio	Meetings, radio	Meetings, Radio
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	1	2	1
	Members under 5 with Diarrhea	1	0	0
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	1	1
	Members over 60 with Diarrhea	0	1	0
	Number of Days (combined)	5	7	7
	Main Cause of Diarrhea	food that isn't good for your stomach		
	Dirty Water	Yes	No	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	No	Yes
	Treatment of Diarrhea	Medicines	Hospital and Medicines	Medicines and Bread
	Caregiver for Someone with Diarrhea	Mother and Father	Mother and Father	Mother and Father
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	No	No	Yes
	Before Eating	Yes	Yes	Yes
	Before Cooking	No	No	Yes
	Use Soap When Washing Hands	Yes	No	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Free Range	Free Range	Free Range
	Public/Private/Shared			
	Time to Toilet Facility	10	15	2
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Dam	Dam	Dam
	Other Water Source in Dry Season			Borehole
	Main Water Source in Wet Season	Unprotected Well	Unprotected Well	Unprotected Well
	Other Water Source in Dry Season		Rainwater collection	Borehole, Rainwater collection
	Days Per Week Tap Flows	.	.	.
	Main Water Collectors	Mother and Female Child	Mothers	Mother and Female Children
	Daily Trips to Collect Water in Dry Season	5	6	6
	Daily Trips to Collect Water in Wet Season	3	10	8
	Total Trip Time in Dry Season	40	30	30
	Total Trip Time in Wet Season	10	10	20
	Water Source when not at Home	Tied (Ice)	Tied (Ice), Any Available	Sachet (Pure), Any Available
	Water Storage Vessels	Ceramic Vessels	Ceramic Vessels	Ceramic Vessels
	Storage Vessels Always Covered	Yes	No	No
	Method of Taking Water from Containers	Cup without Handle	Cup without Handle	Cup without Handle
	General Comments			

Survey Responses: General, Households 13-15

Survey Details	Survey Number	13	14	15
	Community	Gbalahi	Gbalahi	Gbalahi
	Date of Interview	11-Jan-07	11-Jan-07	11-Jan-07
	GPS North	9.43591	9.43552	9.43557
	GPS West	0.7676	0.76834	0.76821
	Filter User	No	Yes	Yes
	Surveyors Present	Wahabu, Ali	Shaq, Sophie	Shaq, Sophie
Household Information	Respondent's Age	65	57	45
	Total Household Members	19	13	14
	Members under 5	4	2	4
	Members Age 6-15	3	2	3
	Members Age 16-59	10	9	7
	Members over 60	2	0	0
	Years of Education	0	0	0
	Monthly Household Expenses (GHC)	1,000,000	Unknown	Unknown
	Energy Access	Firewood	Firewood and Charcoal	Firewood
	House Type	Traditional	Traditional	Traditional
	Source of Information	Meetings, Radio	Radio, People	Friends
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	0	1	0
	Members under 5 with Diarrhea	0	1	0
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	0	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	2	.
	Main Cause of Diarrhea	dirty food	sweets	dirty water
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	Medicines	Hospital or Clinic	Hospital or Clinic
	Caregiver for Someone with Diarrhea	Mother	Mother and Father	Mother, Father, Children
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	No	No	Yes
	Before Eating	Yes	Yes	Yes
	Before Cooking	No	Yes	Yes
	Use Soap When Washing Hands	No	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Free Range	Free Range	Free Range
	Public/Private/Shared			
	Time to Toilet Facility	2	2	3
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Dam	Dam	Dam
	Other Water Source in Dry Season			
	Main Water Source in Wet Season	Unprotected Well	Unprotected Well	Unprotected Well
	Other Water Source in Dry Season	Borehole, rainwater collection	Dam	
	Days Per Week Tap Flows	.	.	.
	Main Water Collectors	Mother and Female Child	Mother and Female Children	Mother and Children
	Daily Trips to Collect Water in Dry Season	5	5	3
	Daily Trips to Collect Water in Wet Season	3	5	3
	Total Trip Time in Dry Season	20	90	90
	Total Trip Time in Wet Season	15	15	15
	Water Source when not at Home	Tied (Ice), Any Available	Cloth Filtered	Cloth Filtered
	Water Storage Vessels	Ceramic Vessels	Jerry Can	Jerry Can
	Storage Vessels Always Covered	Yes	Yes	Yes
	Method of Taking Water from Containers	Cup without Handle	Pour directly or Spigot	Pour directly or Spigot
	General Comments			

Survey Responses: General, Households 16-18

Survey Details	Survey Number	16	17	18
	Community	Gbalahi	Chenshegu	Chenshegu
	Date of Interview	11-Jan-07	16-Jan-07	16-Jan-07
	GPS North	9.43546	9.36264	9.36232
	GPS West	0.76891	0.87102	0.8715
	Filter User	Yes	No	No
	Surveyors Present	Shaq, Sophie	Wahabu, Ali	Wahabu, Ali
Household Information	Respondent's Age	46	19	Not Sure
	Total Household Members	14	15	15
	Members under 5	1	6	1
	Members Age 6-15	8	4	4
	Members Age 16-59	4	4	8
	Members over 60	1	1	2
	Years of Education	0	0	0
	Monthly Household Expenses (GHC)	Unknown	1,000,000	2,000,000
	Energy Access	Firewood and Charcoal	Firewood and Charcoal	Firewood and Charcoal
	House Type	Traditional	Traditional	Traditional
	Source of Information	Radio, People	Radio - Justice Radio Station, meetings	Radio - Justice Radio station, Meetings, Children
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	0	0	0
	Members under 5 with Diarrhea	0	0	0
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	0	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	.	.
	Main Cause of Diarrhea	dirty water, hygiene, environment		dirty water and food
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	Hospital or Clinic	Medicines	Hospital and Medicines
	Caregiver for Someone with Diarrhea	Mother and Father	Mother and Father	Mother and Father
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	Yes	No	No
	Before Eating	Yes	Yes	Yes
	Before Cooking	Yes	No	Yes
	Use Soap When Washing Hands	Yes	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Free Range	Free Range	Free Range
	Public/Private/Shared			
	Time to Toilet Facility	3	5	2
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Dam	Dam	Dam
	Other Water Source in Dry Season			
	Main Water Source in Wet Season	Unprotected Well	Dam	Dam
	Other Water Source in Dry Season			
	Days Per Week Tap Flows	.	.	.
	Main Water Collectors	Mother and Female Children	Mother, Father, Children	Male and Female Children
	Daily Trips to Collect Water in Dry Season	7	4	2
	Daily Trips to Collect Water in Wet Season	7	4	4
	Total Trip Time in Dry Season	120	90	120
	Total Trip Time in Wet Season	20	10	10
	Water Source when not at Home	Cloth Filtered, Tied (Ice)	Tied (Ice)	Tied (Ice), Any Available
	Water Storage Vessels	Ceramic Filter Receptacle	Ceramic Vessels	Ceramic Vessels
	Storage Vessels Always Covered	Yes	No	Yes
	Method of Taking Water from Containers	Spigot	Cup without Handle	Cup without Handle
	General Comments	Chief's household		

Survey Responses: General, Households 19-21

Survey Details	Survey Number	19	20	21
	Community	Chenshegu	Chenshegu	Chenshegu
	Date of Interview	16-Jan-07	16-Jan-07	16-Jan-07
	GPS North	9.36251	9.36253	9.36361
	GPS West	0.87258	0.87139	0.8711
	Filter User	No	Yes	Yes
	Surveyors Present	Wahabu, Ali	Shaq, Sophie	Shaq, Sophie
Household Information	Respondent's Age	38	57	38
	Total Household Members	15	19	11
	Members under 5	4	3	2
	Members Age 6-15	5	2	3
	Members Age 16-59	3	12	5
	Members over 60	3	2	1
	Years of Education	0	0	0
	Monthly Household Expenses (GHC)	2,000,000	500,000	200,000
	Energy Access	Firewood and Charcoal	Firewood	Firewood
	House Type	Traditional	Traditional	Traditional
	Source of Information	Meetings, Radio, Husband, Children	Radio	Radio
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	0	0	0
	Members under 5 with Diarrhea	0	0	0
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	0	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	.	.
	Main Cause of Diarrhea	dirty water, when feel sick and weak	dirty water, dirty food, poor hygiene	dirty food, environment
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	Hospital and Medicines	Hospital or Clinic	Hospital or Clinic
	Caregiver for Someone with Diarrhea	Mother and Father	Mother and Father	Mother and Father
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	Yes	No	Yes
	Before Eating	Yes	Yes	No
	Before Cooking	Yes	No	No
	Use Soap When Washing Hands	Yes	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Free Range	Free Range	Free Range
	Public/Private/Shared			
	Time to Toilet Facility	2	3	3
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Dam	Dam	Dam
	Other Water Source in Dry Season			
	Main Water Source in Wet Season	Dam	Dam	Dam
	Other Water Source in Dry Season			
	Days Per Week Tap Flows	.	.	.
	Main Water Collectors	Mothers	Female Children, sometimes young men on bikes	Mother and Children
	Daily Trips to Collect Water in Dry Season	2	4	2
	Daily Trips to Collect Water in Wet Season	4	4	2
	Total Trip Time in Dry Season	120	180	180
	Total Trip Time in Wet Season	10	30	20
	Water Source when not at Home	Tied (Ice), Any Available	Sachet (Pure)	Sachet (Pure)
	Water Storage Vessels	Ceramic Vessels	Ceramic Filter Receptacle	Ceramic Filter Receptacle
	Storage Vessels Always Covered	No	Yes	Yes
	Method of Taking Water from Containers	Cup without Handle	Spigot	Spigot
	General Comments		Chief's family - own 2. One free, one bought	

Survey Responses: General, Households 22-24

Survey Details	Survey Number	22	23	24
	Community	Chenshegu	Gbanyamni	Gbanyamni
	Date of Interview	16-Jan-07	17-Jan-07	17-Jan-07
	GPS North	9.36403	9.4721	9.47249
	GPS West	0.87128	0.81858	0.81865
	Filter User	Yes	No	No
	Surveyors Present	Shaq, Sophie	Wahabu, Ali	Wahabu, Ali
Household Information	Respondent's Age	65	35	58
	Total Household Members	11	21	4
	Members under 5	3	6	0
	Members Age 6-15	3	4	1
	Members Age 16-59	3	9	2
	Members over 60	2	2	1
	Years of Education	0	0	0
	Monthly Household Expenses (GHC)	400,000	800,000	Unknown
	Energy Access	Firewood	Firewood and Charcoal	Firewood and Charcoal
	House Type	Traditional	Traditional	Traditional
	Source of Information	People	Radio, Meetings	Meetings, Radio
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	0	2	0
	Members under 5 with Diarrhea	0	2	0
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	0	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	14	.
	Main Cause of Diarrhea	dirty food, environment	dirty water, food, children eating sand	dirty food, insects, types of foods
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	Medicines	ORS and Medicines	Medicines
	Caregiver for Someone with Diarrhea	Mother and Father	Mother and Father	Mother
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	Yes	Yes	Yes
	Before Eating	No	Yes	Yes
	Before Cooking	No	No	Yes
	Use Soap When Washing Hands	Yes	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Free Range	Free Range	Free Range
	Public/Private/Shared			
	Time to Toilet Facility	3	5	4
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Dam	Tap in neighboring residential area	Dam
	Other Water Source in Dry Season			Buy tap water from nearby houses when dam tries up
	Main Water Source in Wet Season	Dam	Dam	Dam
	Other Water Source in Dry Season			
	Days Per Week Tap Flows	.	.	.
	Main Water Collectors	Female Children	Mother and Children	Female Child
	Daily Trips to Collect Water in Dry Season	1	2	4
	Daily Trips to Collect Water in Wet Season	4	6	8
	Total Trip Time in Dry Season	300	180	120
	Total Trip Time in Wet Season	30	10	10
	Water Source when not at Home	Tied (Ice), Sachet (Pure)	Tied (Ice), Any Available	Any Available
	Water Storage Vessels	Ceramic Filter Receptacle	Ceramic Vessels	Ceramic Vessels
	Storage Vessels Always Covered	Yes	No	Yes
	Method of Taking Water from Containers	Spigot	Cup without Handle	Cup without Handle
	General Comments	They sometimes get piped water from town.	They don't treat water with cloth filter if it's from a piped source	

Survey Responses: General, Households 25-27

Survey Details	Survey Number	25	26	27
	Community	Gbanyamni	Gbanyamni	Gbanyamni
	Date of Interview	17-Jan-07	17-Jan-07	17-Jan-07
	GPS North	9.47213	9.47223	9.47223
	GPS West	0.81916	0.81936	0.81863
	Filter User	No	No	Yes
	Surveyors Present	Wahabu, Ali	Wahabu, Ali	Shaq, Sophie
Household Information	Respondent's Age	40	25	40
	Total Household Members	8	12	8
	Members under 5	1	3	1
	Members Age 6-15	4	1	1
	Members Age 16-59	2	6	6
	Members over 60	1	2	0
	Years of Education	0	0	0
	Monthly Household Expenses (GHC)	400,000	500,000	120,000
	Energy Access	Firewood and Charcoal	Firewood and Charcoal	Firewood and Charcoal
	House Type	Traditional	Traditional	Traditional
	Source of Information	Radio-Justice FM and Fiila, Meetings	Meetings, Radio, Market, Visitors	Radio, people
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	0	0	0
	Members under 5 with Diarrhea	0	0	0
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	0	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	.	.
	Main Cause of Diarrhea		some foods	dirty food, hygiene
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	Hospital and Medicines	Hospital and Medicines	ORS
	Caregiver for Someone with Diarrhea	Mother and Father	Mother	Mother and Father
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	Yes	Yes	Yes
	Before Eating	Yes	Yes	Yes
	Before Cooking	Yes	Yes	No
	Use Soap When Washing Hands	Yes	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Free Range	Free Range	Free Range
	Public/Private/Shared			
	Time to Toilet Facility	10	5	3
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Dam	Dam	Dam
	Other Water Source in Dry Season	Buy tap water from nearby houses when dam tries up	Buy tap water from nearby houses when dam tries up	
	Main Water Source in Wet Season	Dam	Dam	Dam
	Other Water Source in Dry Season	Unprotected well		
	Days Per Week Tap Flows	.	.	.
	Main Water Collectors	Mother and Male Child	Mother and Children	Female Children
	Daily Trips to Collect Water in Dry Season	3	3	7
	Daily Trips to Collect Water in Wet Season	6	7	7
	Total Trip Time in Dry Season	120	60	10
	Total Trip Time in Wet Season	10	15	10
	Water Source when not at Home	Tied (Ice), Any Available	Tied (Ice), Sachet (Pure)	Sachet (Pure)
	Water Storage Vessels	Ceramic Vessels	Ceramic Vessels, Pots	Ceramic Filter Receptacle, Jerry Can
	Storage Vessels Always Covered	No	No	No
	Method of Taking Water from Containers	Cup without Handle	Cup without Handle	Pour directly or Spigot
	General Comments			Volunteer's house.

Survey Responses: General, Households 28-30

Survey Details	Survey Number	28	29	30
	Community	Gbanyamni	Gbanyamni	Gbanyamni
	Date of Interview	17-Jan-07	17-Jan-07	17-Jan-07
	GPS North	9.47256	9.47211	9.47198
	GPS West	0.81822	0.81714	0.81679
	Filter User	Yes	Yes	Yes
	Surveyors Present	Shaq, Sophie	Shaq, Sophie	Shaq, Sophie
Household Information	Respondent's Age	40	35	40
	Total Household Members	28	3	6
	Members under 5	3	0	0
	Members Age 6-15	5	1	1
	Members Age 16-59	17	2	5
	Members over 60	3	0	0
	Years of Education	0	0	0
	Monthly Household Expenses (GHC)	800,000	1,000,000	200,000
	Energy Access	Firewood and Charcoal	Firewood and Charcoal	Firewood and Charcoal
	House Type	Traditional	Traditional	Traditional
	Source of Information	Other people	Radio, People	Radio, People
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	0	0	0
	Members under 5 with Diarrhea	0	0	0
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	0	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	.	.
	Main Cause of Diarrhea	dirty water, food, environment	dirty water, food, environment	dirt
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	Hospital and Medicines	Medicines	Hospital or Clinic
	Caregiver for Someone with Diarrhea	Mother and Father	Mother and Father	Mother and Father
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	Yes	Yes	Yes
	Before Eating	No	Yes	No
	Before Cooking	No	Yes	No
	Use Soap When Washing Hands	Yes	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Free Range	Free Range	Free Range
	Public/Private/Shared			
	Time to Toilet Facility	3	3	3
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Dam	Dam	Dam
	Other Water Source in Dry Season		Borehole	Borehole
	Main Water Source in Wet Season	Dam	Dam	Dam
	Other Water Source in Dry Season			
	Days Per Week Tap Flows	.	.	.
	Main Water Collectors	Mother, Father, Children - When dry men go on bikes	Mother, Father	Mothers
	Daily Trips to Collect Water in Dry Season	1	1	6
	Daily Trips to Collect Water in Wet Season	4	6	4
	Total Trip Time in Dry Season	120	120	180
	Total Trip Time in Wet Season	10	20	20
	Water Source when not at Home	Tied (Ice)	Sachet (Pure), Tied (Ice)	Sachet (Pure)
	Water Storage Vessels	Ceramic Filter Receptacle	Ceramic Filter Receptacle	Ceramic Filter Receptacle
	Storage Vessels Always Covered	No	Yes	Yes
	Method of Taking Water from Containers	Spigot	Spigot	Spigot
	General Comments	Chief's house.		Not sure about collection times.

Survey Responses: General, Households 31-33

Survey Details	Survey Number	31	32	33
	Community	Kalariga	Kalariga	Kalariga
	Date of Interview	18-Jan-07	18-Jan-07	18-Jan-07
	GPS North	9.38199	9.38156	9.38292
	GPS West	0.82104	0.82173	0.82071
	Filter User	No	No	Yes
	Surveyors Present	Wahabu, Iman	Wahabu, Iman	Shaq, Sophie
Household Information	Respondent's Age	23	45	20
	Total Household Members	8	10	8
	Members under 5	1	0	0
	Members Age 6-15	1	2	1
	Members Age 16-59	4	8	6
	Members over 60	2	0	1
	Years of Education	0	0	0
	Monthly Household Expenses (GHC)	500,000	1,000,000	300,000
	Energy Access	Firewood and Charcoal	Firewood and Charcoal	Firewood and Charcoal
	House Type	Traditional	Traditional	Traditional
	Source of Information	Meetings, radio, market	Radio	Radio, People
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	0	1	0
	Members under 5 with Diarrhea	0	0	0
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	1	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	3	.
	Main Cause of Diarrhea	unsure	food that is not receptive to your stomach	dirty food, environment
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	Medicines	Hospital and Medicines	Hospital or Clinic
	Caregiver for Someone with Diarrhea	Father	Mother and Father	Mother and Father
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	Yes	No	Yes
	Before Eating	Yes	Yes	No
	Before Cooking	Yes	Yes	No
	Use Soap When Washing Hands	Yes	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Free Range	Free Range	Free Range
	Public/Private/Shared			
	Time to Toilet Facility	5	2	3
	Hand Washing Available at Toilet	No	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Dam	Dam	Dam
	Other Water Source in Dry Season		Public Standpipe	Public Standpipe
	Main Water Source in Wet Season	Dam	Dam	Dam
	Other Water Source in Dry Season			
	Days Per Week Tap Flows	.	.	.
	Main Water Collectors	Mother and Children	Mother and Children, Boys go on bikes in dry season	Mothers
	Daily Trips to Collect Water in Dry Season	3	3	4
	Daily Trips to Collect Water in Wet Season	5	4	4
	Total Trip Time in Dry Season	45	35	10
	Total Trip Time in Wet Season	10	10	10
	Water Source when not at Home	Tied (Ice), Any Available	Tied (Ice), Any Available	Sachet (Pure), Tied (Ice)
	Water Storage Vessels	Ceramic Vessels	Ceramic Vessels	Ceramic Filter Receptacle
	Storage Vessels Always Covered	No	No	Yes
	Method of Taking Water from Containers	Cup without Handle	Cup without Handle	Spigot
	General Comments			One of Alioune Dia's research families. They store piped water from Vitin Estates.

Survey Responses: General, Households 34-36

Survey Details	Survey Number	34	35	36
	Community	Kalariga	Kalariga	Vitin Estates
	Date of Interview	18-Jan-07	18-Jan-07	22-Jan-07
	GPS North	9.38308	9.38374	9.38601
	GPS West	0.8207	0.82038	0.81516
	Filter User	Yes	Yes	Yes
	Surveyors Present	Shaq, Sophie	Shaq, Sophie	Wahabu, Sophie
Household Information	Respondent's Age	65	32	38
	Total Household Members	8	10	4
	Members under 5	1	1	0
	Members Age 6-15	1	2	0
	Members Age 16-59	4	5	4
	Members over 60	2	2	0
	Years of Education	0	0	20
	Monthly Household Expenses (GHC)	400,000	300,000	2,000,000
	Energy Access	Firewood	Firewood and Charcoal	Electricity, Gas
	House Type	Traditional	Traditional	Modern
	Source of Information	Radio	Radio, People	Radio, Television, Newspaper
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	0	0	2
	Members under 5 with Diarrhea	0	0	0
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	0	2
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	.	4
	Main Cause of Diarrhea	dirty food, environment	dirty water, food, environment	dirty water, food
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	ORS	Hospital or Clinic	Medicines
	Caregiver for Someone with Diarrhea	Father	Mother and Father	Mother
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	No	Yes	Yes
	Before Eating	Yes	No	Yes
	Before Cooking	Yes	No	Yes
	Use Soap When Washing Hands	Yes	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Free Range	Free Range	Flush Toilet
	Public/Private/Shared			Private
	Time to Toilet Facility	2	3	0
	Hand Washing Available at Toilet	No	No	Yes
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Dam	Dam	Household Tap
	Other Water Source in Dry Season	Public Standpipe	Public Standpipe	Tanker truck
	Main Water Source in Wet Season	Dam	Dam	Household Tap
	Other Water Source in Dry Season	Public Standpipe		Tanker truck
	Days Per Week Tap Flows	.	.	1
	Main Water Collectors	Mother and Children	Mother and Children	
	Daily Trips in Dry Season	3	3	0
	Daily Trips in Wet Season	3	3	0
	Total Trip Time in Dry Season	60	60	0
	Total Trip Time in Wet Season	10	20	0
	Water Source when not at Home	Tied (Ice)	Sachet (Pure)	Sachet (Pure)
	Water Storage Vessels	Ceramic Vessels, Ceramic Filter Recept.	Ceramic Filter Receptacle	Ceramic Filter Receptacle
	Storage Vessels Always Covered	Yes	Yes	Yes
	Method of Taking Water	Spigot or Cup without Handle	Spigot	Spigot
	General Comments	One of Alioune Dia's research families.	One of Alioune Dia's research families.	Rachel interviewed her. She and her husband had diarrhea from food poisoning.

Survey Responses: General, Households 37-39

Survey Details	Survey Number	37	38	39
	Community	Vitin Estates	Vitin Estates	Kamina Barracks
	Date of Interview	22-Jan-07	22-Jan-07	23-Jan-07
	GPS North	9.38603	9.38524	9.46396
	GPS West	0.81498	0.81487	0.84917
	Filter User	Yes	Yes	Yes
	Surveyors Present	Wahabu, Sophie	Wahabu, Sophie	Wahabu, Sophie, Susan
Household Information	Respondent's Age	19	19	35
	Total Household Members	9	10	6
	Members under 5	0	1	1
	Members Age 6-15	4	2	1
	Members Age 16-59	5	7	4
	Members over 60	0	0	0
	Years of Education	12	0	9
	Monthly Household Expenses (GHC)	1,800,000	900,000	2,000,000
	Energy Access	Electricity, Gas	Electricity, Charcoal, Gas	Electricity, Firewood, Charcoal
	House Type	Modern	Modern	Modern
	Source of Information	Radio, Television	Radio, Friends	Radio, Television
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	0	1	1
	Members under 5 with Diarrhea	0	0	1
	Members Age 6-15 with Diarrhea	0	0	0
	Members Age 16-59 with Diarrhea	0	1	0
	Members over 60 with Diarrhea	0	0	0
	Number of Days (combined)	.	4	2
	Main Cause of Diarrhea	dirty water	dirty food	dirt
	Dirty Water	Yes	Yes	Yes
	Dirty Food	Yes	Yes	Yes
	Flies/Insects	Yes	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes	Yes
	Treatment of Diarrhea	Hospital or Clinic	Hospital and Medicines	ORS, Medicines, Good Water
	Caregiver for Someone with Diarrhea	Doctor	Mother and Father	Father
Hygiene Practices and Sanitation Access	Hand-washing Practices			
	After Using the Toilet	Yes	Yes	No
	Before Eating	Yes	Yes	Yes
	Before Cooking	No	Yes	Yes
	Use Soap When Washing Hands	No	Yes	Yes
	Has Soap Right Now	Yes	Yes	Yes
	Type of Toilet Facility	Flush Toilet	Flush Toilet	Flush Toilet
	Public/Private/Shared	Private	Private	Shared
	Time to Toilet Facility	0	0	2
	Hand Washing Available at Toilet	Yes	No	No
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Household Tap	Household Tap	Standpipe
	Other Water Source in Dry Season			
	Main Water Source in Wet Season	Household Tap	Household Tap	Standpipe
	Other Water Source in Dry Season			
	Days Per Week Tap Flows	1	2	7
	Main Water Collectors			Mothers
	Daily Trips to Collect Water in Dry Season	0	0	10
	Daily Trips to Collect Water in Wet Season	0	0	10
	Total Trip Time in Dry Season	0	0	4
	Total Trip Time in Wet Season	0	0	4
	Water Source when not at Home	Tied (Ice)	Sachet (Pure)	Sachet (Pure)
	Water Storage Vessels	Ceramic Filter Receptacle	Ceramic Filter Receptacle	Plastic bottles
	Storage Vessels Always Covered	Yes	Yes	Yes
	Method of Taking Water	Spigot	Spigot	Pour Directly
	General Comments	His mother was gone. Rachel interviewed the household last year.	Niece interviewed since mother was gone. Rachel's family.	Rachel interviewed her.

Survey Responses: General, Households 40-41

Survey Details	Survey Number	40	41
	Community	Kamina Barracks	Kamina Barracks
	Date of Interview	23-Jan-07	23-Jan-07
	GPS North	9.46393	9.46401
	GPS West	0.85066	0.85077
	Filter User	Yes	Yes
	Surveyors Present	Wahabu, Sophie, Susan	Wahabu, Sophie, Susan
Household Information	Respondent's Age	31	28
	Total Household Members	4	3
	Members under 5	1	1
	Members Age 6-15	1	0
	Members Age 16-59	2	2
	Members over 60	0	0
	Years of Education	10	9
	Monthly Household Expenses (GHC)	1,000,000	1,900,000
	Energy Access	Electricity, Charcoal	Electricity, Charcoal, Gas
	House Type	Modern	Modern
	Source of Information	Radio	Radio, Television
Diarrhea Prevalence and Knowledge	Members with Diarrhea in Past Week	1	0
	Members under 5 with Diarrhea	0	0
	Members Age 6-15 with Diarrhea	0	0
	Members Age 16-59 with Diarrhea	1	0
	Members over 60 with Diarrhea	0	0
	Number of Days (combined)	4	.
	Main Cause of Diarrhea	types of food - okra for her	dirt causes it
	Dirty Water	Yes	Yes
	Dirty Food	Yes	Yes
	Flies/Insects	Yes	Yes
	Poor Hygiene/Environment	Yes	Yes
	Treatment of Diarrhea	Hospital and Medicines	Hospital or Clinic
	Caregiver for Someone with Diarrhea	Mother and Father	Mother and Father
Hygiene Practices and Sanitation Access	Hand-washing Practices		
	After Using the Toilet	Yes	Yes
	Before Eating	Yes	Yes
	Before Cooking	Yes	Yes
	Use Soap When Washing Hands	Yes	Yes
	Has Soap Right Now	Yes	Yes
	Type of Toilet Facility	Flush Toilet	Flush Toilet
	Public/Private/Shared	Private	Private
	Time to Toilet Facility	0	0
	Hand Washing Available at Toilet	Yes	Yes
Drinking Water Source, Collection, and Storage	Main Water Source in Dry Season	Household Tap	Household Tap
	Other Water Source in Dry Season		
	Main Water Source in Wet Season	Household Tap	Household Tap
	Other Water Source in Dry Season		
	Days Per Week Tap Flows	7	7
	Main Water Collectors		
	Daily Trips to Collect Water in Dry Season	0	0
	Daily Trips to Collect Water in Wet Season	0	0
	Total Trip Time in Dry Season	0	2
	Total Trip Time in Wet Season	0	2
	Water Source when not at Home	Sachet (Pure)	Takes it with her
	Water Storage Vessels	Ceramic Filter Receptacle	Ceramic Filter Receptacle, Plastic Bottles
	Storage Vessels Always Covered	Yes	Yes
	Method of Taking Water from Containers	Spigot	Pour directly or Spigot
	General Comments		

Appendix C: Water Treatment Survey Responses

Treatment Survey Responses: Households 1-3

Survey Information	Survey Number	1	2	3
	Community	Shenshegu	Shenshegu	Shenshegu
	Date of Interview	8-Jan-07	8-Jan-07	8-Jan-07
	GPS North	9.64438	9.40225	9.4031
	GPS West	0.19055	0.88243	0.88222
General Questions	Water is Safe to Drink without Treatment	No	Yes	No
	Why Water is Unsafe without Treatment	Dirty, microbes	But dirty	Dirt
	Treatment Method	Cloth and Ceramic Filter	Cloth Filter	Cloth and Ceramic Filter
	Attended PHW Presentation	Not Asked	Not Asked	Not Asked
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	.	Yes	.
	Amount Willing to Spend on Treatment	.	60,000	.
	Family Decision Maker		Oldest family members	
	Aware of Ceramic Filters in Village	.	No	.
	Has Had Water from Filter	.	No	.
Questions for Filter Users	Source for Learning about the Filter	Husband is community liaison		Not Asked
	Family Member who Decided to Buy It	Father		Father
	Days a Week System is Used	7	.	7
	Water Quality (better, same, worse)	Better	.	Better
	Treat All Water Family Drinks	No	.	No
	When Water is Not Treated	When outside, but children drink treated always		When not convenient
	Notice Health Improvements with Treatment	Yes	.	Yes
	Who Treats the Water	Mother		Mother
	Happy with the Technology	Yes	.	Yes
	Why or why not	Design is nice		Improves health
	Easy to Use	Yes	.	Yes
	Would Recommend it to Others	Yes	.	Yes
	Problems with Technology	None		None
	Cleaning Frequency	When it isn't flowing well		Every 3 days
	Would Buy a New One if Filter Broke	Yes	.	Yes
	Willing to Pay for New Filter (GHC)	60,000	.	20,000
	Neighbors Would Buy One at this Price	Yes	.	Yes
	Comments about Water Treatment and the Filter			

Treatment Survey Responses: Households 4-6

Survey Information	Survey Number	4	5	6
	Community	Shenshegu	Taha	Taha
	Date of Interview	8-Jan-07	9-Jan-07	9-Jan-07
	GPS North	9.40292	9.4359	9.43547
	GPS West	0.88244	0.782	0.78462
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	Dirt, people get sick	Dirty	Dirty
	Treatment Method	Cloth and Ceramic Filter	Cloth and Ceramic Filter	Cloth and Ceramic Filter
	Attended PHW Presentation	Not Asked	No	Yes
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	.	.	.
	Amount Willing to Spend on Treatment	.	.	.
	Family Decision Maker			
	Aware of Ceramic Filters in Village	.	.	.
	Has Had Water from Filter	.	.	.
Questions for Filter Users	Source for Learning about the Filter	Brothers had one - saw theirs	Husband saw it at volunteer's house and learned how good it was	Meeting
	Family Member who Decided to Buy It	Father	Father	Mother
	Days a Week System is Used	7	7	7
	Water Quality (better, same, worse)	Better	Better	Better
	Treat All Water Family Drinks	Yes	Yes	Yes
	When Water is Not Treated			
	Notice Health Improvements with Treatment	Yes	Yes	Yes
	Who Treats the Water	Mother	Male Child	Mother
	Happy with the Technology	Yes	Yes	Yes
	Why or why not	Good for health	Easy to use	Makes water clear
	Easy to Use	Yes	Yes	Yes
	Would Recommend it to Others	Yes	Yes	Yes
	Problems with Technology	None	They need the brush to clean it	None
	Cleaning Frequency	Haven't needed to yet - just got it	Not yet	Twice a week
	Would Buy a New One if Filter Broke	Yes	Yes	Yes
	Willing to Pay for New Filter (GHC)	60,000	60,000	60,000
	Neighbors Would Buy One at this Price	Some	Yes	Yes
	Comments about Water Treatment and the Filter	Knows about using alum, but says alum gives diarrhea		

Treatment Survey Responses: Households 7-9

Survey Information	Survey Number	7	8	9
	Community	Taha	Taha	Taha
	Date of Interview	9-Jan-07	9-Jan-07	9-Jan-07
	GPS North	9.43492	9.43591	9.43604
	GPS West	0.78602	0.78391	0.78422
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	Guinea worm	People get sick	Guinea worm
	Treatment Method	Cloth and Ceramic Filter	Cloth Filter	Cloth Filter
	Attended PHW Presentation	Yes	No	No
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	.	Yes	Yes
	Amount Willing to Spend on Treatment	.	60,000	60,000
	Family Decision Maker		Father	Senior wife
	Aware of Ceramic Filters in Village	.	Yes	Yes
	Has Had Water from Filter	.	No	No
Questions for Filter Users	Source for Learning about the Filter	Children encouraged them to buy it		Heard from her mother
	Family Member who Decided to Buy It	Mother and father		
	Days a Week System is Used	7	.	.
	Water Quality (better, same, worse)	Better	.	.
	Treat All Water Family Drinks	Yes	.	.
	When Water is Not Treated			
	Notice Health Improvements with Treatment	Yes	.	.
	Who Treats the Water	Mother		
	Happy with the Technology	Sort of	.	.
	Why or why not	Overall yes, but don't like the taste or smell		
	Easy to Use	Yes	.	.
	Would Recommend it to Others	Yes	.	.
	Problems with Technology	None		
	Cleaning Frequency	Not yet		
	Would Buy a New One if Filter Broke	Yes	.	.
	Willing to Pay for New Filter (GHC)	50,000	.	.
	Neighbors Would Buy One at this Price	Yes	.	.
	Comments about Water Treatment and the Filter			

Treatment Survey Responses: Households 10-12

Survey Information	Survey Number	10	11	12
	Community	Taha	Gbalahi	Gbalahi
	Date of Interview	9-Jan-07	11-Jan-07	11-Jan-07
	GPS North	9.43569	9.43483	9.435
	GPS West	0.78303	0.76883	0.76762
General Questions	Water is Safe to Drink without Treatment	No	No	Yes
	Why Water is Unsafe without Treatment	Dirty	Dirty, larvae, living organisms	But still use cloth for dirt and organisms
	Treatment Method	Cloth Filter	Cloth Filter	Cloth Filter
	Attended PHW Presentation	Not Asked	.	.
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	Yes	Yes	Yes
	Amount Willing to Spend on Treatment	10,000	60,000	60,000
	Family Decision Maker	Father	Male and female adults	Father
	Aware of Ceramic Filters in Village	Yes	Yes	Yes
	Has Had Water from Filter	No	No	Yes
Questions for Filter Users	Source for Learning about the Filter			
	Family Member who Decided to Buy It			
	Days a Week System is Used	.	.	.
	Water Quality (better, same, worse)	.	.	.
	Treat All Water Family Drinks	.	.	.
	When Water is Not Treated			
	Notice Health Improvements with Treatment	.	.	.
	Who Treats the Water			
	Happy with the Technology	.	.	.
	Why or why not			
	Easy to Use	.	.	.
	Would Recommend it to Others	.	.	.
	Problems with Technology			
	Cleaning Frequency			
	Would Buy a New One if Filter Broke	.	.	.
	Willing to Pay for New Filter (GHC)	.	.	.
	Neighbors Would Buy One at this Price	.	.	.
	Comments about Water Treatment and the Filter		family has requested a filter but has not gotten it yet	family has requested a filter but has not gotten it yet. Respondent saw the filter in Tamale and had water from it there (and not in her village)

Treatment Survey Responses: Households 13-15

Survey Information	Survey Number	13	14	15
	Community	Gbalahi	Gbalahi	Gbalahi
	Date of Interview	11-Jan-07	11-Jan-07	11-Jan-07
	GPS North	9.43591	9.43552	9.43557
	GPS West	0.7676	0.76834	0.76821
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	Larvae, worms present in water	Dirty, larvae, stomach issues	Stomach problems, people get sick
	Treatment Method	Cloth Filter	Tamakloe Ceramic Filter	Cloth and Ceramic Filter
	Attended PHW Presentation	.	No	Yes
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	Yes	.	.
	Amount Willing to Spend on Treatment	Needs to know the price first	.	.
	Family Decision Maker	Young males		
	Aware of Ceramic Filters in Village	Yes	.	.
	Has Had Water from Filter	No	.	.
Questions for Filter Users	Source for Learning about the Filter		Popular in village	Village volunteer brings information to them
	Family Member who Decided to Buy It		Mother and father	Father
	Days a Week System is Used	.	7	7
	Water Quality (better, same, worse)	.	Better	Better
	Treat All Water Family Drinks	.	Yes	Yes
	When Water is Not Treated			
	Notice Health Improvements with Treatment	.	Yes	Yes
	Who Treats the Water		Mother	Mother
	Happy with the Technology	.	Yes	Yes
	Why or why not			Health
	Easy to Use	.	Yes	Yes
	Would Recommend it to Others	.	Yes	Yes
	Problems with Technology		Takes some time to start flowing when water is first added	None
	Cleaning Frequency		When flow is low, every 4-5 days	Washes the plastic some
	Would Buy a New One if Filter Broke	.	Yes	Yes
	Willing to Pay for New Filter (GHC)	.	60,000	60,000
	Neighbors Would Buy One at this Price	.	Yes	Yes
	Comments about Water Treatment and the Filter		She's praying about the water problems. She has seen good changes in the village since the filter came and hopes God will continue to help.	

Treatment Survey Responses: Households 16-18

Survey Information	Survey Number	16	17	18
	Community	Gbalahi	Chenshegu	Chenshegu
	Date of Interview	11-Jan-07	16-Jan-07	16-Jan-07
	GPS North	9.43546	9.36264	9.36232
	GPS West	0.76891	0.87102	0.8715
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	Guinea worm	Sicknesses	Dirty, worms, living organisms in it
	Treatment Method	Cloth and Ceramic Filter	Cloth Filter	Cloth Filter
	Attended PHW Presentation	Not Asked	No	No
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	.	Yes	Yes
	Amount Willing to Spend on Treatment	.	80,000	20,000
	Family Decision Maker		Father	Father
	Aware of Ceramic Filters in Village	.	Yes	Yes
	Has Had Water from Filter	.	Yes	No
Questions for Filter Users	Source for Learning about the Filter	Chief is husband		
	Family Member who Decided to Buy It	n/a		
	Days a Week System is Used	7	.	.
	Water Quality (better, same, worse)	Better	.	.
	Treat All Water Family Drinks	Yes	.	.
	When Water is Not Treated			
	Notice Health Improvements with Treatment	Yes	.	.
	Who Treats the Water	Mother		
	Happy with the Technology	Yes	.	.
	Why or why not	Makes pure water		
	Easy to Use	Yes	.	.
	Would Recommend it to Others	Yes	.	.
	Problems with Technology	None		
	Cleaning Frequency	Every 4 days with the brush. washes plastic with soap		
	Would Buy a New One if Filter Broke	Yes	.	.
	Willing to Pay for New Filter (GHC)	60,000	.	.
	Neighbors Would Buy One at this Price	Yes	.	.
	Comments about Water Treatment and the Filter	Chief's household	This family wants to buy the filter. They have tried the water and thinks it's very good.	Says they can't afford the filter.

Treatment Survey Responses: Households 19-21

Survey Information	Survey Number	19	20	21
	Community	Chenshegu	Chenshegu	Chenshegu
	Date of Interview	16-Jan-07	16-Jan-07	16-Jan-07
	GPS North	9.36251	9.36253	9.36361
	GPS West	0.87258	0.87139	0.8711
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	Worms/larvae, people get sick	Guinea worm	Guinea worm
	Treatment Method	Cloth Filter	Cloth and Ceramic Filter	Cloth and Ceramic Filter
	Attended PHW Presentation	No	Yes	Yes
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	Yes	.	.
	Amount Willing to Spend on Treatment	40,000	.	.
	Family Decision Maker	Husband		
	Aware of Ceramic Filters in Village	Yes	.	.
	Has Had Water from Filter	No	.	.
Questions for Filter Users	Source for Learning about the Filter		Chief is husband. They have 2 - 1 free, 1 bought	
	Family Member who Decided to Buy It		Father	Mother and father
	Days a Week System is Used	.	7	7
	Water Quality (better, same, worse)	.	Better	Better
	Treat All Water Family Drinks	.	No	Yes
	When Water is Not Treated		When not enough water for everyone	
	Notice Health Improvements with Treatment	.	Yes	Yes
	Who Treats the Water		Mother	Mother
	Happy with the Technology	.	Yes	Yes
	Why or why not			
	Easy to Use	.	Yes	Yes
	Would Recommend it to Others	.	Yes	Yes
	Problems with Technology		They drink unfiltered when there isn't enough filtered water for everyone	None
	Cleaning Frequency		Every 2 days - their water is bad	Every 3 days
	Would Buy a New One if Filter Broke	.	Yes	Yes
	Willing to Pay for New Filter (GHC)	.	60,000	60,000
	Neighbors Would Buy One at this Price	.	Yes	Some
	Comments about Water Treatment and the Filter		Chief's family - own 2. One free, one bought	The price is still a lot for some people.

Treatment Survey Responses: Households 22-24

Survey Information	Survey Number	22	23	24
	Community	Chenshegu	Gbanyamni	Gbanyamni
	Date of Interview	16-Jan-07	17-Jan-07	17-Jan-07
	GPS North	9.36403	9.4721	9.47249
	GPS West	0.87128	0.81858	0.81865
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	Guinea worm	Living organisms - worms	Dirty, worms
	Treatment Method	Cloth and Ceramic Filter	Cloth Filter	Cloth Filter
	Attended PHW Presentation	Yes	No	Yes
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	.	Yes	Yes
	Amount Willing to Spend on Treatment	.	20,000	40,000
	Family Decision Maker		Husbands	Mother, father
	Aware of Ceramic Filters in Village	.	Yes	Yes
	Has Had Water from Filter	.	No	No
Questions for Filter Users	Source for Learning about the Filter	Mother		
	Family Member who Decided to Buy It	Mother		
	Days a Week System is Used	7	.	.
	Water Quality (better, same, worse)	Better	.	.
	Treat All Water Family Drinks	Yes	.	.
	When Water is Not Treated			
	Notice Health Improvements with Treatment	Yes	.	.
	Who Treats the Water	Mother		
	Happy with the Technology	Yes	.	.
	Why or why not	It's cool - don't see holes, but water goes through		
	Easy to Use	Yes	.	.
	Would Recommend it to Others	Yes	.	.
	Problems with Technology	None		
	Cleaning Frequency	Once per week		
	Would Buy a New One if Filter Broke	Yes	.	.
	Willing to Pay for New Filter (GHC)	60,000	.	.
	Neighbors Would Buy One at this Price	Yes	.	.
	Comments about Water Treatment and the Filter	Lots of people want it, so PHW needs to bring more to sell.	They don't treat water with cloth filter if it's from a piped source	They think filter produces good water. She is busy and husband is sick - not interested in producing HWTS products.

Treatment Survey Responses: Households 25-27

Survey Information	Survey Number	25	26	27
	Community	Gbanyamni	Gbanyamni	Gbanyamni
	Date of Interview	17-Jan-07	17-Jan-07	17-Jan-07
	GPS North	9.47213	9.47223	9.47223
	GPS West	0.81916	0.81936	0.81863
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	Worms	Worms	Worms, sickness
	Treatment Method	Cloth Filter	Cloth Filter	Cloth and Ceramic Filter
	Attended PHW Presentation	Yes	Yes	Yes
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	Yes	Yes	.
	Amount Willing to Spend on Treatment	20,000	20,000	.
	Family Decision Maker	Husband	Husband and wife	
	Aware of Ceramic Filters in Village	Yes	Yes	.
	Has Had Water from Filter	Yes	No	.
Questions for Filter Users	Source for Learning about the Filter			Volunteer's house
	Family Member who Decided to Buy It			n/a
	Days a Week System is Used	.	.	7
	Water Quality (better, same, worse)	.	.	Better
	Treat All Water Family Drinks	.	.	Yes
	When Water is Not Treated			
	Notice Health Improvements with Treatment	.	.	Yes
	Who Treats the Water			Mother
	Happy with the Technology	.	.	Yes
	Why or why not			
	Easy to Use	.	.	Yes
	Would Recommend it to Others	.	.	Yes
	Problems with Technology			None
	Cleaning Frequency			Once per week
	Would Buy a New One if Filter Broke	.	.	Yes
	Willing to Pay for New Filter (GHC)	.	.	60,000
	Neighbors Would Buy One at this Price	.	.	Yes
	Comments about Water Treatment and the Filter	They don't filter tap water. They say filter performs well and is excellent quality.		Volunteer's house. Thinks more people will get them once PHW brings more. Filter is good for their child's health - was vomiting, now ok.

Treatment Survey Responses: Households 28-30

Survey Information	Survey Number	28	29	30
	Community	Gbanyamni	Gbanyamni	Gbanyamni
	Date of Interview	17-Jan-07	17-Jan-07	17-Jan-07
	GPS North	9.47256	9.47211	9.47198
	GPS West	0.81822	0.81714	0.81679
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	Worms	Guinea worm	Guinea worm
	Treatment Method	Cloth and Ceramic Filter	Cloth and Ceramic Filter	Cloth and Ceramic Filter
	Attended PHW Presentation	Yes	Yes	Yes
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	.	.	.
	Amount Willing to Spend on Treatment	.	.	.
	Family Decision Maker			
	Aware of Ceramic Filters in Village	.	.	.
	Has Had Water from Filter	.	.	.
Questions for Filter Users	Source for Learning about the Filter	Chief's house		Husband went to the PHW presentation
	Family Member who Decided to Buy It	n/a	Father	Father
	Days a Week System is Used	7	7	7
	Water Quality (better, same, worse)	Better	Better	Better
	Treat All Water Family Drinks	Yes	Yes	Yes
	When Water is Not Treated	Looks like lots of people don't use it		
	Notice Health Improvements with Treatment	Yes	Yes	Yes
	Who Treats the Water	Mother	Mother, father	Mother
	Happy with the Technology	Yes	Yes	Yes
	Why or why not			
	Easy to Use	Yes	Yes	Yes
	Would Recommend it to Others	Yes	Yes	Yes
	Problems with Technology	Weren't using it correctly	None	Need brush to clean it
	Cleaning Frequency	Every 1-2 days	Once per week	Sometimes rinse it; need brush
	Would Buy a New One if Filter Broke	Yes	Yes	Yes
	Willing to Pay for New Filter (GHC)	60,000	60,000	60,000
	Neighbors Would Buy One at this Price	Yes	Yes	Yes
	Comments about Water Treatment and the Filter	Chief's house. Looked like people weren't really using it - saw people drinking straight from ceramic vessels, and it wasn't set up correctly.	Very enthusiastic about filter. Husband is herbalist, and many people visit their home. They're not shy to provide the water to visitors, and people come from other places and want to buy the filter. The filtered water can't even be compared to unfiltered	

Treatment Survey Responses: Households 31-33

Survey Information	Survey Number	31	32	33
	Community	Kalariga	Kalariga	Kalariga
	Date of Interview	18-Jan-07	18-Jan-07	18-Jan-07
	GPS North	9.38199	9.38156	9.38292
	GPS West	0.82104	0.82173	0.82071
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	People get sick	Worms	Worms
	Treatment Method	Cloth Filter	Cloth Filter	Cloth and Ceramic Filter
	Attended PHW Presentation	.	.	Yes
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	Yes	Yes	.
	Amount Willing to Spend on Treatment	20,000	20,000	.
	Family Decision Maker	Mother, father	Father	
	Aware of Ceramic Filters in Village	Yes	Yes	.
	Has Had Water from Filter	Yes	Yes	.
Questions for Filter Users	Source for Learning about the Filter			Ali's research
	Family Member who Decided to Buy It			n/a
	Days a Week System is Used	.	.	7
	Water Quality (better, same, worse)	.	.	Better
	Treat All Water Family Drinks	.	.	Yes
	When Water is Not Treated			
	Notice Health Improvements with Treatment	.	.	Yes
	Who Treats the Water			Mother, father
	Happy with the Technology	.	.	Yes
	Why or why not			
	Easy to Use	.	.	Yes
	Would Recommend it to Others	.	.	Yes
	Problems with Technology			None
	Cleaning Frequency			2 times per week
	Would Buy a New One if Filter Broke	.	.	Yes
	Willing to Pay for New Filter (GHC)	.	.	60,000
	Neighbors Would Buy One at this Price	.	.	Yes
	Comments about Water Treatment and the Filter	She really likes the filtered water.	Thought water from filter was very good.	One of Alioune Dia's research families. They store piped water from Vitin Estates - pay some for it.

Treatment Survey Responses: Households 34-36

Survey Information	Survey Number	34	35	36
	Community	Kalariga	Kalariga	Vitin Estates
	Date of Interview	18-Jan-07	18-Jan-07	22-Jan-07
	GPS North	9.38308	9.38374	9.38601
	GPS West	0.8207	0.82038	0.81516
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	Guinea worm	Guinea worm	Dirty
	Treatment Method	Cloth and Ceramic Filter	Tamakloe Ceramic Filter	Tamakloe Ceramic Filter
	Attended PHW Presentation	Yes	Yes	No
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	.	.	.
	Amount Willing to Spend on Treatment	.	.	.
	Family Decision Maker			
	Aware of Ceramic Filters in Village	.	.	.
	Has Had Water from Filter	.	.	.
Questions for Filter Users	Source for Learning about the Filter	Ali's research	Ali's research	
	Family Member who Decided to Buy It	n/a	n/a	Father
	Days a Week System is Used	7	7	7
	Water Quality (better, same, worse)	Better	Better	Better
	Treat All Water Family Drinks	Yes	Yes	Yes
	When Water is Not Treated			
	Notice Health Improvements with Treatment	Yes	Yes	No
	Who Treats the Water	Grandmother	Mother	Mother
	Happy with the Technology	Yes	Yes	Yes
	Why or why not			
	Easy to Use	Yes	Yes	Yes
	Would Recommend it to Others	Yes	Yes	Yes
	Problems with Technology	None	None	Some spigot problems
	Cleaning Frequency	Every 2 days	When dirty	Once per week
	Would Buy a New One if Filter Broke	Yes	Yes	Yes
	Willing to Pay for New Filter (GHC)	60,000	60,000	50,000
	Neighbors Would Buy One at this Price	Yes	Yes	Yes
	Comments about Water Treatment and the Filter	One of Alioune Dia's research families.	One of Alioune Dia's research families.	Rachel interviewed her last year. She mostly likes the filter for improving the water's taste and getting rid of dirt.

Treatment Survey Responses: Households 37-39

Survey Information	Survey Number	37	38	39
	Community	Vitin Estates	Vitin Estates	Kamina Barracks
	Date of Interview	22-Jan-07	22-Jan-07	23-Jan-07
	GPS North	9.38603	9.38524	9.46396
	GPS West	0.81498	0.81487	0.84917
General Questions	Water is Safe to Drink without Treatment	No	No	No
	Why Water is Unsafe without Treatment	Dirty	Dirty	Dust settles in bucket
	Treatment Method	Tamakloe Ceramic Filter	Tamakloe Ceramic Filter	Tamakloe Ceramic Filter
	Attended PHW Presentation	No	No	No
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	.	.	.
	Amount Willing to Spend on Treatment	.	.	.
	Family Decision Maker			
	Aware of Ceramic Filters in Village	.	.	.
	Has Had Water from Filter	.	.	.
Questions for Filter Users	Source for Learning about the Filter			
	Family Member who Decided to Buy It	Mother	Mother	Father
	Days a Week System is Used	7	7	7
	Water Quality (better, same, worse)	Better	Better	Better
	Treat All Water Family Drinks	Yes	Yes	Yes
	When Water is Not Treated			
	Notice Health Improvements with Treatment	Yes	Yes	Yes
	Who Treats the Water	Son	Everyone	Mother
	Happy with the Technology	Yes	Yes	Yes
	Why or why not	Cleans the water, less diarrhea	Takes out the dirt	
	Easy to Use	Yes	Yes	Yes
	Would Recommend it to Others	Yes	Yes	Yes
	Problems with Technology	Flows too slow	Spigot broke - had to replace it	Blue part comes off of tap, slow flow
	Cleaning Frequency	Once per week	Once per week	Once per week
	Would Buy a New One if Filter Broke	Yes	Yes	Yes
	Willing to Pay for New Filter (GHC)	50,000	150,000	120,000
	Neighbors Would Buy One at this Price	No	Yes	Yes
	Comments about Water Treatment and the Filter	His mother was gone. Rachel interviewed the household last year.	Niece interviewed since mother was gone. Rachel's family.	Rachel interviewed her.

Treatment Survey Responses: Households 40-41

Survey Information	Survey Number	40	41
	Community	Kamina Barracks	Kamina Barracks
	Date of Interview	23-Jan-07	23-Jan-07
	GPS North	9.46393	9.46401
	GPS West	0.85066	0.85077
General Questions	Water is Safe to Drink without Treatment	No	No
	Why Water is Unsafe without Treatment	See dirt	Dirt in it
	Treatment Method	Tamakloe Ceramic Filter	Tamakloe Ceramic Filter
	Attended PHW Presentation	No	No
Questions for Non Filter Users	Want to Treat Water Additionally before Drinking	.	.
	Amount Willing to Spend on Treatment	.	.
	Family Decision Maker		
	Aware of Ceramic Filters in Village	.	.
	Has Had Water from Filter	.	.
Questions for Filter Users	Source for Learning about the Filter		
	Family Member who Decided to Buy It	Father	Mother, father
	Days a Week System is Used	7	7
	Water Quality (better, same, worse)	Better	Better
	Treat All Water Family Drinks	Yes	Yes
	When Water is Not Treated		
	Notice Health Improvements with Treatment	Yes	Yes
	Who Treats the Water	Mother	Mother
	Happy with the Technology	Yes	Yes
	Why or why not	Taste is better, can see dirt that settled in it	Works well, makes water clear
	Easy to Use	Yes	Yes
	Would Recommend it to Others	Yes	Yes
	Problems with Technology	Container cracked - leaks a little	Initially tasted like clay, but now it doesn't - but she said she liked the clay taste ok
	Cleaning Frequency	Once per week	Every 3 weeks
	Would Buy a New One if Filter Broke	Yes	Yes
	Willing to Pay for New Filter (GHC)	50000 for replacement filter	200000 for complete system
	Neighbors Would Buy One at this Price	Unsure	Yes
	Comments about Water Treatment and the Filter	Tap is ok since kids don't use it - turn it so they don't get to it. Chose it to get bacteria out.	She's recommended it to 3-4 people who then bought it. Price she'd pay is for complete system. Thinks neighbors who see its importance will buy it.

Appendix D: Water Quality Results

Membrane Filtration Complete Data

Household	Type	Dilution	Red Colonies	Blue Colonies	Sum	E. coli per 100mL	Total Coliform per 100mL	Average E. coli per 100mL	Average TC per 100mL
1	Blank	1	10	1	11	1	11		
	Unfiltered	10	10	0	10	0	100	0	100
	Unfiltered	1	TNTC	0	TNTC	0	TNTC		
	Blank	1	11	0	11	0	11		
	Filtered	10	8	0	8	0	80	0	76.5
	Filtered	1	73	0	73	0	73		
2	Blank	1	13	0	13	0	13		
	Unfiltered	10	TNTC	0	TNTC	0	TNTC	0	TNTC
	Unfiltered	1	TNTC	0	TNTC	0	TNTC		
3	Blank	1	1	0	1	0	1		
	Unfiltered	10	6	0	6	0	60	0	60
	Unfiltered	1	Unsure	Unsure	Unsure	Unsure	Unsure		
	Blank	1	1	1	2	1	2		
	Filtered	10	Unsure	Unsure	Unsure	Unsure	Unsure	Unsure	Unsure
	Filtered	1	Unsure	Unsure	Unsure	Unsure	Unsure		
4	Blank	1	1	0	1	0	1		
	Unfiltered	10	41	0	41	0	410	0	410
	Unfiltered	1	TNTC	0	TNTC	0	TNTC		
	Blank	1	0	0	0	0	0		
	Filtered	10	41	1	42	10	420	5.5	420
	Filtered	1	TNTC	1	TNTC	1	TNTC		
5	Blank	1	0	0	0	0	0		
	Unfiltered	100	TNTC	1	TNTC	100	TNTC	100	TNTC
	Unfiltered	10	TNTC	TNTC	TNTC	TNTC	TNTC		
	Blank	1	1	0	1	0	1		
	Filtered	10	1	1	2	10	20	5	10
	Filtered	1	0	0	0	0	0		
6	Blank	1	0	0	0	0	0		
	Unfiltered	100	TNTC	11	TNTC	1100	TNTC	915	TNTC
	Unfiltered	10	TNTC	73	TNTC	730	TNTC		
	Blank	1	0	0	0	0	0		
	Filtered	10	35	0	35	0	350	3.5	266
	Filtered	1	175	7	182	7	182		
7	Blank	1	0	0	0	0	0		
	Unfiltered	100	8	0	8	0	800	0	750
	Unfiltered	10	70	0	70	0	700		
	Blank	1	1	0	1	0	1		
	Filtered	10	0	0	0	0	0	0	0
	Filtered	1	0	0	0	0	0		
8	Blank	1	0	0	0	0	0		
	Unfiltered	100	99	15	114	1500	11400	1255	11400
	Unfiltered	10	TNTC	101	TNTC	1010	TNTC		

Household	Type	Dilution	Red Colonies	Blue Colonies	Sum	E. coli per 100mL	Total Coliform per 100mL	Average E. coli per 100mL	Average TC per 100mL
9	Blank	1	0	0	0	0	0		
	Unfiltered	100	87	4	91	400	9100	525	9100
	Unfiltered	10	TNTC	65	TNTC	650	TNTC		
10	Blank	1	0	0	0	0	0		
	Unfiltered	100	TNTC	5	TNTC	500	TNTC	435	TNTC
	Unfiltered	10	TNTC	37	TNTC	370	TNTC		
11	Blank	1	0	0	0	0	0		
	Unfiltered	200	118	3	121	600	24200	600	24200
	Unfiltered	100	TNTC	6	TNTC	600	TNTC		
12	Blank	1	0	0	0	0	0		
	Unfiltered	200	80	0	80	0	16000	50	16000
	Unfiltered	100	TNTC	1	TNTC	100	TNTC		
13	Blank	1	0	0	0	0	0		
	Unfiltered	200	19	1	20	200	4000	100	4000
	Unfiltered	100	TNTC	0	TNTC	0	TNTC		
14	Blank	1	0	0	0	0	0		
	Unfiltered	200	TNTC	9	TNTC	1800	TNTC	1400	TNTC
	Unfiltered	100	TNTC	10	TNTC	1000	TNTC		
	Blank	1	0	0	0	0	0		
	Filtered	10	1	0	1	0	10	0	9
	Filtered	1	8	0	8	0	8		
15	Blank	1	0	0	0	0	0		
	Unfiltered	200	75	8	83	1600	16600	1250	12450
	Unfiltered	100	74	9	83	900	8300		
	Blank	1	0	0	0	0	0		
	Filtered	10	0	0	0	0	0	0	0.5
	Filtered	1	1	0	1	0	1		
16	Blank	1	0	0	0	0	0		
	Unfiltered	200	TNTC	65	TNTC	13000	TNTC	8200	TNTC
	Unfiltered	100	TNTC	34	TNTC	3400	TNTC		
	Blank	1	0	0	0	0	0		
	Filtered	10	4	1	5	10	50	7	50
	Filtered	1	TNTC	4	TNTC	4	TNTC		
17	Blank	1	1	0	1	0	1		
	Unfiltered	1000	39	1	40	1000	40000	600	26900
	Unfiltered	200	68	1	69	200	13800		
18	Blank	1	0	0	0	0	0		
	Unfiltered	1000	54	1	55	1000	55000	600	38600
	Unfiltered	200	110	1	111	200	22200		
19	Blank	1	0	0	0	0	0		
	Unfiltered	1000	57	0	57	0	57000	0	43800
	Unfiltered	200	153	0	153	0	30600		
20	Blank	1	0	0	0	0	0		
	Unfiltered	1000	45	0	45	0	45000	0	45000
	Unfiltered	200	TNTC	0	TNTC	0	TNTC		
	Blank	1	4	0	4	0	4		
	Filtered	10	36	0	36	0	360	0	210
	Filtered	1	60	0	60	0	60		

Household	Type	Dilution	Red Colonies	Blue Colonies	Sum	E. coli per 100mL	Total Coliform per 100mL	Average E. coli per 100mL	Average TC per 100mL
21	Blank	1	0	0	0	0	0		
	Unfiltered	1000	26	0	26	0	26000	0	18800
	Unfiltered	200	58	0	58	0	11600		
	Blank	1	5	0	5	0	5		
	Filtered	10	37	0	37	0	370	0	370
	Filtered	1	TNTC	0	TNTC	0	TNTC		
22	Blank	1	0	0	0	0	0		
	Unfiltered	1000	166	0	166	0	166000	300	166000
	Unfiltered	200	TNTC	3	TNTC	600	TNTC		
	Blank	1	4	0	4	0	4		
	Filtered	10	24	0	24	0	240	0	240
	Filtered	1	TNTC	0	TNTC	0	TNTC		
23	Blank	1	0	0	0	0	0		
	Unfiltered	1000	12	0	12	0	12000	0	11300
	Unfiltered	200	53	0	53	0	10600		
24	Blank	1	1	0	1	0	1		
	Unfiltered	1000	11	1	12	1000	12000	600	8800
	Unfiltered	200	27	1	28	200	5600		
25	Blank	1	0	0	0	0	0		
	Unfiltered	1000	17	0	17	0	17000	0	15400
	Unfiltered	200	69	0	69	0	13800		
26	Blank	1	0	0	0	0	0		
	Unfiltered	1000	19	1	20	1000	20000	1400	19900
	Unfiltered	200	90	9	99	1800	19800		
27	Blank	1	0	0	0	0	0		
	Unfiltered	1000	22	0	22	0	22000	300	19200
	Unfiltered	200	79	3	82	600	16400		
	Blank	1	1	0	1	0	1		
	Filtered	10	5	0	5	0	50	0	50.5
	Filtered	1	51	0	51	0	51		
28	Blank	1	0	0	0	0	0		
	Unfiltered	1000	TNTC	1	TNTC	1000	TNTC	1100	TNTC
	Unfiltered	200	TNTC	6	TNTC	1200	TNTC		
	Blank	1	0	0	0	0	0		
	Filtered	10	90	3	93	30	930	24.5	930
	Filtered	1	TNTC	19	TNTC	19	TNTC		
29	Blank	1	3	0	3	0	3		
	Unfiltered	1000	3	1	4	1000	4000	500	2800
	Unfiltered	200	8	0	8	0	1600		
	Blank	1	0	0	0	0	0		
	Filtered	10	0	0	0	0	0	0	1.5
	Filtered	1	3	0	3	0	3		
30	Blank	1	0	0	0	0	0		
	Unfiltered	1000	13	0	13	0	13000	0	7800
	Unfiltered	200	13	0	13	0	2600		
	Blank	1	0	0	0	0	0		
	Filtered	10	10	0	10	0	100	0	58.5
	Filtered	1	17	0	17	0	17		

Household	Type	Dilution	Red Colonies	Blue Colonies	Sum	E. coli per 100mL	Total Coliform per 100mL	Average E. coli per 100mL	Average TC per 100mL
31	Blank	1	0	0	0	0	0		
	Unfiltered	1000	7	0	7	0	7000	100	4000
	Unfiltered	200	4	1	5	200	1000		
32	Blank	1	0	0	0	0	0		
	Unfiltered	100	TNTC	36	TNTC	3600	TNTC	3600	TNTC
	Unfiltered	10	TNTC	TNTC	TNTC	TNTC	TNTC		
33	Blank	1	0	0	0	0	0		
	Unfiltered	100	180	0	180	0	18000	25	18000
	Unfiltered	10	TNTC	5	TNTC	50	TNTC		
	Blank	1	0	0	0	0	0		
	Filtered	10	TNTC	0	TNTC	0	TNTC	0	TNTC
	Filtered	1	TNTC	0	TNTC	0	TNTC		
34	Blank	1	0	0	0	0	0		
	Unfiltered	1000	25	0	25	0	25000	0	24300
	Unfiltered	200	118	0	118	0	23600		
	Blank	1	23	0	23	0	23		
	Filtered	10	1	0	1	0	10	0	7
	Filtered	1	4	0	4	0	4		
35	Blank	1	0	0	0	0	0		
	Unfiltered	1000	69	0	69	0	69000	200	69000
	Unfiltered	200	TNTC	2	TNTC	400	TNTC		
	Blank	1	0	0	0	0	0		
	Filtered	10	25	0	25	0	250	0	250
	Filtered	1	TNTC	0	TNTC	0	TNTC		
36	Blank	1	0	0	0	0	0		
	Unfiltered	50	28	0	28	0	1400	10	985
	Unfiltered	10	55	2	57	20	570		
	Blank	1	0	0	0	0	0		
	Filtered	10	124	0	124	0	1240	0	676
	Filtered	1	112	0	112	0	112		
37	Blank	1	0	0	0	0	0		
	Unfiltered	50	121	0	121	0	6050	0	4875
	Unfiltered	10	TNTC	0	TNTC	0	TNTC		
	Unfiltered	100	37	0	37	0	3700		
	Blank	1	0	0	0	0	0		
	Filtered	10	3	0	3	0	30	0	20.5
	Filtered	1	11	0	11	0	11		
38	Blank	1	0	0	0	0	0		
	Unfiltered	100	29	0	29	0	2900	0	1475
	Unfiltered	10	5	0	5	0	50		
	Blank	1	0	0	0	0	0		
	Filtered	10	0	0	0	0	0	0.5	2
	Filtered	1	3	1	4	1	4		
39	Blank	1	0	0	0	0	0		
	Unfiltered	50	52	0	52	0	2600	0	2600
	Unfiltered	2	TNTC	0	TNTC	0	TNTC		
	Blank	1	0	0	0	0	0		
	Filtered	10	22	0	22	0	220	0	166.5

Household	Type	Dilution	Red Colonies	Blue Colonies	Sum	E. coli per 100mL	Total Coliform per 100mL	Average E. coli per 100mL	Average TC per 100mL
	Filtered	1	113	0	113	0	113		
40	Blank	1	0	0	0	0	0		
	Unfiltered	50	4	0	4	0	200	0	101
	Unfiltered	2	1	0	1	0	2		
	Blank	1	1	0	1	0	1		
	Filtered	10	3	0	3	0	30	1	18.5
	Filtered	1	5	2	7	2	7		
41	Blank	1	0	0	0	0	0		
	Unfiltered	50	9	0	9	0	450	0	234
	Unfiltered	2	9	0	9	0	18		
	Blank	1	0	0	0	0	0		
	Filtered	10	10	0	10	0	100	0	53
	Filtered	1	6	0	6	0	6		
42	Blank	1	0	0	0	0	0		
	Unfiltered	50	5	0	5	0	250	0	128
	Unfiltered	2	3	0	3	0	6		
	Blank	1	0	0	0	0	0		
	Filtered	20	10	0	10	0	200	0	117.5
	Filtered	5	7	0	7	0	35		

Summarized Membrane Filtration Data

Community	Household	Description	Membrane Filtration (per 100mL average)	
			E. coli	Total Coliform
Shenshegu	1	Unfiltered	0	100
Shenshegu	1	Filtered	0	76.5
Shenshegu	2	Unfiltered	0	TNTC
Shenshegu	3	Unfiltered	0	60
Shenshegu	3	Filtered	Unsure	Unsure
Shenshegu	4	Unfiltered	0	410
Shenshegu	4	Filtered	5.5	420
Taha	5	Unfiltered	100	TNTC
Taha	5	Filtered	5	10
Taha	6	Unfiltered	915	TNTC
Taha	6	Filtered	3.5	266
Taha	7	Unfiltered	0	750
Taha	7	Filtered	0	0
Taha	8	Unfiltered	1255	11400
Taha	9	Unfiltered	525	9100
Taha	10	Unfiltered	435	TNTC
Gbalahi	11	Unfiltered	600	24200
Gbalahi	12	Unfiltered	50	16000
Gbalahi	13	Unfiltered	100	4000
Gbalahi	14	Unfiltered	1400	TNTC
Gbalahi	14	Filtered	0	9
Gbalahi	15	Unfiltered	1250	12450
Gbalahi	15	Filtered	0	0.5
Gbalahi	16	Unfiltered	8200	TNTC
Gbalahi	16	Filtered	7	50
Chenshegu	17	Unfiltered	600	26900
Chenshegu	18	Unfiltered	600	38600
Chenshegu	19	Unfiltered	0	43800
Chenshegu	20	Unfiltered	0	45000
Chenshegu	20	Filtered	0	210
Chenshegu	21	Unfiltered	0	18800
Chenshegu	21	Filtered	0	370
Chenshegu	22	Unfiltered	300	166000
Chenshegu	22	Filtered	0	240
Gbanyamni	23	Unfiltered	0	11300
Gbanyamni	24	Unfiltered	600	8800
Gbanyamni	25	Unfiltered	0	15400
Gbanyamni	26	Unfiltered	1400	19900
Gbanyamni	27	Unfiltered	300	19200
Gbanyamni	27	Filtered	0	50.5
Gbanyamni	28	Unfiltered	1100	TNTC
Gbanyamni	28	Filtered	24.5	930
Gbanyamni	29	Unfiltered	500	2800
Gbanyamni	29	Filtered	0	1.5
Gbanyamni	30	Unfiltered	0	7800
Gbanyamni	30	Filtered	0	58.5

Community	Household	Description	Membrane Filtration (per 100mL average)	
			E. coli	Total Coliform
Kalariga	31	Unfiltered	100	4000
Kalariga	32	Unfiltered	3600	TNTC
Kalariga	33	Unfiltered	25	18000
Kalariga	33	Filtered	0	TNTC
Kalariga	34	Unfiltered	0	24300
Kalariga	34	Filtered	0	7
Kalariga	35	Unfiltered	200	69000
Kalariga	35	Filtered	0	250
Vitin Estates	36	Unfiltered	10	985
Vitin Estates	36	Filtered	0	676
Vitin Estates	37	Unfiltered	0	4875
Vitin Estates	37	Filtered	0	20.5
Vitin Estates	38	Unfiltered	0	1475
Vitin Estates	38	Filtered	0.5	2
Kamina Barracks	39	Unfiltered	0	2600
Kamina Barracks	39	Filtered	0	166.5
Kamina Barracks	40	Unfiltered	0	101
Kamina Barracks	40	Filtered	1	18.5
Kamina Barracks	41	Unfiltered	0	234
Kamina Barracks	41	Filtered	0	53
Kamina Barracks	42	Unfiltered	0	128
Kamina Barracks	42	Filtered	0	117.5

3M™ Petrifilm™ Data

Community	Household	Description	Petrifilm Results (per 100mL)	
			E. coli	Total Coliform
Shenshegu	1	Filtered	0	0
Shenshegu	3	Filtered	0	0
Shenshegu	4	Filtered	0	0
Gbalahi	11	Unfiltered	1600	6600
Gbalahi	12	Unfiltered	300	4100
Gbalahi	13	Unfiltered	400	1400
Gbalahi	14	Unfiltered	500	8000
Gbalahi	14	Filtered	0	0
Gbalahi	15	Unfiltered	2600	7200
Gbalahi	15	Filtered	0	0
Gbalahi	16	Unfiltered	400	4300
Gbalahi	16	Filtered	0	600
Chenshegu	17	Unfiltered	400	3700
Chenshegu	18	Unfiltered	700	5800
Chenshegu	19	Unfiltered	200	5700
Chenshegu	20	Unfiltered	200	12700
Chenshegu	20	Filtered	0	0
Chenshegu	21	Unfiltered	0	3300
Chenshegu	21	Filtered	0	1800
Chenshegu	22	Unfiltered	200	8800
Chenshegu	22	Filtered	0	0
Gbanyamni	23	Unfiltered	0	4500
Gbanyamni	24	Unfiltered	100	3200
Gbanyamni	25	Unfiltered	100	3700
Gbanyamni	26	Unfiltered	200	3600
Gbanyamni	27	Unfiltered	100	9800
Gbanyamni	27	Filtered	0	0
Gbanyamni	28	Unfiltered	200	18500
Gbanyamni	28	Filtered	0	0
Gbanyamni	29	Unfiltered	0	4300
Gbanyamni	29	Filtered	0	0
Gbanyamni	30	Unfiltered	0	200
Gbanyamni	30	Filtered	0	0
Kalariga	31	Unfiltered	0	1500
Kalariga	32	Unfiltered	0	200
Kalariga	33	Unfiltered	0	1000
Kalariga	33	Filtered	0	10300
Kalariga	34	Unfiltered	0	4800
Kalariga	34	Filtered	0	0
Kalariga	35	Unfiltered	0	15200
Kalariga	35	Filtered	0	300
Vitin Estates	36	Unfiltered	0	100
Vitin Estates	36	Filtered	0	0
Vitin Estates	37	Unfiltered	0	2400
Vitin Estates	37	Filtered	0	0
Vitin Estates	38	Unfiltered	0	0

Community	Household	Description	Petrifilm Results (per 100mL)	
			E. coli	Total Coliform
Vitin Estates	38	Filtered	0	0
Kamina Barracks	39	Unfiltered	0	600
Kamina Barracks	39	Filtered	0	400
Kamina Barracks	40	Unfiltered	0	0
Kamina Barracks	40	Filtered	0	0
Kamina Barracks	41	Unfiltered	0	0
Kamina Barracks	41	Filtered	0	0
Kamina Barracks	42	Unfiltered	0	0
Kamina Barracks	42	Filtered	0	0

H_2S Test Data

Community	Household	Description	Positive (+) or Negative (-)
Shenshegu	1	Unfiltered	
Shenshegu		Filtered	
Shenshegu	2	Unfiltered	
Shenshegu	3	Unfiltered	
Shenshegu		Filtered	
Shenshegu	4	Unfiltered	
Shenshegu		Filtered	
Taha	5	Unfiltered	+
Taha		Filtered	-
Taha	6	Unfiltered	+
Taha		Filtered	+
Taha	7	Unfiltered	-
Taha		Filtered	-
Taha	8	Unfiltered	+
Taha	9	Unfiltered	+
Taha	10	Unfiltered	+
Gbalahi	11	Unfiltered	+
Gbalahi	12	Unfiltered	+
Gbalahi	13	Unfiltered	+
Gbalahi	14	Unfiltered	+
Gbalahi		Filtered	-
Gbalahi	15	Unfiltered	+
Gbalahi		Filtered	-
Gbalahi	16	Unfiltered	+
Gbalahi		Filtered	+
Chenshegu	17	Unfiltered	+
Chenshegu	18	Unfiltered	+
Chenshegu	19	Unfiltered	+
Chenshegu	20	Unfiltered	+
Chenshegu		Filtered	-
Chenshegu	21	Unfiltered	+
Chenshegu		Filtered	-
Chenshegu	22	Unfiltered	+
Chenshegu		Filtered	-
Gbanyamni	23	Unfiltered	+
Gbanyamni	24	Unfiltered	+
Gbanyamni	25	Unfiltered	+
Gbanyamni	26	Unfiltered	+
Gbanyamni	27	Unfiltered	+
Gbanyamni		Filtered	-
Gbanyamni	28	Unfiltered	+
Gbanyamni		Filtered	-
Gbanyamni	29	Unfiltered	+
Gbanyamni		Filtered	-
Gbanyamni	30	Unfiltered	+
Gbanyamni		Filtered	-

Community	Household	Description	Positive (+) or Negative (-)
Kalariga	31	Unfiltered	+
Kalariga	32	Unfiltered	+
Kalariga	33	Unfiltered	+
Kalariga		Filtered	-
Kalariga	34	Unfiltered	+
Kalariga		Filtered	-
Kalariga	35	Unfiltered	+
Kalariga		Filtered	-
Vitin Estates	36	Unfiltered	+
Vitin Estates		Filtered	-
Vitin Estates	37	Unfiltered	+
Vitin Estates		Filtered	-
Vitin Estates	38	Unfiltered	-
Vitin Estates		Filtered	-
Kamina Barracks	39	Unfiltered	-
Kamina Barracks		Filtered	-
Kamina Barracks	40	Unfiltered	-
Kamina Barracks		Filtered	-
Kamina Barracks	41	Unfiltered	-
Kamina Barracks		Filtered	-
Kamina Barracks	42	Unfiltered	-
Kamina Barracks		Filtered	-

Turbidity Test Data

Community	Household	Description	Turbidity
Shenshegu	1	Unfiltered	
Shenshegu		Filtered	0.59
Shenshegu	3	Unfiltered	4.01
Shenshegu		Filtered	0.76
Shenshegu	4	Unfiltered	7
Shenshegu		Filtered	0.62
Taha	5	Unfiltered	349
Taha		Filtered	4.74
Taha	6	Unfiltered	97.8
Taha		Filtered	17
Taha	7	Unfiltered	86.7
Taha		Filtered	0.9
Gbalahi	14	Unfiltered	317
Gbalahi		Filtered	69.5
Gbalahi	15	Unfiltered	365
Gbalahi		Filtered	2.23
Gbalahi	16	Unfiltered	355
Gbalahi		Filtered	27.5
Chenshegu	20	Unfiltered	355
Chenshegu		Filtered	0.76
Chenshegu	21	Unfiltered	136
Chenshegu		Filtered	1.21
Chenshegu	22	Unfiltered	717
Chenshegu		Filtered	0.93
Gbanyamni	27	Unfiltered	146
Gbanyamni		Filtered	12.1
Gbanyamni	28	Unfiltered	143
Gbanyamni		Filtered	22.2
Gbanyamni	29	Unfiltered	132
Gbanyamni		Filtered	3.52
Gbanyamni	30	Unfiltered	127
Gbanyamni		Filtered	31.5
Kalariga	33	Unfiltered	8.6
Kalariga		Filtered	1
Kalariga	34	Unfiltered	225
Kalariga		Filtered	0.6
Kalariga	35	Unfiltered	244
Kalariga		Filtered	11.1
Vitin Estates	36	Unfiltered	4.08
Vitin Estates		Filtered	0.67
Vitin Estates	37	Unfiltered	3.11
Vitin Estates		Filtered	0.78
Vitin Estates	38	Unfiltered	3.55
Vitin Estates		Filtered	0.42
Kamina Barracks	39	Unfiltered	4.03
Kamina Barracks		Filtered	3.7

Community	Household	Description	Turbidity
Kamina Barracks	40	Unfiltered	8.28
Kamina Barracks		Filtered	1.29
Kamina Barracks	41	Unfiltered	4.05
Kamina Barracks		Filtered	0.85
Kamina Barracks	42	Unfiltered	4.48
Kamina Barracks		Filtered	1.88