CROSS-SECTIONAL EPIDEMIOLOGICAL STUDY ON WATER AND SANITATION PRACTICES IN THE NORTHERN REGION OF GHANA

By

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Submitted to the Department of Civil and Environmental Engineering
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ABSTRACT

A cross-sectional epidemiological study was conducted to obtain baseline data on drinking water and sanitation practices in the Northern Region of Ghana. This study was performed in conjunction with Pure Home Water (PHW) which aims to provide safe drinking water to the Northern Region of Ghana by selling household water treatment and safe storage devices as a sustainable business. Currently ceramic filters constitute PHW's major sales. In the study, fifty households were surveyed, including both homes that had and had not purchased the PHW products in order to obtain baseline data and product feedback. Targeted participants were mothers of the households with children under five. At each household, drinking water samples were collected and analyzed for bacterial contamination with hydrogen sulfide (H_2S) and membrane filtration testing techniques.

This data is analyzed as an epidemiological cross-sectional study and basic risk assessment. In general, the surveys were well received within the communities, resulting in 100% participation. The product users responded positively to the PHW technologies, with 93% of customers still using the products within six months of purchase. From the overall survey results, there is a great need for safe water and sanitation in the Northern Region of Ghana, with 36% of respondents not having access to an improved water source, and 54% not having access to an improved sanitation facility. In the rural traditional communities, households were more likely to suffer from diarrheal illness, lack improved drinking water, and lack sanitation facilities. A variety of factors were compared in analysis, such as community type, district, diarrheal illness, and ownership of the PHW products.

Thesis Supervisor: Susan Murcott
Title: Senior Lecturer of Civil and Environmental Engineering

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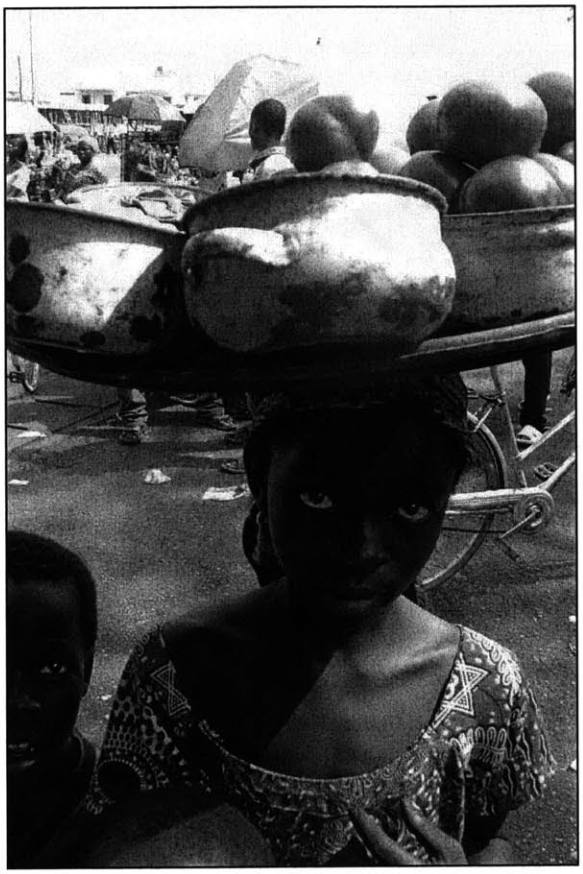
TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1:

INTRODUCTION



CHAPTER 1: INTRODUCTION

1.1 The Need for Safe Water and Sanitation

Globally 1.1 billion people lack access to safe drinking water, and 2.6 billion people lack access to adequate sanitation (WHO, 2004). Primarily from unsafe water and sanitation, approximately 5000 people die everyday from diarrheal illness, mostly children under five and virtually all in developing countries. The seventh of the eight United Nations Millennium Development Goals (MDGs) is to "halve by 2015 the proportion of people without sustainable access to safe drinking water" (U.N. MDGs, 2004). Water supply, safe drinking water, adequate sanitation, and hygiene have an incredible potential to save and improve lives.

1.2 Ghana

Ghana is located in West Africa, bordered by the Gulf of Guinea (South), Cote D'Ivoire (West), Burkina Faso (North), and Togo (East). The land area is about the size of Oregon at 239,000 square kilometers with a population of 21 million people (Briggs, 2004). English is the official language, though there are over 60 local languages.

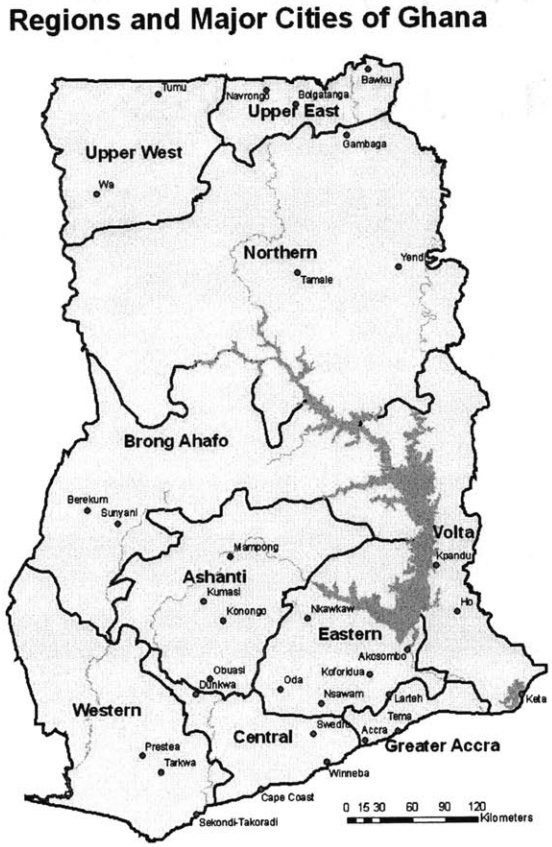


Figure 1: Ghana
Map by Jenny VanCalcar, 2006 (VanCalcar, 2006)

The Pure Home Water (PHW) Project is taking place in the Northern Region of Ghana, one of the poorest regions in the country and with a population of 1.8 million people. The Northern Region consists of 13 districts, and the project targets six of these districts (population 851,000), with a current focus on the three districts: Tamale, Tolon-Kumbungu, and Savelugu-Nanton (population 520,000) (GSS, 2004). See Figure 2 below for the geographic focus of the PHW Project.

Figure 2: PHW Target Districts in the Northern Region of Ghana
Map by Jenny VanCalcar, 2006

According to the World Bank, the infant mortality rate in Ghana is 57/1000 and the under five mortality rate is 100/1000 (World Bank, 2003). [1] Diarrhea prevalence is at 19% for children under five (Gyimah, 2003). In Ghana diarrhea has been identified as the second most common health problem treated in outpatient clinics, and one of the most common causes of infant deaths (Gyimah, 2003). It is widely recognized that diarrhea results from exposure to a variety of environmental factors, particularly pathogens in water and toilet facilities.

1.3 Project Background

Pure Home Water (PHW) is a social business enterprise to implement, monitor, and evaluate household drinking water treatment and safe storage technologies in the Northern Region of Ghana. The project is the full-time effort of two social entrepreneurs named Hamdiyah

[1] According to the World Factbook, infant mortality is 51/1000 for 2005 (The World Factbook, 2006).

Alhassan, a civil and environmental engineer, and Wahabu Salifu, a development planner. Additional team members include MIT students: three Master of Engineering students (Jenny VanCalcar, Claire Mattelet, and myself), four business students (Rachel Lawson, Casey Gordon, Brendan Monaghan, and Kenichi Honna), and project advisor Susan Murcott, senior lecturer at MIT. The project has been generously assisted by World Vision-Ghana and funded by the Conrad N. Hilton Foundation for two years, 2005-2007.

Hamdiyah and Wahabu, the two Ghanaian social entrepreneurs, are selling household drinking water treatment and safe storage technologies (HWTS) through door-to-door sales, community meetings, and retail sales. The purpose of the project is to demonstrate the potential to sell a range of technologies to low-income users in urban and rural areas of Ghana.

1.3.1 Goals and Objectives of PHW Project

PHW aims to provide safe drinking water to the Northern Region of Ghana as a sustainable business selling drinking water treatment and safe storage devices.

1.3.2 World Vision and WAWI partnership

Our project has an informal partnership with World Vision-Ghana. World Vision is an international Christian relief organization that began working on rural development in Ghana in 1979. In 1985, World Vision began the Ghana Rural Water Project (GRWP) which has provided over 1700 wells for over 1000 communities and 176 institutions in Ghana (World Vision). World Vision is part of the larger West Africa Water Initiative (WAWI) partnership, which is a collaboration of ten international institutions dedicated to improving the lives of poor vulnerable populations in Ghana, Mali, and Niger (World Vision).

1.3.3 G-Lab Business Team

MIT Sloan Business students joined the engineering team as part of the Global Entrepreneurship Lab (G-Lab) 15.389 course. The G-Lab team helped to develop the business model of PHW as a social entrepreneurship business. The business students focused on promotion and sales, product development, and set up and refinement of a financial accounting system and pricing strategies. While in Ghana, the business students spent the majority of their time with the two social entrepreneurs, focusing on the "4Ps": product, place, price, and promotion of the technologies.

1.3.4 Household Water Treatment Products and Safe Storage (HWTS)

A systematic review of 64 studies concludes that household treatment systems significantly reduce waterborne illness by improving drinking water quality (Fewtrell and Colford, 2004). Though NSF/ANSI (National Science Foundation/American National Standards Institute) does not have specific standards for HWTS, the World Health Organization (WHO) has initiated a HWTS technology verification process as part of its rolling revisions of the *Guidelines for Drinking Water Quality*. Various HWTS technologies have proven to be available and feasible for implementation in Ghana (See Table 1).

Table 1: Household Water Treatment Systems and Safe Storage

#	Safe Household Water Product	Retail Price (US$)
1	Ceramic "Potters for Peace" Filtron (known locally as the "CT Filtron" manufactured by Peter Tamakloe or Ceramica Tamakloe	$16
2	Ceramic Candle filter (known locally as the "Nnsupa Filter," manufactured by Michael Commeh)	$21
3	Solar Disinfection (SODIS)	$1/year
4	Biosand Filter	$11
5	Modified Traditional Clay Pots for safe storage with 3/4" brass taps, manufactured by Kukuo Village women potters	$10
6	Plastic Safe Storage Container (50 L size) +Spigot	$9
7	Household Chlorination*	$7.20/year
8	PUR**	$73/year

* Assumes $0.60 per 500 ml bottle, each bottle lasting 1 family 1 month. $0.60x12=$7.20/year. In practice, the amount used would likely be lower.

** Assumes $0.05 per sachet treating 10 L, requiring 4 sachets per day per family x 365 days/year. In practice, the amount would likely be lower.

Though this range of technologies was considered during the first six months of market analysis, the main products as of January 2006 were the Tamakloe ceramic filter, Nnsupa candle ceramic filter, and safe storage container (Figure 3). These products were chosen for their feasibility and practicability in Ghana. The Tamakloe filter is manufactured by Peter Tamakloe in Accra and the Nnsupa filter is made by Michael Commeh in Kumasi, so both are available in-country. The two different safe storage products do not treat the water, but prevent recontamination by providing a covered container with a spigot.

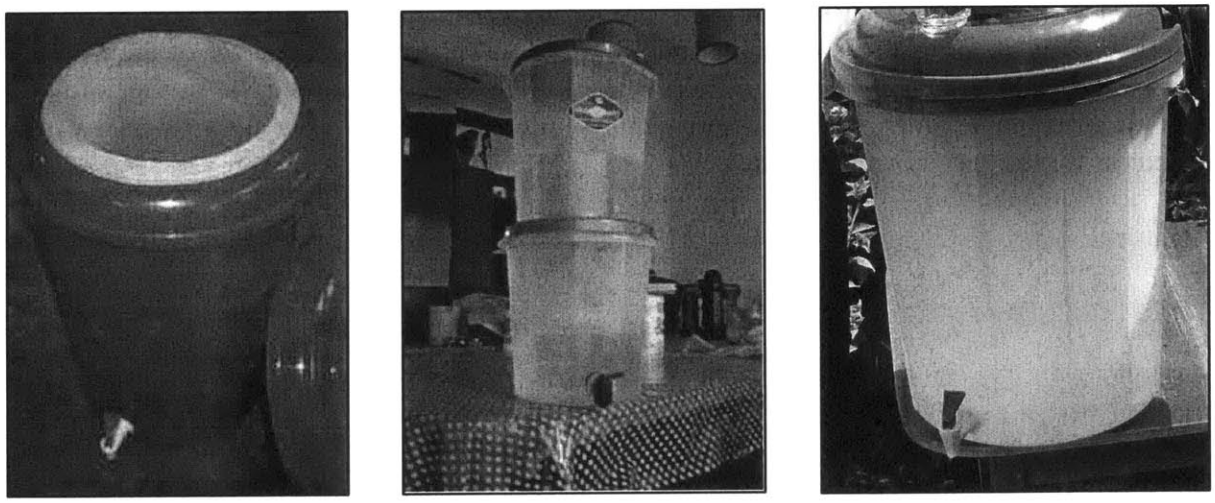


Figure 3: Tamakloe Filter, Nnsupa Filter, and Safe Storage Products
Products sold by PHW as of January 2006.
Photos courtesy of Susan Murcott

1.4 The World Health Organization *Guidelines for Drinking Water Quality* (WHO, 2004)
The World Health Organization *Guidelines* provide the background and foundation for the project. The World Health Organization has established *Guidelines for Drinking Water Quality* (GDWQ) to provide a common point of reference for all countries. These guidelines define what can be considered 'safe' by establishing a basis for most national, regional, and agency level water-quality requirements worldwide.

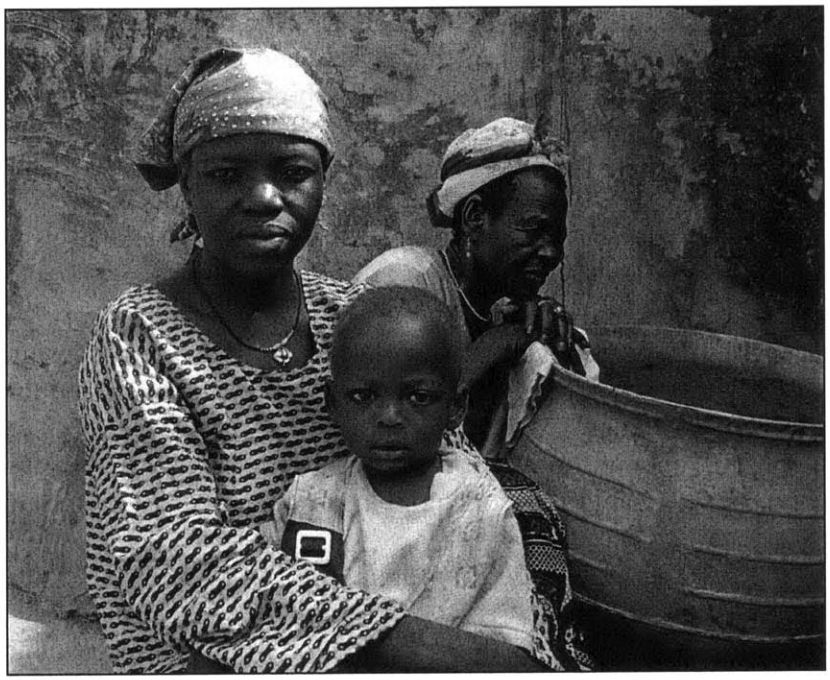
The first step involves *health based targets* including health burdens and priorities. An epidemiological evaluation and risk assessment should initially be performed to establish the reductions in disease burdens from a given intervention. The disease burden is the estimate of disease level from water and sanitation, and is generally expressed in terms of disability-adjusted life years (DALYs). As first presented in the 1993 World Bank Development Report, DALYs measure both the global burden of disease and the effectiveness of health interventions, as indicated by reductions in disease burden (World Bank, 1993). (Section 2.2 of this thesis further discusses DALYS.) The health-based assessment also includes baseline water quality data, the establishment of performance targets, and the identification of specific technologies. For this project, the epidemiological study serves as the first stage in evaluating the disease burden.

The second step in determining GDWQ is developing a system or technology specific *Water Safety Plan (WSP).* The goal is to ensure drinking water quality through source protection, effective treatment, and safe storage. The WSP will organize systematic management practices, ensure process control to exclude hazards, and incorporate hygiene education. In the WSP, a system assessment should be performed to determine whether the drinking water supply can deliver water to meet the health-based targets. The targets are health outcome targets, water quality targets, performance targets, and specified technology targets. Currently, the PHW project is working towards effective treatment and safe storage, but while recognizing its importance does not address source protection as one of its organizational goals.

The third step includes *independent surveillance* to verify that the system plan is operating properly. This stage includes continual public health assessment and review of the safety and acceptability of the drinking water supply system. The surveillance can be in the form of an audit or direct assessment. The assessment is often a cost-effective way to provide clear objectives for the surveillance program.

CHAPTER 2:

EPIDEMIOLOGICAL STUDY CONTEXT



CHAPTER 2: EPIDEMIOLOGICAL STUDY CONTEXT

2.1 Background

Epidemiological studies have demonstrated the positive health impacts of household water treatment systems. From a review of recent epidemiological studies, household treatment systems have been found to reduce the incidence of diarrhea up to 48% (Crump et al., 2005; Brin 2003; Varghese, 2002). Hand-washing also has the potential to reduce diarrhea rates up to 50% (Parker, 2004). A six-month intervention study by Clasen et al. (2004) on ceramic drinking water filters in Bolivia was found to reduce diarrheal disease risk by 70% for individuals and 84% for children under five (Nath et al., 2006).

Most relevant to the this study, the organization Macro International, in collaboration with the Ghana Statistical Service, performed the 1998 Ghana Demographic and Health Survey (GDHS) (Gyimah, 2003). The household questionnaire included 4843 women ages 15-49 years and collected data on birth history, household, and health information. From this survey, the prevalence of diarrhea was determined to be 19.1% for children under 5, which was defined as 3 or more diarrhea episodes per day in the last two weeks. Of the study population, 40% lived in households without toilet facilities. For water sources, 27% received their drinking water from piped facilities, 15% from wells, 26% from boreholes, and 32% from streams, lakes, dams, or other sources. Diarrheal prevalence was found to be higher in accordance with the following factors: children with younger mothers, high number of children in a family, and lower education level of the mother. Uneducated mothers may not be entirely aware of the causal agents of diarrheal disease.

2.2 Disability-Adjusted Life Years (DALYs)

To further characterize the health burden, the disease burden can be estimated in terms of disability-adjusted life years (DALYs). DALYs attempt to characterize the time lost because of disability and death from a disease compared to a long life free of disease. DALYs are calculated by the present value of the future years of disability-free life that are lost as a result of premature death or cases of disability occurring in a particular year (World Bank, 1993).

$$DALYS = YLL + YLD$$

YLL = the years lost to premature death, calculated from age-specific mortality rates and the standard life expectancies of a given population

YLD = years lived with a disability
= (number of cases) x (average duration) x (severity factor)

The severity factor for watery diarrhea ranges from 0.09 to 0.12 depending on the age group (Cortruvo et al., 2004). DALYs is a significant parameter that should be considered when determining the burden of waterborne illness.

Diarrheal illness and intestinal worms contribute significantly to global DALYs, particularly in developing countries. In 1993, the burden in developing countries was estimated to be 99 million DALYs from diarrhea and 18 million DALYs from intestinal worms per year, with a reduction of 40% achievable from feasible interventions (World Bank, 1993). Currently diarrheal illness contributes to 60 million DALYs in low- and middle-income countries, as displayed in the Table 2 below (Lopez et al., 2006). For sub-Saharan Africa in 1993, 10.4% of the total DALYs were attributed to diarrhea and 1.8% were attributed to intestinal worms (World Bank, 1993). Currently in Africa, 6 to 10 million DALYs are attributed to poor water supply, sanitation, and hygiene practices, totaling approximately 4% of the total DALYs for the continent (Jamison et al., 2006). Diarrheal illness is the third leading cause of death for children under five (World Bank, 1993; Lopez et al., 2006). Demonstrating the burden of diarrheal illness on children under five, Table 2 below displays the thousands of DALYs stratified by age and sex for low- and middle-income countries. Children under five have increased susceptibility to diarrheal illness because of their underdeveloped immune system and smaller size, and therefore, they are often targeted for epidemiological studies concerning water and sanitation.

Table 2: Burden of Diarrheal Illness by Age and Sex for Low- and Middle-Income Countries
(Lopez et al., 2006)

Age (years)	0-4	5-14	15-29	30-44	45-59	60-69	70-79	80+	Total
Diarrhea (thousands of DALYS)									
Male	27,757	691	528	564	463	270	203	115	30,592
Female	25,568	654	424	398	378	281	244	159	28,105

2.3 The West Africa Water Initiative (WAWI) Monitoring and Evaluation Plan

This project is associated by way of an informal partnership not only with World Vision Ghana, but also with the West Africa Water Initiative (WAWI). WAWI has developed six core indicators to evaluate water and sanitation progress in West Africa. These indicators were considered in the development of the epidemiological study.

The goal of WAWI is to improve the health and well-being of families and communities in Ghana, Mali, and Niger, with four main objectives. The first objective is to increase access to sustainable, safe water and environmental sanitation services for the poor and vulnerable population, through access to year-round potable water supplies and hygiene facilities. The second objective is to reduce the prevalence of waterborne diseases, including trachoma, guinea worm, and diarrheal diseases through education and community awareness. The third objective focuses on ensuring ecological and financially sustainable management of water quantity and quality with sound environmental practices. The final objective is to foster a partnership framework and institutional synergy for sustainable water and sanitation development and water resources management.

To measure the progress towards the above objectives, six core indicators were established as part of the monitoring and evaluation plan:

1. *ACCESS TO SAFE WATER:* $\frac{\textit{People with access}}{\textit{Total Population}}$

The number of people with access to safe water is defined as within 30 minutes or 1 kilometer of the household in rural areas, and 5 minutes or 200 meters in urban areas. [2] The time includes traveling each way, waiting, and collection of water. This indicator relates water quantity to water quality, and may vary seasonally.

2. ACCESS TO SANITATION: $\frac{\text{People with access}}{\text{Total Population}}$

Sanitation is defined as an improved sanitation facility such as a latrine that is functional and hygienic. For people to have access, it should be located within 30 meters or less of the household, be available at all hours, and be useable by children and the elderly. [3] Other considerations include whether the facility is shared, public, or private and the time to reach the facility. Specific observations may involve the type of facility (simple pit latrine, ventilated improved pit latrine, etc), basic structure of facility to provide privacy and keep out animals, place for hand-washing within or near the facility, and proper disposal of the feces of young children. Hygienic facilities must not include feces on the floor, seat, or walls, and bucket latrines are not considered sanitary. For a maximum health impact, at least 75% of households in a given community should use hygienic toilets or latrines (Bateman and Smith, 1991).

3. APPROPRIATE HANDWASHING: $\frac{\text{People with correct hand-washing}}{\text{Total Population}}$

Appropriate hand-washing for caregivers and food preparation consists of three main elements: 1) an available hand-washing area, with soap and water 2) correct hand-technique, and 3) hand-washing at critical moments. A proper technique includes using water, using soap or other detergent, washing both hands, rubbing hands together at least three times, and drying hands hygienically, by air or with a clean cloth. Critical moments include after defecation, after handling children's feces, before feeding, before eating, and before preparing food. Hand-washing appropriateness can be determined through observations and questioning caregivers or food preparers, as "how and when do you wash your hands (usually or in the last 24 hours)?"

4. NUMBER OF WATER-RELATED DISEASES

This indicator measures the number of guinea worm cases per thousand people and trachoma cases per thousand people

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[2] The UNICEF/WHO Joint Monitoring Programme for Water Supply & Sanitation defines an "improved" water source as a household connection, public standpipe, borehole, protected dug well, protected spring, or rainwater collection, and must be within one kilometer of the user's dwelling. Unimproved sources include unimproved wells, unprotected springs, vendor provided water, bottles water, and tanker truck water. (JMP, 2005).

[3] The UNICEF/WHO Joint Monitoring Programme for Water Supply & Sanitation defines sanitation facilities as "improved" if they are private and they separate human excreta from human contact. Improved sources include connection to a public sewer, connection to a septic system, pour-flush latrines, simple-pit latrines, and ventilated-improved pit latrines. Sanitation is considered not improved if households are using public or shared latrines, open pit latrines, or bucket latrines. (JMP 2005).

5. *PERCENTAGE OF SITES WITH OPERATING PUMPS:*

$$\frac{\textit{Number of pumps with less than 10 days of breakdowns per year}}{\textit{Total number of pumps}}$$

Operating pumps are defined as pumps with no more than 10 days without operation per year. Pump operation is based on the functioning of the pump, maintenance of the pump over time, and capacity of the pump to extend water to the community. The target for this indicator is 90% of pumps should be operational.

6. *WORK PLANS* created and adopted by country teams

The Ghana branch of WAWI has one main work plan each year. This indicator examines the success of the WAWI monitoring and evaluation program.

2.4 Household Water Treatment System and Safe Storage (HWTS) Indicators

As part of the WHO International Network, additional indicators have been developed to quantify the sustainability of HWTS (Murcott, 2005). In particular the rate of use within six months of adoption and the market penetration for one time purchases are relevant to this project. The market penetration will also be examined for the business aspects of the project.

1) *Rate Of Adoption (ROA) = Fraction using HWTS one month after receiving unit*

2) *Rate Of Sustained Use (ROSU) = Fraction using HWTS 1 year after receiving unit*

3) *Market Penetration:*

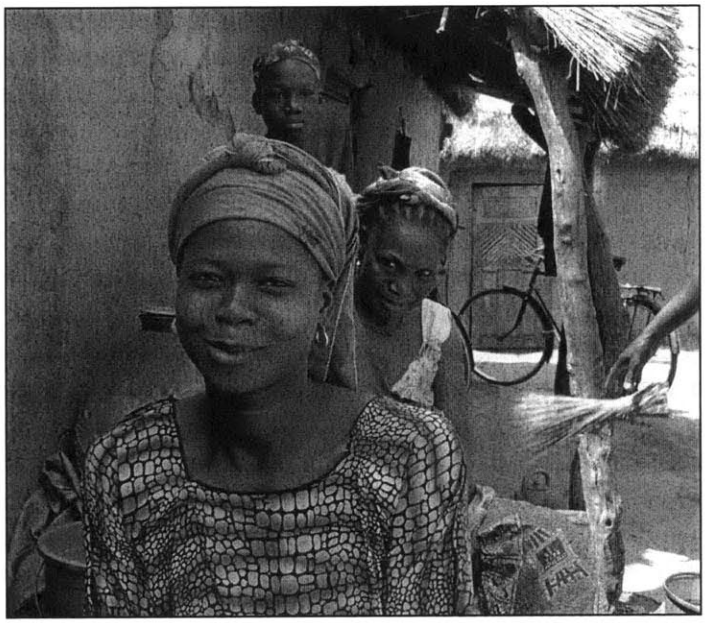
For 1 time purchases: $\dfrac{\textit{Number of Units sold}}{\textit{Population}}$

For recurrent purchases: $\dfrac{\textit{Number of Units sold}}{\textit{Units needed for 1 year x Population}}$

4) *Acceptance Level =* $\dfrac{\textit{Household that adopted HWTS}}{\textit{Total households reached/trained}}$

CHAPTER 3:

EPIDEMIOLOGICAL STUDY METHODOLOGY



CHAPTER 3: EPIDEMIOLOGICAL STUDY METHODOLOGY

3.1 Research Objective

The purpose of this study is to obtain baseline data on drinking water and sanitation practices for households in the Northern Region of Ghana in order to aid the PHW Project to achieve its objectives. Through household questionnaires, data was gathered to compare households with and without the technologies and to obtain baseline information on communities that have not had exposure to the HWTS treatment options. This data is analyzed as an epidemiological cross-sectional study and basic risk assessment. The results are available to the two Ghanaian entrepreneurs and future MIT teams that will continue this project in Ghana.

3.2 Introduction to Epidemiology

Cross-sectional studies are snapshots of a population's status that simultaneously assesses information on exposure and disease (Hennekens and Buring, 1987). Because all of the data is collected at once, this method is unable to establish a temporal relationship between the presumed cause and effect. Cross-sectional studies are descriptive methods, generally used to gather baseline data rather than perform formal analytical hypothesis testing. For analysis of cross sectional-studies, disease prevalence can be calculated and compared to other exposure factors. Prevalence is the percentage of people with the disease in the total population. Relative risks can also be calculated to compare disease to the different types of exposure.

Confounding factors must be avoided for accurate analysis and may be minimized through study design and analysis. A confounding variable is a third factor associated with the exposure and disease that may be responsible for the observed association. To minimize confounders, the study should be designed as a *randomization* of participant selection. This design distributes the known and unknown confounders evenly throughout the study population to prevent skewed results. In our study, we attempted for household selection to be randomized, though many households are chosen based on HTWS implementation and location (see 3.7 Population Selection for more detail). Additionally, *restriction* limits the study to one category or level of confounder. In this study, the participants were limited to the woman of the household with children under five to minimize the differences in responses. Another method to limit confounders is *matching*, which restricts the selection of a comparison group according to the confounder. In our study, households with the HWTS technologies were matched to similar households without HTWS to minimize the general differences between the households in order to make an appropriate comparison.

Bias must also be minimized in a study design, which may occur as *selection bias* and *observation bias*. It was difficult to minimize selection bias because most households were selected by our project leaders, Hamdiyah Alhassan or Wahabu Salifu, or by local village guides. Participants were chosen with the effort to minimize selection bias. Observation bias was minimized by asking all participants the same questions in the same manner, since all were interviewed by the same person. Differences may have occurred from having Hamdiyah or Wahabu present, since communities respond differently to male and female visitors.

3.3 Survey Development

In order to perform epidemiological analysis, a household questionnaire was developed to obtain the necessary data. Various survey examples were considered in the development of the PHW household questionnaire. The main format is a modification of the UNICEF Baseline Household Survey: Household-Based Drinking Water Treatment (UNICEF, 2005), the Population Services International (PSI) Questionnaire for Clean Drinking Water in Burundi, and the WHO IWG Household Survey Tool developed by the 2004-2005 MIT Master of Engineering Kenya team of Robert Baffrey, Jill Baumgartner, and Susan Murcott in 2005 (Baffrey, 2005). Over ten other surveys were reviewed and considered during survey development.

Categories and questions were chosen based on their relevance to the PHW project. For example, initially questions were included about the main concerns of the community, but this was omitted because the response, though interesting, would not directly benefit the PHW project. The focus of the survey is to provide useful background knowledge that will aid the PHW Ghana team in project implementation.

Additionally, questions were added for comparison with the West Africa Water Initiative (WAWI) core indicators (Nichols, 2004). The WAWI core indicators given consideration in this survey are: the access to safe water (core indicator #1), access to sanitation (core indicator #2), and appropriate hand-washing (core indicator #3). The two other core indicators, the number of individuals with guinea worm and trachoma (core indicator # 4), and the work plans (core indicator #6) are not relevant for the scope of this survey because of the small sample size. The number of days with operating pumps (core indicator #5) was also not included in the survey, since many pumps or taps were intermittent throughout the day.

3.4 Survey Review

Prior to implementation, the survey was reviewed to provide feedback and necessary modifications. The questionnaire was reviewed by Susan Murcott, the project advisor, and the MIT Ghana team, including the engineering and business students. In order to word questions in accordance with the PHW Ghanaian team and with the Ghanaian culture, feedback was given by Hamdiya Alhassan and Wahabu Salifu, the social entrepreneurs in Ghana, and Ato Ulzen-Appiah, a Ghanaian MIT student through email contact. The epidemiological format of the study was reviewed in a personal interview with Julie Buring, professor of epidemiology at the Harvard School of Public Health. Dr. William Duke from CAWST (Centre for Affordable Water System Technology) reviewed and recommended modifications to the survey implementation plan by email.

3.5 Institutional Review Board (IRB) Approval

Before survey implementation in Ghana, the survey was assessed by MIT's Institutional Review Board (IRB), the Committee on the Use of Humans as Experimental Subjects (COUHES). The study qualified as "exempt status" and "expedited review" because it involved minimum risk to the subjects involved. Included in the review process was a web based course and application, with the study purpose, study protocol, and survey draft. In-country IRB is not required because the study poses minimum risk to the subjects involved.

3.6 Survey Modification in Ghana

The questionnaire was further modified in-country with the help of Hamdiyah Alhassan and Wahabu Salifu. After a few initial runs through the survey, certain questions were omitted or modified based on cultural understanding. For example, rather than ask people when they wash their hands in general, the survey was modified to ask about hand-washing before or after certain activities, such as cooking, going to the toilet, and eating. After careful consideration, observations of hand-washing and sanitation facilities were omitted from the study because of cultural appropriateness and accuracy, since individuals may wash hands more carefully if observed and may bring guests to other cleaner nearby sanitation facilities rather than their own. Additionally, questions were added by the business students to gain information about product selection and advertising, such as why consumers chose their product and where consumers learned about PHW.

As an extension of the household survey, the implementation of the *smilie diary* (Appendix A) was considered. For the *smilie diary,* participants would record weekly diarrhea episodes for children under five to obtain diarrheal incidence for comparison with the questionnaire data. The implementation of this portion of the study was discussed with Hamdiyah and Wahabu, and we decided to omit this part based on cultural acceptance and the logistics of time and transportation, since it required at least two visits to each household.

3.7 Survey Overview

A copy of the survey used in Ghana is presented in Appendix B. The general survey structure is as follows:

3.7.1 Household Information

- *Number of people in household*
- *Ages of household members*
- *General education level of interviewee*
- *Monthly household expenses*
- *Observations and characterization of traditional or modern*

General information was gathered about the household to obtain background data for comparisons. Numbers of the total people in the household and children under five were necessary for data analysis, such as diarrheal prevalence. The mother's age and level of education were recorded as variables that may influence the overall data and responses. Monthly expenses were recorded in order to analyze monthly finances per capita. Additionally, households were characterized as traditional or modern based on the house type. Originally a socioeconomic category with a rating of 1-3 was included in the survey, but upon survey implementation, the dichotomy of traditional and modern households was observed. The traditional communities included mud homes arranged in circles, whereas the modern communities consisted of households constructed of cement. In the traditional communities, generally fuel sources consisted of firewood and charcoal, compared to the modern communities that generally had electricity for at least part of the day.

3.7.2 Diarrheal Illness

- *Prevalence of diarrhea*
- *Perceptions about causes and preventions of diarrhea*

Data was gathered on diarrheal prevalence and knowledge since diarrhea is an indicator of waterborne illness. The number and ages of people with diarrheal in the last week was recorded. Participants were also asked about the causes and treatment methods for diarrhea to assess their overall knowledge of diarrheal illness. The family member who cares for the individual sick with diarrhea was recorded to assess whether the burden of diarrheal illness falls unequally on women.

3.7.3 Hygiene and Sanitation

- *Hand-washing practices*
- *Accessibility of toilet facility*

Participants were asked about hand-washing practices, including when they wash their hands and if they use soap. Originally, the survey included a hand-washing observation, but this was omitted because of cultural appropriateness. Though the questions did not fully evaluate whether the mother was practicing appropriate hand-washing, the questions asked were the best method of assessment under the circumstances. Additionally, the participants were asked about the type of sanitation facility they use, its distance away from the household, and whether hand-washing was available at the facility. Based on these factors, households were classified to have access to safe sanitation facilities if they had a latrine or flush toilet that was always available. Public latrines were not considered improved sanitation facilities as per definition by the UNICEF/WHO Joint Monitoring Programme (JMP, 2005).

3.7.4 Water Use Practices

- *Source Collection: source type and access*
- *Water Storage: pathways for recontamination*
- *Water Quality Perception: water safety and treatment*

Participants were questioned about household drinking water use and practices. Drinking water sources were recorded and classified as improved or unimproved as defined by the UNICEF/WHO Joint Monitoring Programme (JMP, 2005). The time for water collection and number of times per day of collection were recorded in order to assess the overall burden of water collection. The family members that collected the water were also recorded to examine whether the burden of water collection falls unequally on women. Participants were also asked about the drinking water source used when away from home since that may be the cause of waterborne disease. To examine the possibility of safe storage implementation, households were interviewed about their water storage containers and practices. To evaluate pathways of recontamination, participants were asked whether their storage vessels were always covered and how they remove water from the containers. The survey also included questions about water quality perception in order to observe whether people think their water is safe to drink, and if not, whether they are doing anything to treat their water.

3.7.5 Household Treatment and Safe Storage

- *Preparedness to buy HTWS*
- *Acceptability of existing system*

Participants were asked different questions depending on whether or not they had bought a product from PHW. For households without a PHW technology, households were asked if they were interested in treating their drinking water. Households were then asked how much they would be willing to spend on a system and who in the family decides what to buy for the household. For households that had bought a PHW product, participants were asked about why they selected the technology (discussed in Section 5.2) and who in the household made the decision (Section 5.1.9). Additional questions included how often they use the product, who is responsible for treating the water, and whether they were pleased with the technology. This section was used to provide product feedback to the PHW business. Participants were also asked about their method of operation and maintenance of the product in order to assess the sustainability of the project. For both households with and without the technology, the PHW staff added the question "Are you ready to learn how to produce any of the HWTS products?" to find out whether people would be willing to build their own technologies (discussed in Section 5.1.8).

3.8 Population Selection in Ghana

The community, household, and participant selection process defined the study cohort.

3.8.1 Community Selection Strategy

The surveys were conducted in households in the Tamale and Savelugu Districts in the Northern Region of Ghana. The study population was selected with the assistance of the two local entrepreneurs from PHW in Ghana. Originally, the study was designed to compare 25 households that had purchased PHW technologies to 25 households without technologies. However, the entrepreneurs recommended that we also obtain baseline data on communities that have not yet been exposed to the PHW technologies. In Ghana, it was also discovered that many of the products were sold to people at the workplace, rather than within a neighborhood, so that the consumers were from a variety of communities. Often the home addresses of the consumers were unknown, and it was not realistic to survey them during their time at work. With the help of Wahabu Salifu and Hamdiya Alhassan, we were able to identify four communities with three or more people with treatment technologies, which were the Kamina Barracks, Vitin Estates, Jisonayili, and Libga. Additionally, three more communities were identified that did not have exposure to treatment technologies, which were Kaleriga, Bunglung, and Diare. The communities surveyed are mapped in Figure 4.

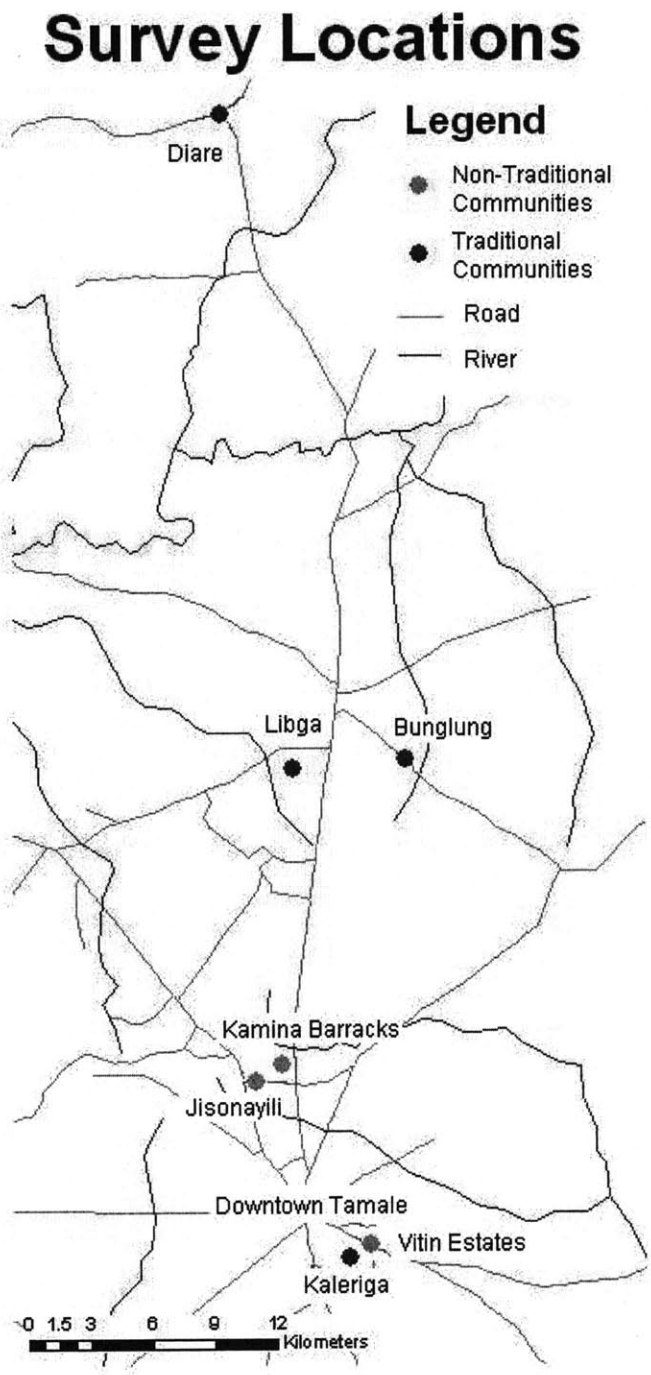


Figure 4: Survey Locations in the Northern Region of Ghana
Map by Jenny VanCalcar, 2006

3.8.2 Household Selection Strategy

In communities with PHW technologies, households were chosen that had purchased technologies and comparison households were chosen from the same neighborhood. Generally, each community had a limited number of people with the treatment technologies, which simplified the selection decision. Households were targeted with children under five, which is standard practice for water and sanitation studies since children under five are most susceptible to waterborne illness. In some communities, the limited number of consumers made it necessary to survey households without children under five; in this case, these households were matched with subsequent households without children under five without the technologies.

In communities without the PHW technologies, a random sampling of households was surveyed to obtain baseline data. Households were targeted with children under five. The actual households were often chosen by a local community guide, since they were knowledgeable about which households had children under five and which women were home and available. In the traditional communities, sometimes it was culturally required to initially survey the wife of the chief upon our entrance into the community. Though a random sampling was attempted, the selection was difficult because of language barriers and cultural requirements, and there is a potential for household selection bias.

3.8.3 Participant Selection Strategy

To minimize the differences in responses, the woman of the household (generally mother, or grandmother if mother was not available) was chosen as the participant in the survey. Women are generally responsible for the water of the household, including water collection, cooking, and cleaning. Therefore, women were chosen since they are assumed to be the most knowledgeable about household water practices. In the traditional households, extended families live together and often many women were present, in which case the household members made the selection, which was assumed to be random.

3.9 Implementation of Surveys in Ghana

Initially, the implementation plan of the overall survey was discussed with PHW and revised as necessary. Ten copies of the survey were brought from MIT, since future revisions were anticipated, and the final version (Appendix B) was printed and copied in country. After the population selection was decided, a schedule was drafted determining which days each community would be visited, considering transportation convenience and efficiency. Because most households did not own telephones, prior notification through calling was not feasible. In traditional communities (including Libga, Kaleriga, Bunglung, and Diare), it was culturally necessary to visit the chiefs and leaders at least a day in advance. In these situations, the chiefs would first approve the visit of PHW to the community and then select a day for survey implementation. All chiefs were receptive to the project and approved our visitation. In modern communities (including Kamina Barracks, Jisonayili, and Vitin Estates), it was not necessary to notify the households prior to visitation.

For each community, the survey was conducted with the help of either Hamdiya Alhassan or Wahabu Salifu, based on their availability, familiarity with the community, and fluency with the local dialects. Hamdiyah accompanied the author to Jisonayili and Kamina Barracks, and Wahabu accompanied the author to Bunglung, Diare, Kaleriga, Libga, and Vitin Estates.

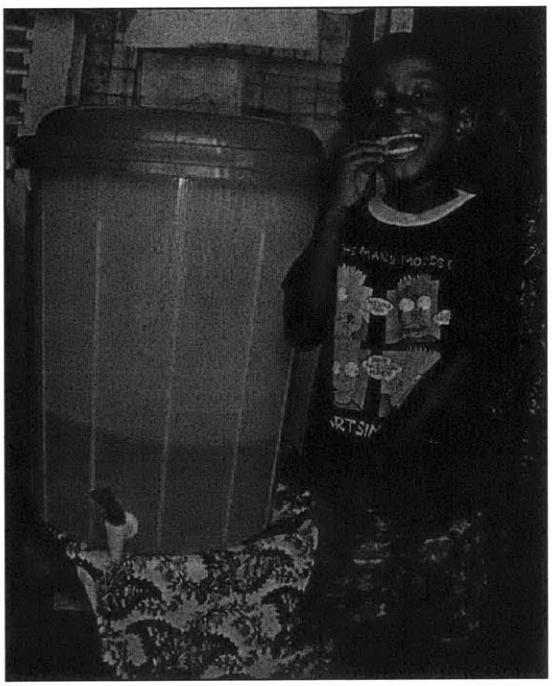
Though the male or female presence may have affected the participants' responses, it was decided that this affect was minimal and was necessary for the survey implementation. The presence of outsiders (particularly Westerners) visiting the community may have influenced the participants' responses and is considered in the analysis. Though the woman of the household was chosen as the participant, often all members of the household would chime in to help answer the questions. This family participation was unavoidable. It is attributed to the familial culture of the community, and it was assumed to minimally affect the survey results. The surveys were conducted in English if possible or in a local dialect with the help of translators (Hamdiyah Alhassan, Wahabu Salifu, or local guides). [4] The entire survey took twenty to forty-five minutes, depending on the level of language barrier. In each community, six to ten households were surveyed, and subsequent water samples were collected and GPS coordinates were recorded.

The participation rate was 100%, extremely high for household survey implementation. A few household participants were not available initially, but were available when we returned later in the day. This high participation rate can be attributed to prior notification in the traditional communities and general cultural acceptance of household visitors.

[4] Though English is the official language, over 60 local dialects are present in Ghana (Briggs, 2004)

CHAPTER 4:

WATER QUALITY TESTING METHODOLOGY



CHAPTER 4: WATER QUALITY TESTING METHODOLOGY

4.1 Water Quality Testing

At each household, water samples of the source water and filtered water (if applicable) were collected directly from the container used for drinking and then tested in the MIT team field laboratory set up at our place of residence in Tamale for bacterial contamination, using H_2S and membrane filtration tests. During the household visits, the participants were asked to offer some drinking water. Because the water samples were taken directly from the cup offered, the sample was assumed to be representative of the water quality being consumed by the household. The water testing was able to detect contamination, regardless of whether the contamination occurred at the source, during transit, or during storage. See Figure 5 for water sample collection.

The samples were collected from the households at the end of the interview, placed in an ice cooler with ice packs during transport, and refrigerated in the laboratory until they were analyzed. These tests were performed at the laboratory in Ghana during the same day as water sample collection. All tests were performed within six hours of collection, as recommended by the water testing protocol.

Figure 5: Water Sample Collection from the Tamakloe Filter
Photo courtesy of Wahabu Salifu

4.2 Hydrogen Sulfide (H_2S) Testing

The H_2S presence/absence (P/A) test was chosen because of its simplicity and feasibility in developing countries. The samples can be incubated between 15°C and 45°C and the results are rapidly available in 24 to 48 hours. This test uses hydrogen sulfide (H_2S) microorganisms as an indicator for fecal contamination in drinking water. If H_2S bacteria are present in the water sample, they produce H_2S gas which reacts with iron in the media to form iron sulfide, a black precipitate that turns the water sample black. However since H_2S is not a perfect indicator for

fecal contamination, it is possible that this test may produce false negatives and false positives (Sobsey and Pfaender, 2002). For example, another source of hydrogen sulfide may exist in the sample without fecal contamination, which would result in false positives. Additionally, for cost and convenience, 20 mL sample sizes were used as opposed to 100 mL samples, though this adaptation of the method affects the sensitivity of the results. (For more information on our MIT team experience in Ghana with H_2S testing, see Mattelet, 2006).

4.2.1 H_2S Testing Materials

- 20 mL glass sampling bottle
- Candle
- Lighter
- Alcohol
- HACH PathoScreen Medium for 20mL sample

4.2.2 H_2S Testing Procedure

(This procedure is based on *Water Analysis Handbook* by Hach, 2003)

1) Add 20 mL of water sample into sterilized bottle
2) Add PathoScreen packet to bottle and mix to dissolve.
3) Incubate at 35°C
4) After 24 hours, observe. If sample is still yellow after 24 hours, incubate another day and observe results after 48 hours.

Results (See Figure 6):
Black=Positive,
Yellow=Negative

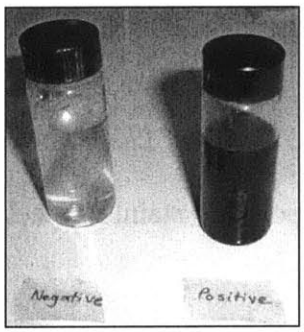


Figure 6: Negative (yellow) and Positive (black) results for H_2S bacterial water testing
Photo courtesy of Rachel Peletz

4.3 Membrane Filtration (MF) Testing

Drinking water quality was analyzed using membrane filtration (MF) in order to quantify the level of bacterial contamination, specifically total coliform (TC) and *E.coli* (EC). Compared to the H_2S test, MF requires the counting of the bacterial colonies and uses a larger water sample (100 mL instead of 20 mL), producing more accurate results. However, the MF test is more expensive and more time consuming. In this project, the author used m-ColiBlue 24 media to target coliform bacteria and selectively eliminate growth of non-coliform cells. After 24 hours

of incubation at 35°C, TC colonies are highlighted red by the dye 2,3,5-Triphenyltetrazoliumchloride (TTC), and EC colonies are highlighted blue by the reaction of a β-glucuronidase enzyme on 5-Bromo-4-Chloro-3-Indolyl-β-D-glucuronide (BCIG or X-Glu). (For more information on our MIT team experience in Ghana with H_2S testing, see Mattelet, 2006).

4.3.1 MF Testing Materials

- Millipore portable MF setup
- Culture medium
- Absorbent pad
- 0.45μm filter paper
- Candle
- Lighter
- Tweezers
- Magnifying glass
- Incubator

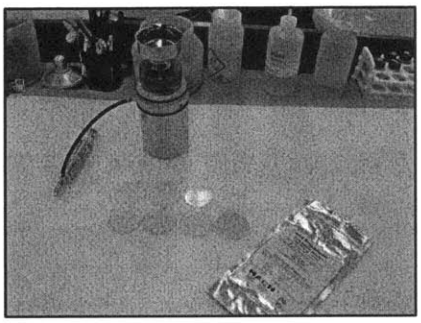


Figure 7: Membrane Filtration Testing Materials
Photo Courtesy of Claire Mattelet

4.3.2 MF Field Testing Procedure

(This procedure is based on *Water Microbiology: Laboratory and Field Procedures* by Millipore)

1) Flame-sterilize the portable Millipore MF stainless steel filter holder

2) Prepare the petri dish:
   - Label the dish
   - Place the absorbent pad into the dish with sterile tweezers
   - Add the culture medium to the petri dish and swirl to ensure that the pad is evenly soaked. Pour off excess liquid.

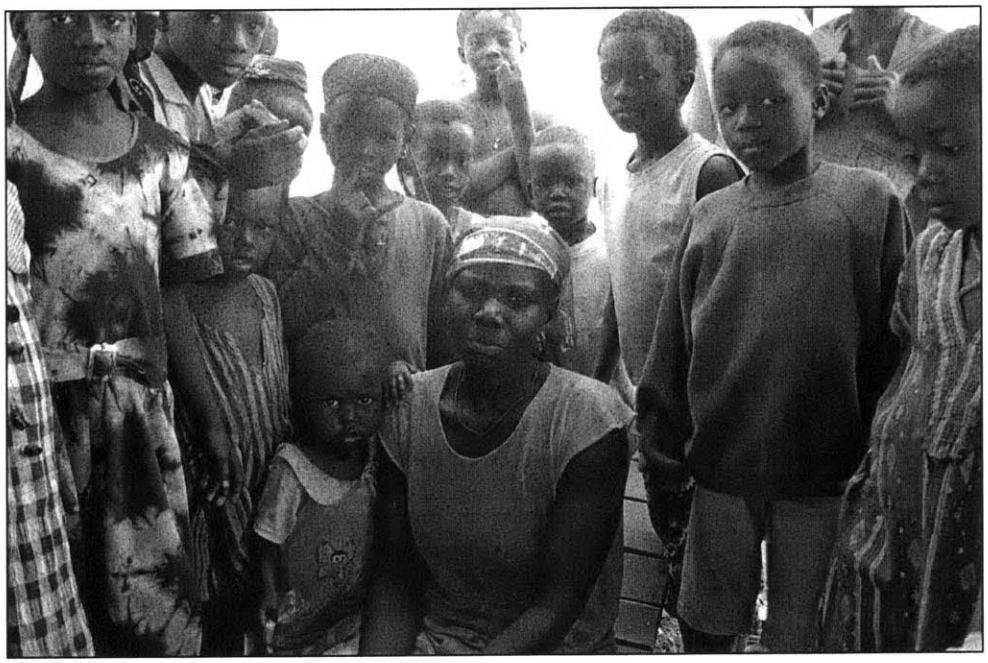
3) Filtration
   - Place the 0.45μm filter paper into the Millipore unit with sterile tweezers
   - Add the 100 mL water sample
   - Run the filtration, pumping to create a vacuum
   - Rinse the unit with 30 mL of sterile water three times to ensure entire flushing of the sample through the filter

4) Filter Removal and incubation
   - Remove the filter with sterilized tweezers and place into the prepared Petri dish
   - Incubate the sample at 35°C for 24 hours. Invert the sample during incubation to prevent steam from forming on the filter, making it difficult to read the samples.

5) Results
   - The colony forming units (CFUs) are counted and represented as CFU/100 mL
   - The number of TC colonies on a plate should be between 20 and 80 CFUs for statistical validity.

CHAPTER 5:

EPIDEMIOLOGICAL STUDY RESULTS



CHAPTER 5: EPIDEMIOLOGICAL STUDY RESULTS

5.1 General Survey Results

The cross-sectional epidemiological survey collected baseline data on water and sanitation practices in the Northern Region of Ghana. The survey results are summarized in Table 3. Categorical data is compared with percentages, and continuous data is compared with the averages, which are taken as the arithmetic mean of the data. The detailed survey responses are included in Appendix C and Appendix D.

Table 3: General Profile of Survey Results

Communities surveyed	Traditional	28/50= 56%
	Diare	7/50 = 14%
	Kaleriga	6/50 = 12%
	Bunglung	7/50 = 14%
	Libga	8/50 = 16%
	Modern	22/50 = 44%
	Kamina Barracks	10/50 = 20%
	Vitin Estates	6/50 = 12%
	Jisonayili	6/50 = 12%
Household Information	Average number of people in household	14 people
	Average number of children under 5	2 children
	Average age of respondent	35 years old
	Average number of years of education of respondent	5 years
	Average expenses per person per month	250,000 cedis ($28)
Diarrheal Prevalence and Knowledge	Diarrheal Prevalence (people)	39/724 = 5.4%
	Diarrheal Prevalence (households)	19/50 = 38%
	Diarrheal Prevalence for children under 5	17 /109 = 16%
	Knowledgeable about diarrheal causes	42/50 = 84%
Hygiene and Sanitation	Appropriate Hand-washing	43/50 = 86%
	Adequate sanitation facility	23/50 = 46%
	Average time to sanitation facility	4 minutes
Water Use Practices	Primary Water source	
	Tap	22/50= 44%
	Standpipe	7/50= 14%
	Borehole	19/50 = 38%
	Dam	2/50 = 4%
	Always using Improved Water Source	32/50 = 64%
	Average time to source	
	Dry season	26 min
	Wet season	10 min
	Primary water sources while traveling	Sachet and tied water
Water Storage	Storage containers*	
	Barrel/plastic drum	2/50=2%
	Ceramic vessels	23/50 = 46%
	Cooler	1/50=2%
	Jerry can	3/50=2%
	Metal tank/drum	2/50=4%
	Plastic bucket	5/50=10%
	Plastic bottles	13/50 = 24%
	Safe Storage	4/50=8%
	Proper Storage	32/50 = 64%
Water Quality Perception and Household Water Treatment	Believe water is safe without treatment	38/50 = 76%
	Treatment method: some type **	40/50 = 80%
	Tamakloe	8/50 = 16%
	Nnsupa	3/50 = 6%
	Cloth	27/50 = 54%
	Boiling	1/50 = 2%
	Settling	5/50 = 10%
	Glucose	1/50 = 2 %
	Alum	1/50 = 2%
Water Testing Results	H2S bacteria in source water	20/50 = 40%
PHW Technology	Households with PHW Technology	15/50=30%
	Interested in Producing PHW Technology	47/50 = 94%
Family Decision-Maker	Who in family decides what to buy	
	Mother	12/50= 24%
	Father	4/50 = 8%
	Mother and father	7/50 = 14%
	Entire household	21/50 = 42 %
	Elders	1/50 = 2%

*Totals over 100% since 3 people using 2 different types of containers

**Totals over 100% since some respondents are using more than one type of treatment

5.1.1 Communities Surveyed

The percentages of respondents from each community are listed in Table 3 and categorized as traditional or modern. The dichotomy of traditional and modern households is based on house type and community layout. The modern communities are comprised of households constructed of cement, whereas traditional communities consisted of homes arranged in a circular fashion (See Figure 8) and are generally ruled by a head chief.

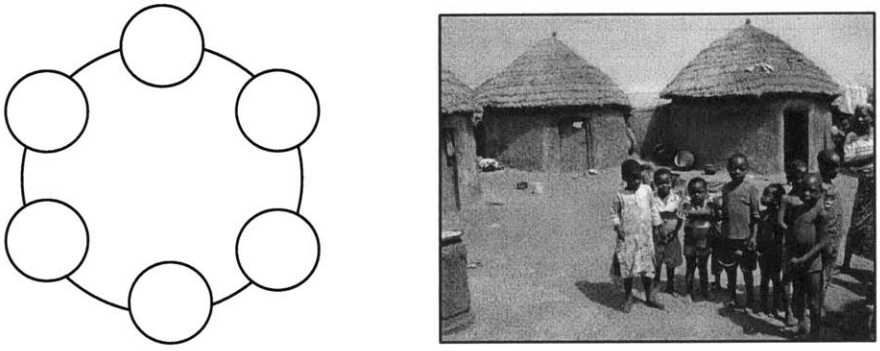


Figure 8: Diagram and Photo of Household Arrangement in Traditional Communities
Photo courtesy of Casey Gordon

5.1.2 Household Information

The survey included general questions to gather background information about the household and respondent. In traditional communities, "households" consist of many dwellings arranged in a circle and surrounded by a wall (See Figure 8). The compound in the middle of the circle is used for cooking and other activities. Sometimes there were so many children around that the respondents were unsure of the exact number of members in the household, and in these cases, the best estimate was recorded. As a result of the definition of "household" in traditional communities, the average number of people for households surveyed is quite high at 14 members, including both traditional and modern households.

The average age of the respondent, generally the mother or the grandmother of children under five, was recorded. This average is increased by the few grandmothers that were interviewed. Years of education were recorded as well. The average expenses per person per month were calculated by summing the total expenses and dividing by the number of household members. The total expenses were determined by asking about monthly costs of food, transportation, education, health, utilities, and other expenses; these questions often ignited a debate among the entire household. Though this data is a rough estimate, it generally profiles the study cohort as people that live on less than a dollar a day. See Table 3 for detailed responses.

- Expenses per person per month = $\frac{\text{Total expenses of each household}}{\text{Number of members in household}}$

5.1.3 Diarrheal Prevalence and Knowledge

The diarrheal prevalence is defined in the PHW survey as the percentage of people that were suffering from diarrhea within one week of the time of the study. The prevalence of the total number of people was calculated by dividing the number of those suffering with diarrhea by the total number of people in all households surveyed. Similarly, the prevalence in the children

under five was calculated by dividing the number of children under five suffering from diarrhea by the number of children under five in all households surveyed. The diarrheal prevalence in households is defined as the households with one or more individuals suffering from diarrhea divided by the total number of households. Households were determined to be knowledgeable about diarrheal causes if they responded affirmatively when asked if dirty water, dirty food, and poor hygiene could all be causes of diarrhea. In general, it seemed that households were knowledgeable about the causes of diarrhea; however, the participants' willingness to respond to please the interviewer must be considered. The costs of the most common treatments were recorded and averaged for the data set (see Table 3). Additionally, respondents were asked about the caretaker for the sick family members, and it was found that this burden fell almost entirely on the mothers and grandmothers of the household.

- Diarrheal Prevalence (people) = $\frac{\text{Total number of people with diarrheal illness within week of survey}}{\text{Total number of people in all households surveyed}}$

- Diarrheal Prevalence (households) = $\frac{\text{Total number of households with at least one person with diarrheal illness}}{\text{Total number of household surveyed}}$

- Diarrheal Prevalence for children under five = $\frac{\text{Number of children under five with diarrheal illness}}{\text{Total number of children under five in households surveyed}}$

- Knowledgeable about diarrheal causes = $\frac{\text{Respondents that acknowledged dirty water, dirty food, and poor hygiene as causes for diarrheal illness}}{\text{Total number of respondents}}$

5.1.4 Hygiene and Sanitation

Respondents were asked about hand-washing practices and adequate sanitation facilities. The general assessment about appropriate hand-washing was based on whether mothers washed their hands at appropriate times and always used soap. In order to be classified as "appropriate," participants had to respond affirmatively when asked if they always used soap, currently had soap in the household, and if they washed their hands before eating, before cooking, and after going to the bathroom. Though there may have been discrepancies between the responses and actual practices, this method of assessment was thought to be the most appropriate. In general, mothers seemed fairly knowledgeable about the importance of hand-washing based on their responses; of the respondents, 86% practiced appropriate hand-washing.

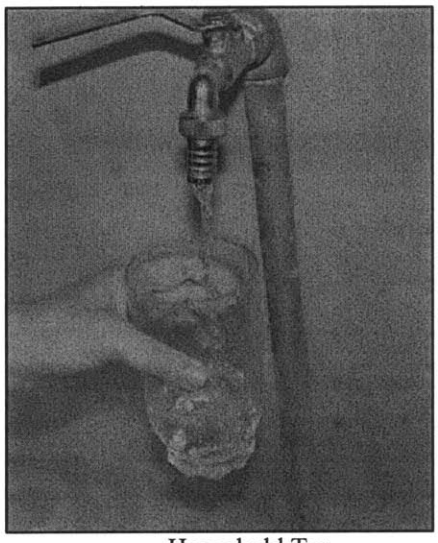
The general survey results determined that 46% of the households surveyed had access to adequate sanitation facilities. Sanitation access is defined as having a flush toilet or private/shared latrine that is always available. Public latrines are not considered improved sanitation facilities as defined by the UNICEF/WHO Joint Monitoring Programme (JMP, 2005). The respondents were also asked if hand-washing was available at the sanitation facility, but this information was not used in the assessment of whether the sanitation facility was adequate. Additionally, the time to the sanitation facility was recorded and averaged four minutes; many families practiced "free range," using nearby fields that required travel time. This average is lowered by the participants that had sanitation facilities within the home, where the time to the facility was recorded to be zero minutes. The time to the sanitation facility was not considered in the determination of sanitation access.

- Appropriate hand-washing = Number of respondents that always use soap, currently have soap in the home, and wash their hands before cooking, before eating, and after using the toilet / Total number of respondents

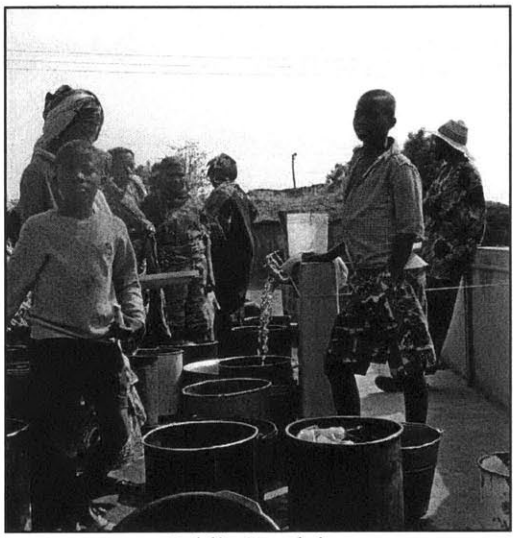
- Adequate sanitation facility = Number of households with flush toilet or latrine (private/shared) that is always available / Total number of household surveyed

5.1.5 Water Use Practices

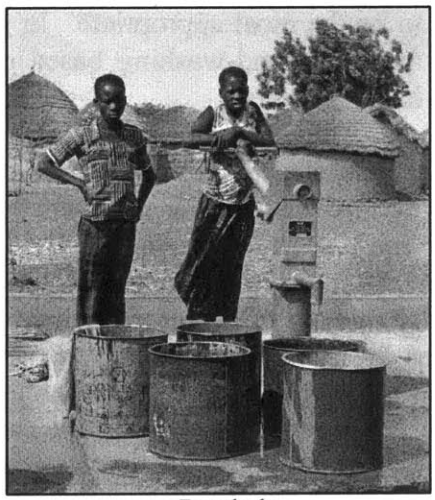
The four primary water sources for the surveyed households include the household tap, public standpipe, borehole, and dam (see Figure 9). Though households may be using an improved source for their primary or main water source, many households used secondary water sources that were not improved. Sixty-four percent of people were classified as always using an improved drinking water source, defined as a tap, standpipe, or borehole that was always available.



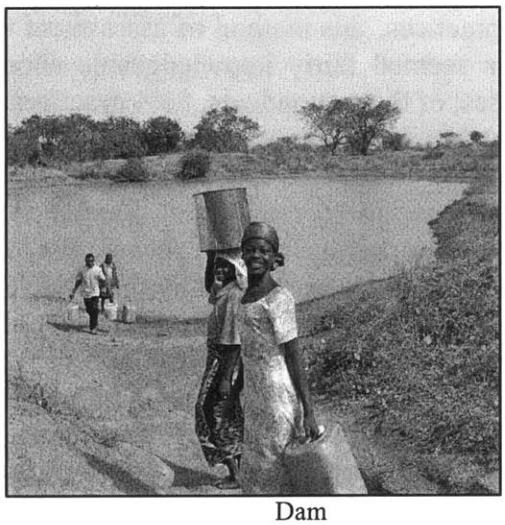
Household Tap



Public Standpipe



Borehole



Dam

Figure 9: Primary Drinking Water Sources for Households Surveyed
Top Left: Household Tap, courtesy of Susan Murcott; Top Right: Public Standpipe, courtesy of Rachel Peletz; Bottom Left: Borehole, courtesy of Jenny VanCalcar; Bottom Right: Dam, courtesy of Jenny VanCalcar

The total time to collect the water in the wet and dry season included traveling, waiting at the source (if applicable), filling containers, and returning. This time averaged 26 minutes in the dry season and 10 minutes in the wet season among those surveyed. Participants were also asked about their primary drinking water source while away from home which was found to be sachet and tied water (Figure 10). Sachet water costs $0.04 (400 cedis) and tied water costs $0.02 (200 cedis) for a small bag of water, about equal to one cup. Because sachet and tied water were sold by vendors, the source was uncertain and potentially unsafe. This water from vendors could potentially be a source of diarrheal illness, and also indicated that the family is willing to pay for drinking water.

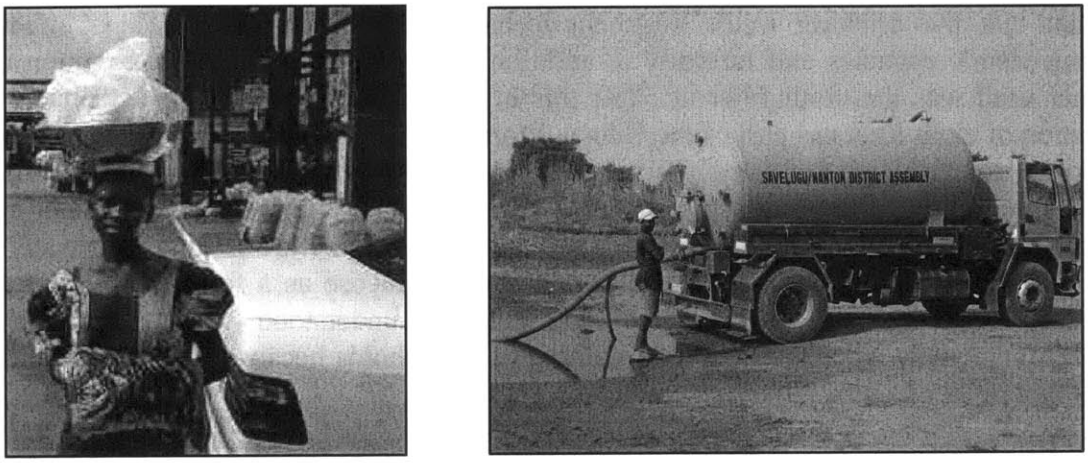


Figure 10: Sachet Vendor and Tanker Truck
Left: courtesy of Susan Murcott; Right: courtesy of Rachel Peletz

Though not included in Table 3, the interview included questions about who collected the water and how many times water was collected each day. It was found that this burden falls unequally on women and children, who travel in groups to the water source as many as eight times a day. (See Appendix C for detailed survey results).

- Always using an improved water source = $\frac{\text{Number of households with an improved water source (household tap, public standpipe, or borehole) always available}}{\text{Total number of household surveyed}}$

5.1.6 Water Storage

The most common types of storage containers were found to be ceramic vessels (46%) and plastic bottles (24%). Because many people are using more than one type of container, the total is more than 100% of the type of container used in Table 3. Additionally, it was found that 64% of people are practicing proper storage, which was determined as keeping the vessel always covered and by the method used to take water from the container. For proper storage, respondents must pour the water directly (as such with a plastic bottle), use a spigot, or draw the water with a scoop with a handle. Using a scoop without a handle was not considered proper storage because of the possibility of recontamination from dirt on the hands.

Despite the attempt to determine proper storage, it is possible that the water was getting recontaminated through ways not addressed by the questionnaire. During household visits, it was observed that yam reeds were sometimes put into the vessels for carrying water which increased stability during transit, according to the local people. The roots may serve as a pathway for contaminating the drinking water during transit.

5.1.7 Water Quality Perception and Household Water Treatment

Seventy-six percent of the respondents believe that their water is safe to drink without treatment. However, 80% of the households are practicing some type of treatment. This discrepancy may be partially attributed to the ignorance as to germ theory of disease; visible particles and dirt rather than pathogens were found to be the main concern about drinking water. Therefore it is important that the drinking water treatment technology promoted by PHW is effective in removing visible particles and turbidity in addition to pathogens. The most common type of treatment used was the cloth filter at 54%; this high usage may be partially attributed to the distribution of cloth filters as part of the Guinea Worm Eradication Campaign. Guinea worm is a waterborne illness which has largely been eradicated worldwide but which is still endemic in Ghana. In addition to the products sold by PHW, one household was practicing boiling, one household was adding alum for coagulation, and five households were settling their water before drinking. Additionally, one household reported adding glucose as a form of water treatment, though the reasoning behind this practice was not fully understood. The summation of the treatment methods is more than the total number of households because some households were practicing more than one treatment method (see Table 3).

5.1.8 PHW Technology

Participants were asked questions to determine their interest in the PHW products. Ninety-four percent of the households reported that they were interested in learning how to produce the PHW products. This question was added by Hamdiyah Alhassan to determine if consumers would be interested in building their own technology and to identify individuals that could potentially assist the PHW business in the future. Households with the PHW products were asked additional questions included in Section 5.2 and summarized in Table 4.

5.1.9 Family Decision-Maker

The participant was asked who in the family decides what to buy in order to determine the family member(s) to target for PHW marketing. It was found that 42% of respondents reported that the entire household determines what to buy, and in 24% of households the mother decided what to buy. Sometimes the family debated about who makes the decisions, and both the mother and father claimed to have this responsibility; in this case, the respondent's answer was recorded. Detailed responses to the survey are displayed in Table 3.

5.2 Product Feedback

Households that had purchased a PHW technology were asked different questions than households without the technology in order to provide user feedback to PHW. Product feedback survey results are summarized in Table 4, and detailed reponses are displayed in Appendix D. Ninety-four percent of households without the technologies were found to be interested in treating their drinking water.

Table 4: PHW Product Feedback Survey Results

Without Treatment Technology	Interest in Water Treatment	33/35 = 94%
	Willingness to pay	80,000 cedis ($9)
With Treatment Technology	Household with Technology	15/50=30%
	Tamakloe	8/50 = 16%
	Nnsupa	3/50 = 6 %
	Safe Storage	4/50 = 8 %
	Always use technology	13/15 = 87%
	Technology still in use	14/15 = 93%
	Overall changes in water	
	Better	12/15 = 80%
	The Same	3/15 = 20 %
	Worse	0%
	Pleased with technology	13/15 = 87%
	Recommend technology to others	15/15 = 100%
	Noticeable improvements in family health	13/15 = 87%
	Who treats the water	
	Mother	12/15 = 80%
	Female child	1/ 15 = 7%
	Male child	1/ 15 = 7%
	Everyone	1/ 15 = 7%
	Adequate resources to maintain technology	13/15 = 87%
	Willingness to pay if technology breaks	72,000 cedis ($8)
	Why more people haven't bought technology	
	Price	7/15 = 47%
	Don't know about it	3/15 = 20%
	Unknown	5/15 = 33%

The willingness-to-pay for filter technologies was comparable between households with and without the technology, at $8 (72,000 cedis) and $9 (80,000 cedis), respectively (see Figure 11). Additionally, the differences between modern and traditional communities for willingness-to-pay were comparable, at $8 (72,000 cedis) for modern communities and $9 (80,000 cedis) for traditional communities. Households without PHW products (most of which were in traditional communities) were unfamiliar with the technologies and therefore uncertain as to what the products would entail, resulting in a broader range of price responses compared to households with the products (Figure 11).

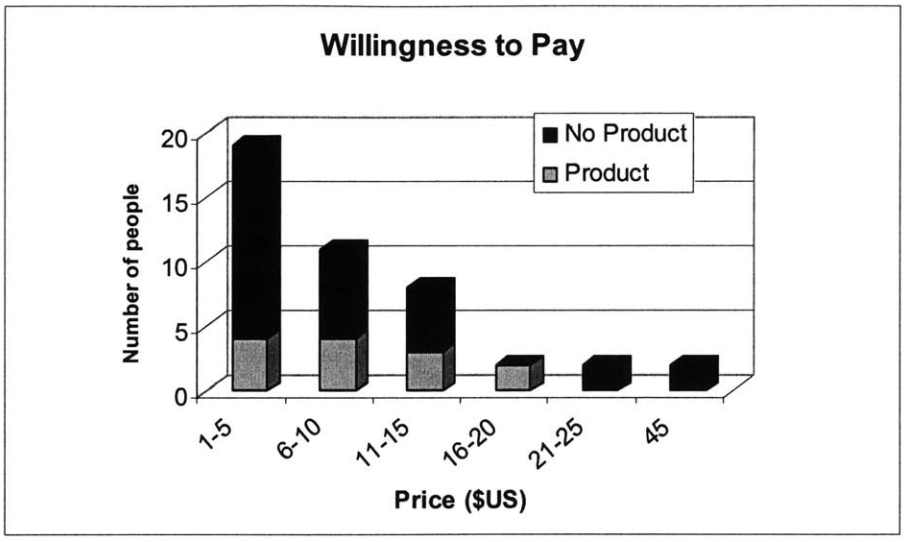


Figure 11: Willingness-to-Pay for Households With and Without PHW Products

In general, the feedback was positive from households with the PHW products. Ninety-three percent of households were still using the technology within six months of purchase. The one household that had discontinued use of the Nnsupa did so because the filter had gotten clogged and the flow rate was unacceptably slow, which was determined to be caused by very turbid water containing many particles that clogged the filter. Eighty-seven percent reported that they always use the technology and 87% reported that they were pleased with the technology. Eighty percent of the people believe that the water is better aesthetically, 20% have not noticed a difference, and no households reported a negative change in the water aesthetics. Every household reported that they would recommend the technology to others. Eighty-seven percent of households have noticed health improvements in their family, but this response may be partially psychological rather than physical, and no health monitoring was performed to verify this response. In general, the mother is most commonly responsible for treating the water at 80% of the households.

When asked why they purchased the technology, customers reported that the products clean the water, prevent recontamination, and save time since treating water by boiling is no longer necessary. Customers liked the appearance, size, and ease-of-use of the products. Some customers even mentioned that they would like a larger filter or another one in their household. Additionally, customers with the Tamakloe mentioned that they chose the Tamakloe filter over the Nnsupa because of the price ($16 versus $21).

Participants also believed that more people have not bought the technology mostly because of price but also because they are not aware of the products. For the Tamakloe filter, additional complaints included that the ceramic was breakable and that clay bits came off of the lip when the lid was opened and closed. Some Tamakloe users also said they would like another one or a bigger unit. One user complained about the price and thought the products should be free since PHW is working with World Vision, a large and well-established NGO in Ghana.

Using the HWTS Indicators of the WHO Network, the rate of adoption and market penetration can be determined for the PHW technologies (Murcott, 2005). For the rate of adoption, 93% of

households were still using the products within six months of purchase. Using the market penetration definition of number of units sold over the total target population, only 152/520,000 or 0.03% of the market in the three districts had been penetrated as of January 2006.

Survey results on product feedback are displayed in Table 4, and detailed responses are included in Appendix D.

5.3 Comparative Survey Results

In addition to the general survey results in Table 3 and the product feedback in Table 4, comparison tables evaluate the differences between particular variables.

5.3.1 Comparison of Modern and Traditional Communities

Because of the apparent lifestyle differences between the modern and traditional communities, the two types of communities are compared in Table 5. For the household information, the traditional households were much larger with more children under five. The size difference can be mainly attributed to the definition of a traditional household as many dwellings arranged in a circle, so that many families are actually living together in a household (see Figure 8). Additionally, none of the respondents in the traditional households had attended school, compared to an average of 12 years for modern households. The average expenses per person per month were significantly lower for traditional households, at the equivalent of $7 per month compared to $55 per month. Traditional households suffer from a higher prevalence of diarrheal illness, particularly for children under five (18% for traditional versus 5% for modern), which may be partially attributed to sanitation and water use practices. Most striking is the difference between access to sanitation facilities: 7% for traditional compared to 95% for modern. The water source of the traditional communities surveyed includes standpipes, boreholes, and dams, compared to the modern communities surveyed that all had household taps. Traditional households generally store their water in ceramic vessels (82%), compared to plastic bottles for modern communities (59%). The detailed responses are presented for comparison in Table 5.

Table 5: Survey Results Comparison of Modern and Traditional Communities

		Modern	Traditional
Communities surveyed	Traditional	0/22 = 0 %	28/28=100%
	Diare	0/22 = 0 %	7/28=25%
	Kaleriga	0/22 = 0 %	6/28=21%
	Bunglung	0/22 = 0 %	7/28=25%
	Libga	0/22 = 0 %	8/28=29%
	Modern	22/22 = 0%	0/28=0%
	Barracks	10/22=45%	0/28=0%
	Vitin Estates	6/22=27%	0/28=0%
	Jisonayili	6/22=27%	0/28=0%
Household Information	Average number of people in household	5 people	22 people
	Average number of children under 5	1 child	3 children
	Average age of respondent	32 years	37 years
	Average number of years of education of respondent	12 years	0 years
	Average expenses per person per month	500,000 cedis ($55)	67,000 cedis ($7)
Diarrheal Prevalence and Knowledge	Diarrheal Prevalence (people)	2/119=2%	37/605=6%
	Diarrheal Prevalence (households)	1/22=5%	18/28=64%
	Diarrheal Prevalence for children under 5	1/21=5%	16/88=18%
	Knowledgeable about diarrheal causes	15/22=68%	27/28=96%
Hygiene and Sanitation	Appropriate Hand-washing	19/22=86%	24/28=86%
	Adequate sanitation facility	21/22=95%	2/28=7%
	Average time to sanitation facility	Under 1 minute	7 minutes
Water Use Practices	Primary Water source		
	Tap	22/22=100%	0%
	Standpipe	0%	7/28=25%
	Borehole	0%	19/28=69%
	Dam	0%	2/28=7%
	Always using Improved Water Source	18/22=82%	14/28=50%
	Average time to source		
	Dry season	13 minutes	37 minutes
	Wet season	5 minutes	14 minutes
	Primary water sources while traveling	Sachet water	Tied water
Water Storage	Storage containers		
	Barrel/plastic drum	2/22=9%	0%
	Ceramic vessels	0%	23/28=82%
	Cooler	1/22=45%	0%
	Jerry can	2/22=9%	1/28=4%
	Metal tank/drum	2/22=9%	0%
	Plastic bucket	5/22=23%	0%
	Plastic bottles	13/22=59%	0%
	Safe Storage	0/22=0%	4/28=14%
	Proper Storage	21/22=95%	11/28=39%
Water Quality Perception and Household Water Treatment	Believe water is safe without treatment	10/22=45%	28/28=100%
	Treatment method: some type	15/22=68%	26/28=93%
	Tamakloe	8/22=36%	0%
	Nnsupa	3/22=14%	0%
	Cloth	3/22=14%	25/28=89%
	Boiling	0/22=0%	1/28=4%
	Settling	4/22=18%	1/28=4%
	Glucose	1/22=5%	0%
	Alum	0/22=0%	1/28=4%
Water Testing Results	H2S Bacteria in source water	4/22=18%	16/28=57%
PHW Technology	Households with Technology	11/22=50%	4/28=14%
	Interested in Producing Technology	19/22=83%	28/28=100%
Family Decision-Maker	Who in family decides what to buy		
	Mother	9/22=41%	2/28=7%
	Father	3/22=14%	1/28=4%
	Mother and father	3/22=14%	4/28=14%
	Entire household	0%	21/28=75%
	Elders	2/22=9%	0%

5.3.2 Comparison of Tamale and Savelugu Districts

Two different districts were surveyed in the Northern Region of Ghana, Tamale and Savelugu. Four communities were surveyed in the Tamale district, including the Kamina Barracks, Vitin Estates, Jisonayili, and Kaleriga. The three communities surveyed in the Savelugu District were Diare, Bunglung, and Libga. Figure 4 on page 29 maps the specific communities. The differences between districts may be mainly attributed to the differences of traditional and modern communities, since the communities surveyed in the Tamale district were primarily modern (3 of the 4 communities), and all of the communities surveyed in the Savelugu district were traditional. See Table 6 for a detailed comparison.

Table 6: Survey Results Comparison of Tamale and Savelugu Districts

		Tamale	Savelugu
Communities surveyed	Traditional	6/28=21%	22/22=100%
	Diare	0%	7/22=32%
	Kaleriga	6/28=21%%	0%
	Bunglung	0%	7/22=32%
	Libga	0%	8/22=36%
	Modern	22/28=79%	0%
	Kamina Barracks	10/28=36%	0%
	Vitin Estates	6/28=21%	0%
	Jisonayili	6/28=21%	0%
Household Information	Average number of people in household	7 people	24 people
	Average number of children under 5	1 child	3 children
	Average age of respondent	33 years	38 years
	Average number of years of education of respondent	9 years	0 years
	Average expenses per person per month	40000 cedis ($44)	58,000 cedis ($6)
Diarrheal Prevalence and Knowledge	Diarrheal Prevalence (people)	11/207=5%	28/517=5%
	Diarrheal Prevalence (households)	5/28=18%	14/22=64%
	Diarrheal Prevalence for children under 5	5/39=13%	12/70=17%
	Knowledgeable about diarrheal causes	20/28=71%	22/22=100%
Hygiene and Sanitation	Appropriate Hand-washing	24/28=86%	19/22=86%
	Adequate sanitation facility	22/28=79%	1/22=5%
	Average time to sanitation facility	2 minutes	8 minutes
Water Use Practices	Primary Water source		
	Tap	22/28=79%	0%
	Standpipe	6/28=21%	1/22=5%
	Borehole	0%	19/22=86%
	Dam	0%	2/22=9%
	Always using Improved Water Source	18/28=64%	14/22=64%
	Average time to source		
	Dry season	25 minutes	28 minutes
	Wet season	10 minutes	10 minutes
	Primary water sources while traveling	Sachet Water	Tied water
Water Storage	Storage containers		
	Barrel/plastic drum	2/28=7%	0%
	Ceramic vessels	5/28=18%	18/22=82%
	Cooler	1/28=4%	0%
	Jerry can	3=11%	0%
	Metal tank/drum	2=7%	0%
	Plastic bucket	5=18%	0%
	Plastic bottles	13/28=46%	0%
	Safe Storage	0%	4/22=18%
	Proper Storage	23/28=82%	9/22=41%
Water Quality Perception and Household Water Treatment	Believe water is safe without treatment	16/28=57%	22/22=100%
	Treatment method: some type	21/28=75%	19/22=86%
	Tamakloe	8/28=44%	0%
	Nnsupa	3/28=11%	0%
	Cloth	8/28=29%	19/22=86%
	Boiling	0%	1/22=5%
	Settling	5/28=18%	0%
	Glucose	1/28=4%	0%
	Alum	1/50=2%	0%
Water Testing Results	H2S Bacteria in source water	8/28=26%	12/22=55%
PHW Technology	Households with Technology	11/28=39%	4/22=18%
	Interested in Producing Technology	25/28=89%	22/22=100%
Family Decision-Maker	Who in family decides what to buy		
	Mother	11/28=39%	1/22=5%
	Father	4/28=14%	0%
	Mother and father	4/28=14%	3/22=14%
	Entire household	3/28=11%	18/22=82%
	Elders	1/28=4%	0%

5.3.3 Comparison of Households With and Without PHW Products

Households that had purchased PHW technologies were compared with households that had not purchased water treatment devices. Most of the households that have purchased the technologies are in modern communities, and all of the households that have purchased Nnsupa or Tamakloe filters were in modern communities. The four homes that purchased safe storage units were in Libga, a traditional community. In general, the respondents of households that purchased the technologies were in smaller households, had more education, and were wealthier than households that had not purchased the technologies. Additionally, the households with the PHW technologies more often had access to adequate sanitation facilities; 74% of households with PHW products had sanitation access while 34% of households without PHW products had sanitation access. Households with the PHW products more often had access to improved drinking water sources; 80% of households with PHW products always had access to an improved water supply while 57% of household without the PHW products always had access to an improved water supply. These responses indicate that the PHW technologies are currently targeting the wealthier population in modern communities that are more likely to have access to adequate sanitation and improved drinking water sources. A detailed comparison is displayed in Table 7.

Table 7: Survey Results Comparison of Households With and Without PHW Products

		With Product	Without Product
Communities surveyed	Traditional	4/15=27%	24/35=69%
	Diare	0%	7/35=20%
	Kaleriga	0%	6/35=17%
	Bunglung	0%	7/35=20%
	Libga	4/15=27%	4/35=11%
	Modern	11/15=73%	11/35=31%
	Kamina Barracks	5/15=33%	5/35=14%
	Vitin Estates	3/15=20%	3/35=9%%
	Jisonayili	3/15=20%	3/35=9%
Household Information	Average number of people in household	10 people	16 people
	Average number of children under 5	2 children	2 children
	Average age of respondent	32 years	36 years
	Average number of years of education of respondent	9 years	4 years
	Average expenses per person per month	$500,000 ($55)	150,000 cedis ($17)
Diarrheal Prevalence and Knowledge	Diarrheal Prevalence (people)	7/148=5%	32/576=6%
	Diarrheal Prevalence (households)	4/15=27%	15/35=43%
	Diarrheal Prevalence for children under 5	5/26=19%	12/83=14%
	Knowledgeable about diarrheal causes	11/15=73%	31/35=89%
Hygiene and Sanitation	Appropriate Hand-washing	14/15=93%	29/35=83%
	Adequate sanitation facility	11/15=73%	12/35=34%
	Average time to sanitation facility	3 minutes	5 minutes
Water Use Practices	Primary Water source		
	Tap	11/15=73%	11/35=31%
	Standpipe	0%	7/35=20%
	Borehole	4/15=27%	15/35=43%
	Dam	0%	2/35=6%
	Always using Improved Water Source	12/15=80%	20/35=57%
	Average time to source		
	Dry season	19 minutes	29 minutes
	Wet season	10 minutes	10 minutes
	Primary water sources while traveling	Sachet water	Tied water
Water Storage	Storage containers		
	Barrel/plastic drum	1/15=7%	1/35=3%
	Ceramic vessels	0%	23/35=66%
	Cooler	0%	1/35=3%
	Jerry can	0%	3/35=9%
	Metal tank/drum	0%	2/35=6%
	Plastic bucket	0%	5/35=14%
	Plastic bottles	10/15=67%	3/35=9%
	Safe Storage	4/15=27%	0%
	Proper Storage		18/35=51%
Water Quality Perception and Household Water Treatment	Believe water is safe without treatment	6/15=40%	32/35=91%
	Treatment method: some type		
	Tamakloe	8/15=53%	0%
	Nnsupa	3/15=20%	0%
	Cloth	3/15=20%	25/35=71%
	Boiling	0%	1/35=3%
	Settling	2/15=13%	3/35=9%
	Glucose	0%	1/35=3%
	Alum	0%	1/35=3%
Water Testing Results *	H2S Bacteria in source water	4/14=29%	16/36=44%
PHW Technology	Households with Technology	100%	0%
	Interested in Producing Technology	14/15=93%	33/35=94%
Family Decision-Maker	Who in family decides what to buy		
	Mother	3/15=20%	9/35=26%
	Father	2/15=13%	2/35=57%
	Mother and father	2/15=13%	5/35=14%
	Entire household	3/15=20%	18/35=51%
	Elders	0%	1/35=3%

* At one household with the technology we did not perform water testing, and at one household without a product they gave us two different source water samples.

5.3.4 Comparison of Households With and Without Diarrheal Illness

Households with one or more people suffering from diarrheal illness were compared to households where no one was suffering from diarrheal illness. In general, 38% of households had at least one household member with diarrheal illness. The diarrheal illness prevalence for all household members was 5%, and for children under five the prevalence was 16% (Figure 12). Ninety-five percent of households that had someone suffering from diarrhea were in traditional communities, and the remaining 5% were in modern communities (Table 8). It is notable that the traditional communities may be particularly likely to be labeled as households with diarrheal illness because of their large household size; since there are more members of the household in total, it is more likely that at least one member will have diarrhea. For households with diarrheal illness, 10% of the total members and 26% of the children under five suffered from diarrhea, underscoring that the burden of diarrheal illness falls largely on children. In general, households with diarrheal illness were found to have more household members, more children under five, fewer expenses per month, less access to adequate sanitation facilities, and less access to improved water sources. Interestingly, of the households with diarrheal illness, no households reported using oral rehydration therapy or the homemade sugar/salt solution, two simple medicines for diarrheal illness to prevent dehyradation. The details of the comparison are in Table 8.

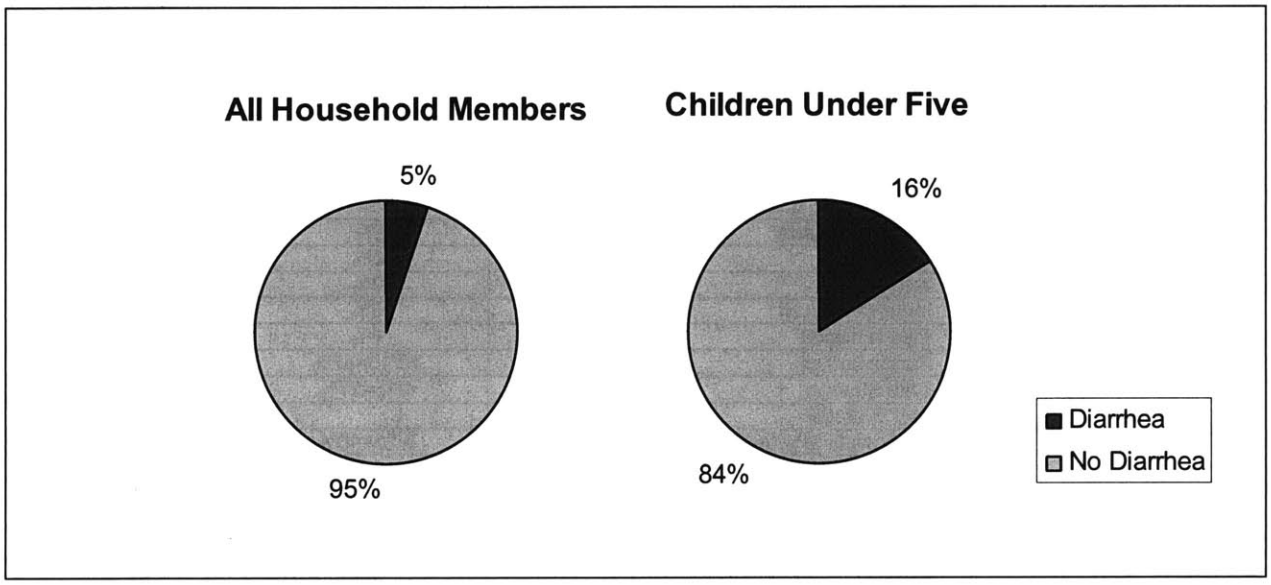


Figure 12: Diarrheal Prevalence for All Household Members and Children Under Five

Table 8: Survey Results Comparison of Households With and Without at Least One Individual with Diarrheal Illness

		Diarrheal Illness	No Diarrheal Illness
Communities surveyed	Traditional	18/19=95%	10/31=32%
	Diare	4/19=21%	3/31=10%
	Kaleriga	4/19=21%	2/31=6%
	Bunglung	4/19=21%	3/31=10%
	Libga	6/19=32%	2/31=6%
	Modern	1/19=5%	21/31=68%
	Kamina Barracks	1/19=5%	9/31=29%
	Vitin Estates	0%	6/31=19%
	Jisonayili	0%	6/31=19%
Household Information	Average number of people in household	21 people	11 people
	Average number of children under 5	3 children	1 child
	Average age of respondent	37 years	34 years
	Average number of years of education of respondent	0.5 years	8 years
	Average expenses per person per month	89000 cedis ($10)	350000 cedis ($39)
Diarrheal Prevalence and Knowledge	Diarrheal Prevalence (people)	39/396 = 10%	0/328=0%
	Diarrheal Prevalence (households)	19/19=100%	0/31=0%
	Diarrheal Prevalence for children under 5	17/66=26%	0/43=0%
	Knowledgeable about diarrheal causes	17/19=89%	25/31=81%
Hygiene and Sanitation	Appropriate Hand-washing	17/19=89%	26/31=84%
	Adequate sanitation facility	2/19=11%	21/31=68%
	Average time to sanitation facility	7 minutes	3 minutes
Water Use Practices	Primary Water source		
	Tap	1/19=5%	21/31=68%
	Standpipe	5/19=26%	2/31=6%
	Borehole	11/19=58%	8/31=26%
	Dam	2/19=11%	0%
	Always using Improved Water Source	9/19=47%	23/31=74%
	Average time to source		
	Dry season	38 minutes	19 minutes
	Wet season	11 minutes	10 minutes
	Primary water sources while traveling	Tied water	Sachet water
Water Storage	Storage containers		
	Barrel/plastic drum	0%	2/31=6%
	Ceramic vessels	14/19=74%	9/31=29%
	Cooler	0/19=0%	1/31=3%
	Jerry can	1/19=5%	2/31=6%
	Metal tank/drum	0%	2/31=6%
	Plastic bucket	0/19=0%	5/31=16%
	Plastic bottles	1/19=5%	12/31=39%
	Safe Storage	3/19=16%	1/31=3%
	Proper Storage	7/19=39%	25/31=81%
Water Quality Perception and Household Water Treatment	Believe water is safe without treatment	19/19=100%	19/31=61%
	Treatment method: some type	16/19=84%	24/31=77%
	Tamakloe	1/19=5%	7/31=23%
	Nnsupa	0/19=0%	3/31=10%
	Cloth	15/19=79%	12/31=39%
	Boiling	1/19=5%	0%
	Settling	1/19=5%	4/31=13%
	Glucose	0/19=0%	1/31=3%
	Alum	1/19=5%	0%
Water Testing Results	H2S Bacteria in source water	10/20=50%*	10/30=33%*
PHW Technology	Households with Technology	4/19=21%**	11/31=35%
	Interested in Producing Technology	19/19=100%	28/31=90%
Family Decision-Maker	Who in family decides what to buy		
	Mother	0%	12/31=39%
	Father	1/19=5%	3/31=10%
	Mother and father	2/19=11%	5/31=16%
	Entire household	15/19=79%	6/31=19%
	Elders	0%	1/31=3%

* Note: 20 samples of source water were taken since one household gave dam and public standpipe water
** 3 of these are safe storage

5.4 Comparison of Survey Data and Ghana Statistical Service Data

The PHW survey data was compared to data collected by the Ghana Statistical Service (GSS), to compare the population targeted by PHW to the greater districts of Tamale and Savelugu and to the entire Northern Region. The differences between the survey data and the statistical information can be partially attributed to varying definitions of the factors considered. For example, in the PHW surveys the household size for traditional communities is defined as the circle of dwellings (Figure 8), which results in a high number of household members, compared to the GSS data which defines a household as a single dwelling. Since all of the traditional communities were in the Savelugu District, the average size of households surveyed was 24 people compared to the GSS data of 6 people. In the surveys, appropriate hand-washing was defined as respondents washing their hands at appropriate times, and currently having soap in the household. The GSS information on hand-washing is the percentage of households that have hand-washing materials available, which was not confirmed during the household surveys. Additionally, the PHW survey sampled a small subset of the population, and the small sample size contributes to the difference between the survey results and the GSS data. The diarrheal prevalence for children under five is comparable, at 16% for the entire surveyed population compared to 15.3% for the GSS data. The comparison is displayed below in Table 9. The water sources used by households according to district are displayed in Figure 13.

Table 9: Comparison of Survey Results and Ghana Statistical Survey Data

		Tamale		Savelugu		Northern Region
		PHW Survey Data	GSS Data*	PHW Survey Data	GSS Data*	GSS Data *
Communities Surveyed	Traditional/Rural	21%	33%	100%	65%	
	Modern/Urban	79%	67%	0%	35%	
Household Information	Average household size	7 people	6.5 people	24 people	6.1 people	
	Female population with no education	21%	59%	100%	83.3%	
Diarrheal Prevalence	Diarrheal Prevalence for children under 5	13%		17%		15.3%
Hygiene and Sanitation	Appropriate Hand-washing	86%		86%		37.6% **
	Adequate sanitation facility	79%	64.4% have facilities, 13.6% have improved facilities	5%	24.1% have facilities, 4.8% have improved facilities	
Water Use Practices	Tap	79%	33.2%	0%	0.4%	
	Standpipe	21%	45.6%	5%	9.6%	
	Borehole	0%	0.6%	86%	15.4%	
	Dam/surface	0%	14.1%	9%	65.5%	
	Tanker	0%	3.9%	0%	0.6%	
	Well	0%	1.7%	0%	3.7%	
	Spring/rain	0%	0.2%	0%	4.4%	
	Always Using Improved Water Source	64%	79.6%	64%	29.8%	

* Ghana Statistical Service, 2005

**Have hand-washing materials available

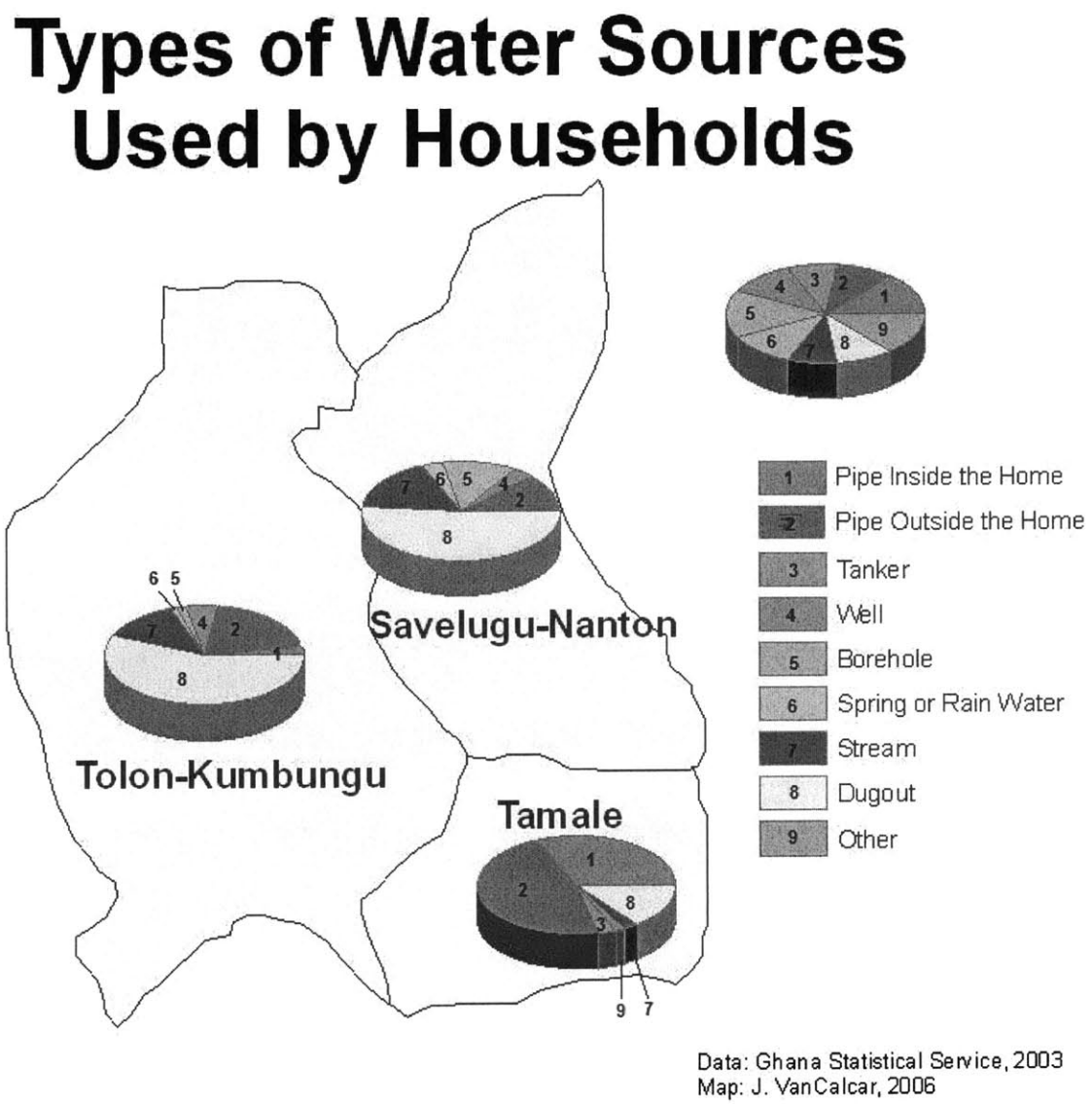
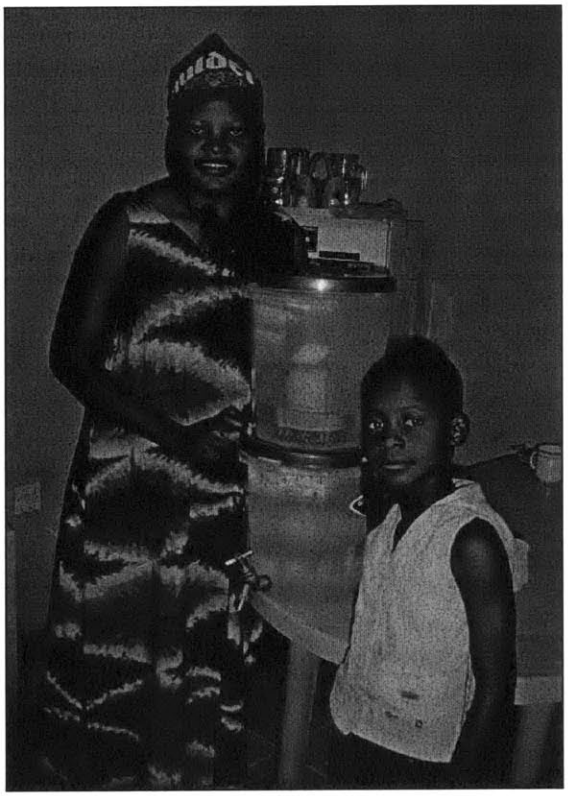


Figure 13: Types of Water Sources Used by Households for Three Districts in the Northern Region: Tolon-Kumbungu, Savelugu-Nanton, and Tamale
Map by Jenny VanCalcar, 2006 (VanCalcar, 2006)

CHAPTER 6:

WATER QUALITY TESTING RESULTS



CHAPTER 6: WATER QUALITY TESTING RESULTS

6.1 Results Summary

To complement the PHW surveys, household drinking water was tested for bacterial contamination. The water quality testing results are summarized in Table 10. For the source water, 100% tested positive for total coliform, 71% tested positive for *E.coli*, and 40% tested positive for H_2S bacteria. For the filtered samples, no contamination was detected, though the sample size was small. Detailed lab results are included in Appendix E.

Table 10: Water Testing Results Summary

	Total Coliform (TC)	*E.coli* (EC)	H_2S Bacteria Presence/Absence
Source Water			
Number of Samples	24 samples	24 samples	50 samples
Results	Average: 3000 CFU/100mL (TNTC) TC present: 24/24 = 100% No TC present: 0/24 = 0%	Average: 50 CFU/100mL EC present 17/24=71% No EC present 7/24=29%	Positive:20/50=40% Negative: 30/50=60%
Filtered Water			
Number of Samples	1 sample	1 sample	9 samples
Results	Nnsupa In: 1 CFU/100mL Nnsupa Out: 0 CFU/100mL	Nnsupa In: 0 CFU/100mL Nnsupa Out: 0 CFU/100mL	Positive: 0/9=0% Negative: 9/9=100%

* P/A= presence/absence

6.1.1 H_2S Results

Fifty source water samples were analyzed for H_2S bacteria, and 40% (20/50) of the results were positive and 60% (30/50) were negative. Forty-nine of the households supplied fifty samples of source water; at one household two different source water samples were given and one household did not supply a sample since the interview was conducted at her workplace. Additionally, nine households with the PHW filters were tested for H_2S bacteria after treatment by PHW products (either Nnsupa and Tamakloe ceramic filters) and all were negative. More extensive field-testing of PHW products was conducted by teammate Claire Mattelet (Mattelet, 2006).

6.1.2 Membrane Filtration (MF) Results

For the membrane filtration, all of the source water was contaminated with total coliform, with an average of 3000 CFU/100 mL. Seventy-one percent of source water samples were contaminated with *E.coli*, with an average of 50 CFU/100 mL. For the filtered water, only one sample was taken due to time constraints and field feasibility. This sample tested negative for both total coliform and *E.coli*, though the source water going into the filter had minimal contamination as well (see Table 10). More extensive field-testing of PHW products was conducted by teammate Claire Mattelet (Mattelet, 2006).

Since the approximate pathogen contamination of the sample was unknown, it was difficult to determine the dilution required to result in 20-80 colonies per plate, as required by the protocol for statistical validity. In some cases, the number of colonies greatly exceeded 80 colonies for total coliform; in these instances the number of colonies per plate was estimated by the number of colonies per square on the plate and extrapolated to number of colonies per plate. This method is not exact, and officially these results were recorded as TNTC, too numerous to count. When possible, 10x and 100x dilutions were made of the samples.

Various factors made membrane filtration difficult to perform in the field. The time required to flame-sterilize the unit between samples made it impossible to analyze every sample. Additionally, sometimes the water sample volume was not sufficient to perform both the H_2S test and the membrane filtration test; in these instances, the H_2S test took precedence. The water samples were collected in Whirlpack bags designed to hold 100 mL, though 100 mL was needed for MF and 20 mL was required by the H_2S test (120 mL total). Though the Whirlpack bags were able to hold this larger volume, sometimes they leaked and there was not enough water available for both tests by the time the samples returned to the laboratory. Ideally, more water would have been collected from each home, but the cooler size was limited and the interviewer was concerned about inconveniencing the respondent. Particularly, more samples should have been analyzed with MF from households using PHW filters; unfortunately, most of these homes were visited first before the water sample collection and testing had been perfected.

6.1.3 Comparison of Membrane Filtration and H_2S Testing Results

The water testing results from the membrane filtration tests and the H_2S tests are compared to examine testing accuracy and precision. In Figure 14, the H_2S presence/absence results are compared to the membrane filtration results for *E.coli*. The H_2S test may determine that sulfide-producing bacteria are present when there is no *E.coli* contamination resulting in false positives. H_2S has been found to detect sulfate-reducing bacteria of non-fecal origin in 25% of samples (Sobsey and Pfadender, 2002). For samples with over 50 *E. Coli* CFUs /100 mL, all H_2S tests performed were positive for hydrogen sulfide bacteria. More extensive comparisons of the water testing methods were conducted by teammate Claire Mattelet (Mattelet, 2006).

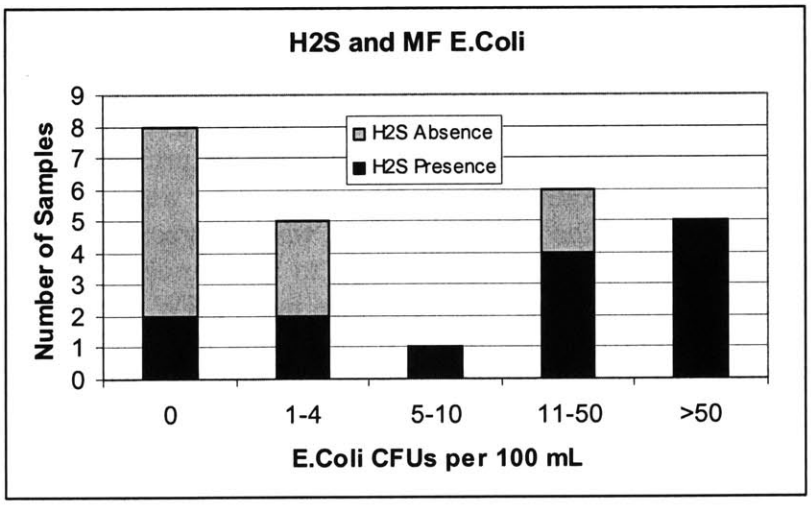


Figure 14: Comparison of H_2S and Membrane Filtration *E.Coli* Results

In Figure 15, the H_2S presence/absence results are compared to the membrane filtration results for total coliform. Samples with total coliform results as TNTC (too numerous to count) were not included in the graph below because the number of CFUs could not be quantified. For samples with fewer than 100 total coliform CFUs per 100 mL, all of the H_2S tests did not detect hydrogen sulfide producing bacteria. For samples with over 1000 total coliform CFUs per 100 mL, all of the H_2S tests detected contamination. More extensive comparisons of the water testing methods were conducted by teammate Claire Mattelet (Mattelet, 2006).

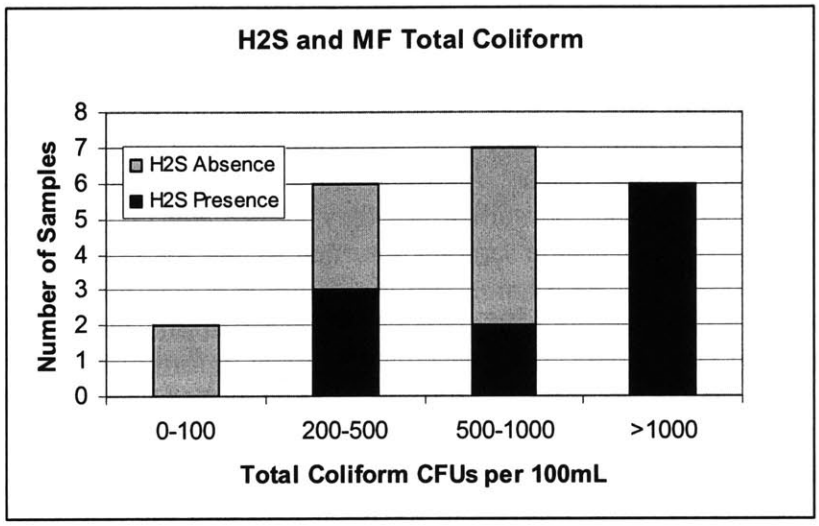


Figure 15: Comparison of H_2S and Membrane Filtration Total Coliform Results

6.2 Source Water

The following graphs display the H_2S water testing results grouped by water source type and community (Figure 16 and Figure 17). The test results displayed in the graph only show source water and not water that had been filtered by PHW products. Comparing the drinking water sources, it is notable that all of the source types had some positive samples for H_2S bacteria. Some people drinking from supposedly improved drinking water sources (tap, standpipe, and borehole) were drinking water contaminated with H_2S bacteria. It is unknown if the water was contaminated at the source, in transit, or in the home, and additional water testing would need to be performed to determine the contamination pathway. It is interesting to note that the types of water sources used do not exactly match the distribution of primary water sources that the respondents reported using (for example, seven dam sources for water testing versus two homes that reported using dam water as the primary drinking water source, see Table 3). This suggests that survey respondents may have given an answer to the source of drinking water question which they suspected was the "correct" answer, since more PHW survey respondents reported using improved water sources than are doing so according to the GSS data, particularly for Savelugu (64% for PHW survey respondents compared to 30% GSS data, see Table 9).

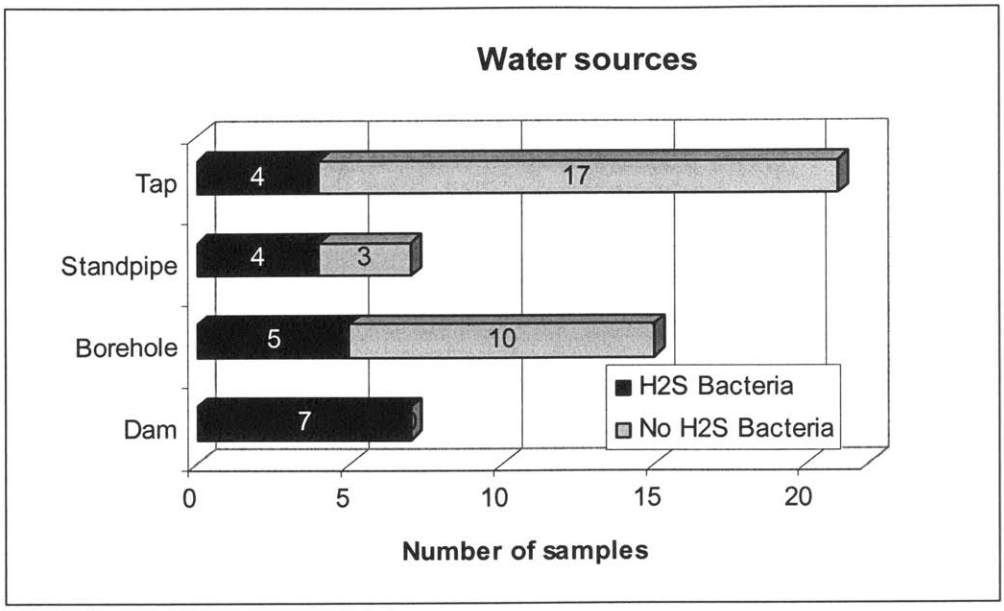


Figure 16: H_2S Water Testing Results Grouped by Drinking Water Source

Additionally, the H_2S results for the source water were grouped by community (Figure 17). Most notable is that all of the water samples from the Diare community tested positive for H_2S bacteria (Figure 18). All of the samples from Diare were from dam water, so it is probable that the water was contaminated at the source. (Interestingly, five of the seven households surveyed in Diare reported that borehole was their main water source, though all communities provided dam water when asked for a water sample). The modern communities, including Kamina Barracks, Vitin Estates, and Jisonayili, had fewer samples that tested positive for H_2S bacteria. Since these households are all drinking household tap water, it is likely that contamination is occurring in the home rather than at the source, though further tests should be performed to determine the pathway of contamination.

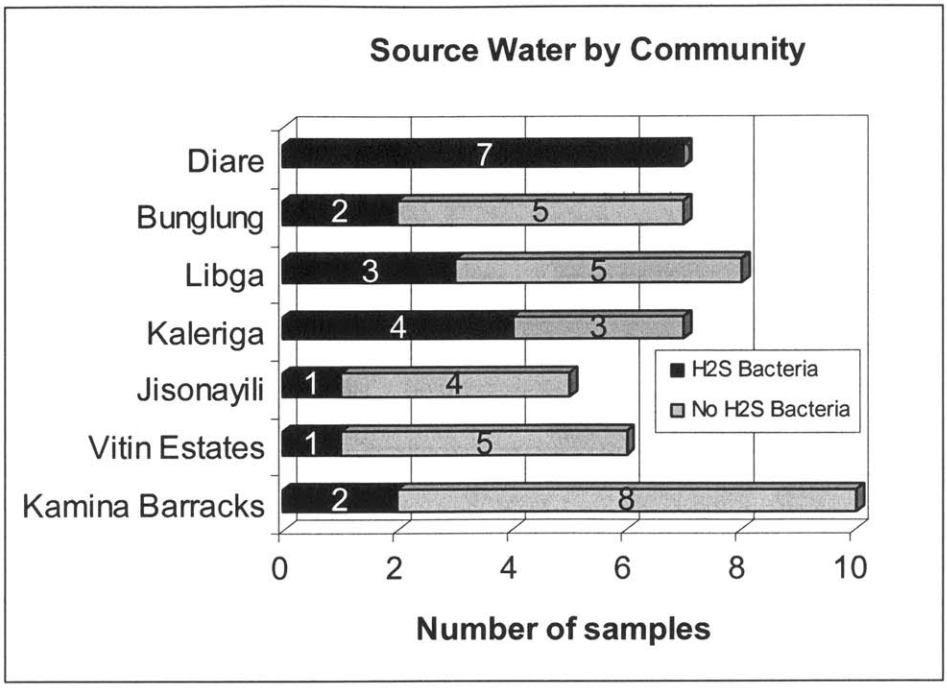


Figure 17: H_2S Water Testing Results Grouped by Community

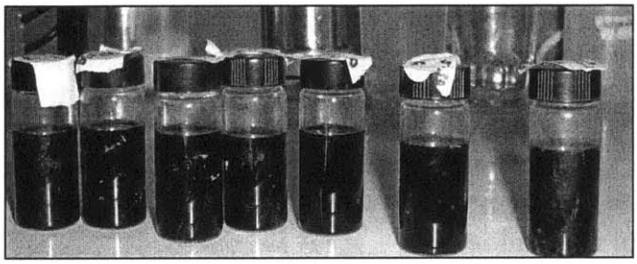


Figure 18: Positive H_2S Results from the Seven Households in Diare.
All are dam water. Photo courtesey of Rachel Peletz.

6.3 Filtered Water

The following figure displays the water testing results for the PHW technologies (see Figure 19). For the Tamakloe and the Nnsupa, all of the filtered water was negative for H_2S bacteria; however, most of the source water was negative as well (except for one household with a Tamakloe). For the safe storage unit, half of the samples tested positive for H_2S bacteria, indicating that the water was still getting contaminated either at the source, in transit, or at the home. Further tests need to be performed to determine the exact source of contamination.

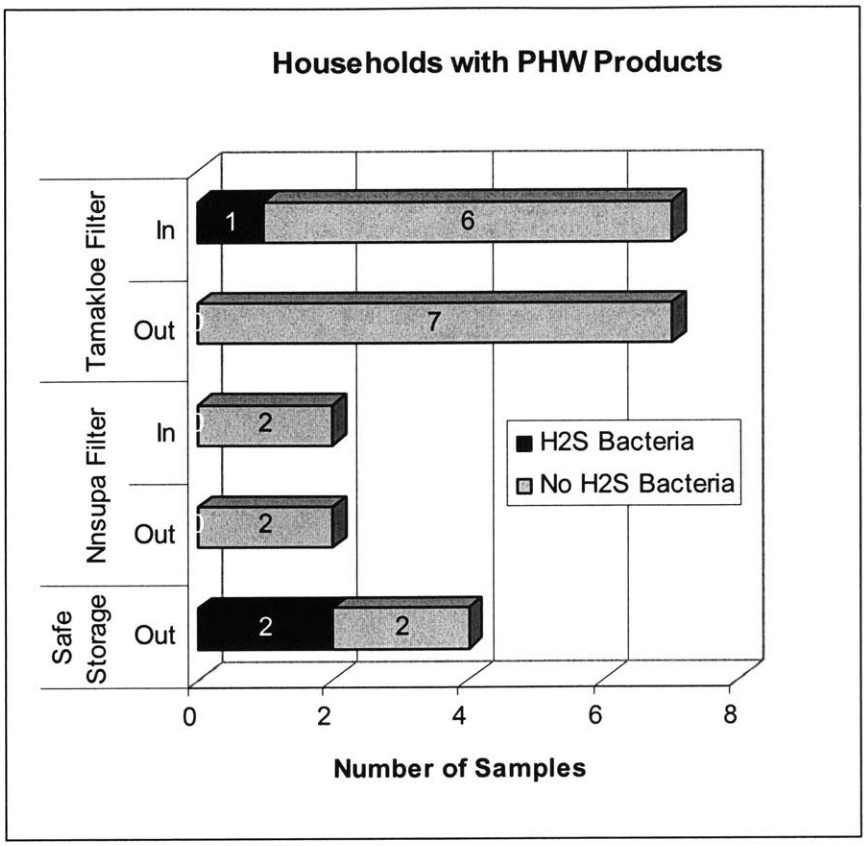


Figure 19: H_2S Bacteria Results for Households with the PHW Product
Tests were performed before and after filtration for the Nnsupa and Tamakloe filters.

6.3.1 Technology Performance

It is difficult to determine the performance of the PHW products from the water quality testing results performed in this study. Though all membrane filtration and H_2S tests indicated that there was no bacterial contamination after filtration, most of the source water was uncontaminated as well. This may have been due to the fact that most of those who purchased and used PHW products were from modern homes with a much higher percent of improved water supplies (82% in modern homes versus 50% in traditional homes from PHW survey). For the H_2S tests, only one source water sample entering the Tamakloe filter was contaminated with H_2S bacteria (Figure 19). For membrane filtration, the one sample performed on the Nnsupa had 1 CFU/100 mL entering the filter and 0 CFU/100 mL after filtration (Table 10). Though the contamination in the source water was minimal, the PHW products did remove the contamination observed.

Fifty-percent of the water exiting the safe storage products was contaminated with H_2S bacteria. The safe storage products are not treatment technologies; they prevent further contamination rather than treating the water. The water exiting the safe storage unit may have been contaminated at the source, in transit, or at the home. In order to detect the exact contamination pathway, more extensive water testing should be performed.

CHAPTER 7:

EPIDEMIOLOGICAL STUDY ANALYSIS

CHAPTER 7: EPIDEMIOLOGICAL STUDY ANALYSIS

7.1 Introduction to Epidemiological Analysis

Relative risk analysis can be performed on epidemiological data to examine the relationship between exposure and outcome. For this study, diarrheal illness is taken as the outcome, and different exposure factors are considered using the tabular format (Hennekens and Buring, 1987):

Table 11: Observed Data in 2x2 Table for Relative Risk Analysis

	Disease	No Disease
Exposure	a	b
No Exposure	c	d

The odds ratio (OR) is calculated to determine the relative risk relationship between exposure and outcome and is defined as:

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

Statistical significance is determined using the chi-square test, as follows:

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

where O=observed outcome, as above, and E=expected outcome. The expected outcome is calculated using the observed data:

Table 12: Calculated Expected Outcome in 2x2 Table for Relative Risk Analysis

	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)

Degrees of freedom (df) are defined as df=(r-1)(c-1), where r = number of rows in the table, and c = number of columns in the table. Since 2x2 tables are used for the analysis, df=(2-1)(2-1)=1. Using the chi-value obtained and df=1, the p-value is derived to determine statistical significance. If $p<5\%$, results are considered statistically significant. If $p<1\%$, results are considered highly statistically significant.

7.2 Disease and Exposure Factors Investigated

For diarrheal illness, a variety of exposure factors are explored. The presence of diarrheal illness in the home and specifically the prevalence of diarrheal illness for children under five are both examined. For the relative risk with filters, only PHW filtration products were considered

(Tamakloe and Nnsupa) and the two safe storage products were not included since they are not treatment technologies. It was found that filtration units in the home significantly reduce diarrheal illness for the total household population. For children under five, the filtration units were not found to significantly reduce diarrheal illness in the statistical analysis.

7.2.1 Filters and Diarrheal Illness in the Household

The relationship is examined between water filtered using PHW products and at least one individual suffering from diarrhea in the household. The odds ratio (OR) equals (21x1)/(10x18)=12%. This means households with filters are 0.12 as likely to have at least one person suffering from diarrheal illness as households without filters. Households with filters have 12% of the risk as those without filters, or 88% less risk of having someone with diarrheal illness. With a chi-square value of 43, resulting in a p-value < 0.001, our results are statistically significant at the 95% level. Therefore, it is very unlikely (less than 0.1%) that this relationship between diarrheal illness and filters can be attributed to chance. The relationship between filters in the home and diarrheal illness in the household is statistically significant at the 0.05 level.

Table 13: Filters and Diarrheal Illness in the Household

	Diarrhea	No Diarrhea
Filters	1	10
No Filters	18	21

OR=12%
X^2=43
p-value= <0.001

7.2.2 Filters and Diarrheal Illness in Children Under Five

The relationship is examined between water filtered using PHW products and diarrheal illness in children under five. The odds ratio (OR) equals (83x1)/(9x16)= 58%. This means that children under five living in households with filters are 0.58 as likely of suffering from diarrheal illness as those living without filters. They have 58% of the risk as those living without filters. With a chi-square value of 1.1 resulting in a p-value of 0.31, our results are not statistically significant at the 95% level. Therefore, this relationship between diarrheal illness and filters occurs 31% of the time from chance alone. The relationship between filters in the home and diarrheal illness for children under five is not significant at the 0.05 level.

Table 14: Filters and Diarrheal Illness in Children Under Five

	Diarrhea	No Diarrhea
Filters	1	9
No Filters	16	83

OR=58%
X^2=1.1
p-value=0.31

7.2.3 Community Type and Diarrheal Illness for Children Under Five

The exposure of community type, modern or traditional, is compared with the outcome of diarrheal illness in children under five. The odds ratio (OR) equals (72x1)/(20x16)=23%. This

means that children under five living in modern communities are 0.23 as likely of suffering from diarrheal illness as those living in traditional communities. They have 23% of the risk as those living in traditional communities. With a chi-square value of 0.71, resulting in a p-value of 0.43, our results are not statistically significant at the 95% level. Therefore, it is 43% likely that this relationship occurred by chance. The relationship between community type and diarrheal illness for children under five is not statistically significant at the 0.05 level.

Table 15: Community Type and Diarrheal Illness for Children Under Five

	Diarrhea	No Diarrhea
Modern	1	20
Traditional	16	72

OR=23%
X^2=0.71
p-value=0.43

7.2.4 Sanitation and Diarrheal Illness for Children Under Five

The relationship is examined between sanitation and diarrheal disease for children under five. The odds ratio (OR) equals (68x1)/(24x16)= 18%. This means that children under five living in households with sanitation facilities are 0.08 as likely, or have 18% of the risk, of suffering from diarrheal illness as those living without sanitation facilities. A chi-square value of 3.1, resulting in a p-value of 0.081, our results are not statistically significant at the 95% level. Therefore, it is 8.1% likely that this relationship occurred by chance. The relationship between sanitation facility access and diarrheal illness for children under five is not statistically significant at the 0.05 level.

Table 16: Sanitation and Diarrheal Illness for Children Under Five

	Diarrhea	No Diarrhea
Proper Sanitation	1	24
Improper Sanitation	16	68

OR=18%
X^2=3.1
p-value=0.08

7.3 Examination of Diarrheal Illness and Water Testing Results

Some basic analysis was performed to look at the connection between contaminated drinking water and diarrheal illness. Using the H_2S bacteria test, basic epidemiological relative risk analysis examines the exposure of positive H_2S results on diarrheal illness. The 2x2 table is displayed below. From the statistical analysis, the relationship between the H_2S bacterial results and the presence of diarrheal illness in the home was not statistically significant at the 0.05 level.

Table 17: H_2S Water Testing Results and Diarrheal Illness in the Household

	Diarrhea	No Diarrhea
H2S +	10	9
H2S -	11	20

OR=200%
X^2=1.4
p-value=0.61

Additionally, the number of individuals per household suffering from diarrheal illness was graphed as a function of the number of colony forming units (CFUs) for *E.coli* and total coliform (Figures 20 and 21). Initially, it was hypothesized that perhaps the number of people per household suffering from diarrheal illness may be proportional to the concentration of *E.coli* and total coliform bacteria in the water sample, but this relationship does not seem to be apparent from the graphs below. In additional to coliform contamination of drinking water, other factors such as sanitation and hygiene contribute to diarrheal illness. It is also proposed that individuals may have developed some level of immunity to pathogenic strains that are commonly present in the home (Vanderslice and Briscoe, 1993).

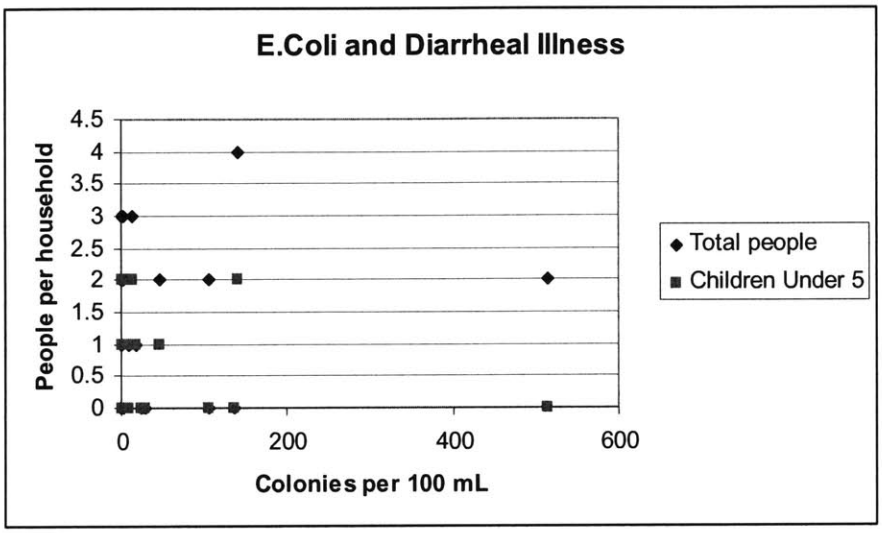


Figure 20: Diarrheal Illness for Survey Population and Children Under Five as a Function of *E.Coli* Concentration in Drinking Water

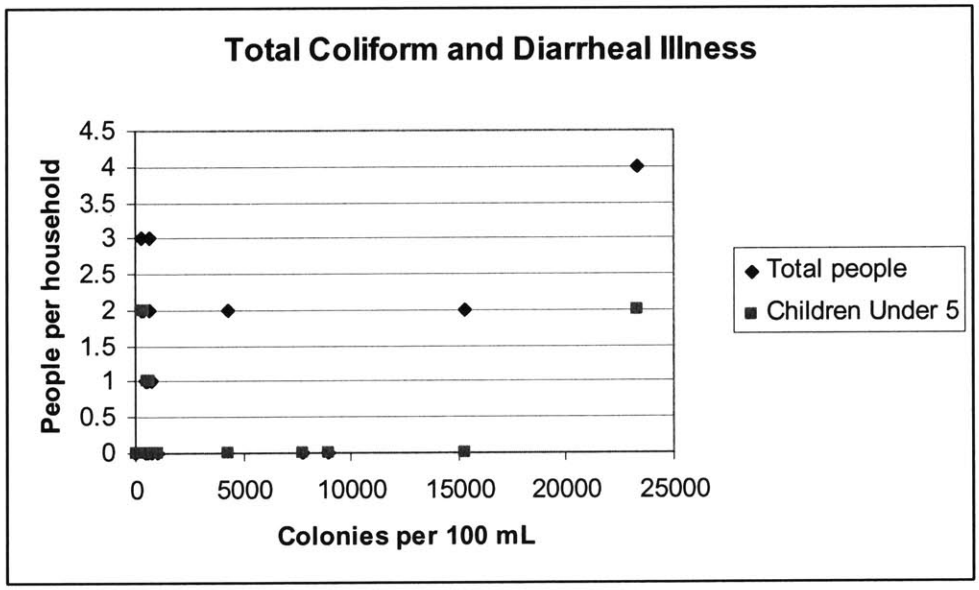


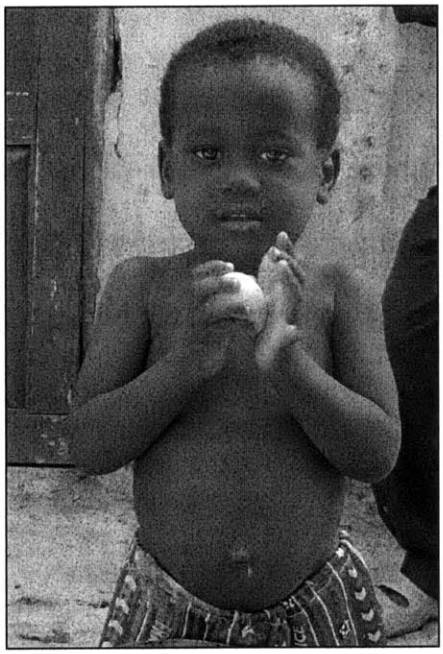
Figure 21: Diarrheal Illness for Survey Population and Children Under Five as a Function of Total Coliform Concentration in Drinking Water

7.4 Discussion of Results

The analysis compares diarrheal illness with different exposure factors, including filtration of drinking water by PHW products, community type, sanitation access, and water testing results. It was found that having a filtration device in the home reduced the diarrheal illness risk by 88% for the overall household. For children under five, the use of a PHW filter reduces the risk of diarrheal illness by 42%, though these results were not found to be statistically significant. Similar studies have found that HWTS technologies may reduce diarrheal illness for the general population though the reduction is undetectable for children under five because of their more widespread exposure to pathogens (Brin, 2003). The exposure factors of community type and sanitation access were examined and found to not be statistically significant. The relationship between the water testing results and diarrheal illness in the household was examined as well, though no correlation was detected. Though the exposure factors examined were not all found to be statistically significant, their association with diarrheal illness may be difficult to detect because of the many exposure factors for the disease and the small sample size in this study.

CHAPTER 8:

RISK ASSESSMENT EVALUATION



CHAPTER 8: RISK ASSESSMENT EVALUATION

8.1 Introduction to Risk Assessment

Risk assessment is an additional evaluation for further analysis of health risks, combining information on exposure and dose-response to estimate the disease burden associated with pathogen doses (WHO, 2004). Although a complete risk assessment cannot be performed based on the data gathered with the PHW surveys, a general assessment can be estimated using the water testing results.

8.2 Data Collection and Evaluation

The first stage in risk assessment is the identification of all possible hazards and pathways from the source to the recipient. These include point sources, such as human and industrial waste, and diffuse sources, such as agricultural and animal waste. For our risk assessment, we are only looking at the exposure pathway of ingestion from drinking water. Many other exposure pathways exist, and thus the analysis is not complete.

8.3 Exposure Assessment

The second stage of risk assessment involves the characterization of human exposure to pathogens, including the environmental concentration and the volumes ingested. The daily exposure is the product of the pathogen concentration and the volume consumed:

Daily Exposure= Pathogen Concentration x Volume Consumed

The pathogen concentration may be measured in the household after treatment or measured in the source water with estimated reductions according to the treatment. The volume ingested is usually assumed to be 1-2 liters of water per day (Pepper et al., 1996). For this analysis, the pathogen concentration was measured in the household, and the volume ingested was assumed to be 2 liters of water per day a conservative estimate. The human exposure is calculated to be 1000 CFU per person per day using the average concentration of *E.coli* as 50 CFU/100 mL (as shown in Table 10):

$$\left(\frac{2L}{1day}\right)\left(\frac{1000mL}{1L}\right)\left(\frac{50CFU}{100mL}\right)=\left(\frac{1000CFU}{day}\right)$$

8.4 Dose-Response Assessment

In the third stage, the risks are characterized through a dose-response assessment. This assessment calculated the probability of an adverse health effect from pathogen exposure. With pathogen exposure, there is generally the assumption that even one single microorganism can cause disease, known as the "single hit principle" (compared to the minimum dose principle with other exposures, such as chemicals). Usually this data is determined with healthy adults, which should be taken into consideration since children, elderly, and immune-compromised individuals are generally more susceptible to disease. The probability of infection from a single exposure, P, can be described as follows (Pepper et al., 1996):

$$P = 1 - \left(1 + \frac{N}{\beta}\right)^{-\alpha}$$

where N is the number of organisms ingested per exposure, and α and β are constants depending on the microorganism of ingestion. For *E.coli*, $\alpha=0.1705$ and $\beta=1.61x10^6$ (Pepper et al., 1996). This assumes that the *E.coli* are pathogenic strains.

8.5 Risk Characterization

The above equation is used to determine the fourth stage of risk assessment, the risk characterization to determine the probability of infection. This calculation assumes that different exposure events are independent (i.e., that no immunity is built up), and this simplification is justified for low risks. The exposure was previously determined in Section 8.3 to be $N=1000$ *CFU/day*. Using the equation above, where $N=1000$ *CFU/day*, $\alpha=0.1705$, and $\beta=1.61x10^6$, the probability of infection from *E.coli* for one day is $P=1.06x10^{-4}$. This means that approximately one person out of 10,000 would get infected from drinking water with this level of *E.coli* contamination. To compare the risk to the survey data, where individuals were asked about diarrheal illness over the past two weeks, the probability of infection can be calculated over fourteen days (Pepper, 1996):

$$P_{7days} = 1 - (1 - P)^7$$

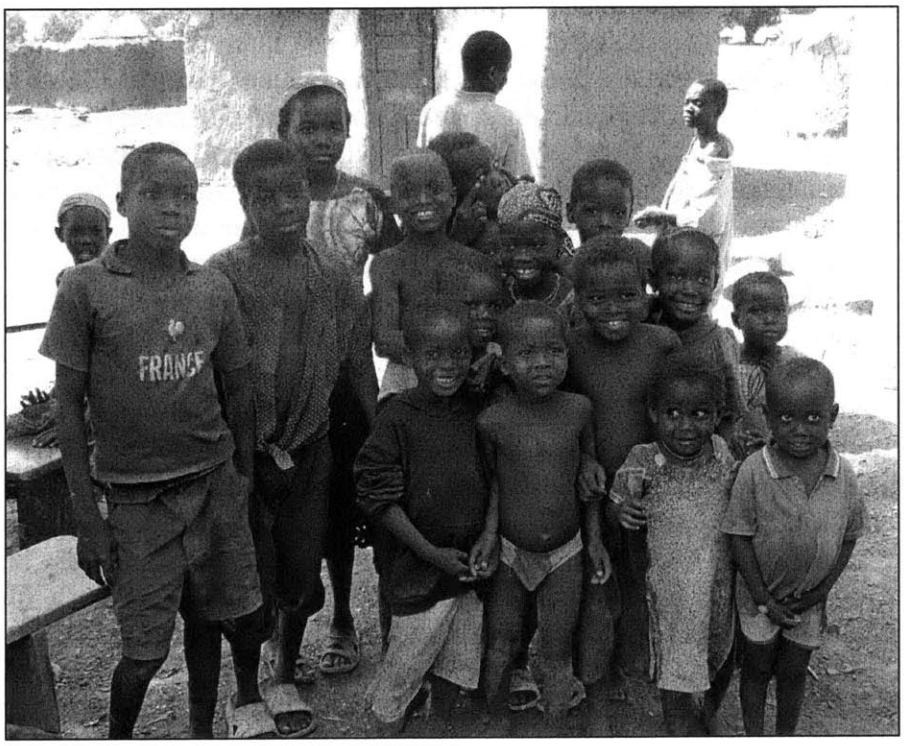
This equation can be solved using $P=1.0586x10^{-4}$ to result in $P_{7days} = 7.4x10^{-4}$, meaning that 0.074% (or approximately 1 out of 10000) of people consuming 2 liters of water a day with a concentration of 50 CFU probably have diarrhea within 7 days. Compared to our survey data, 5% of the people surveyed suffered from diarrheal illness. However, there are many other pathogens in drinking water that cause diarrheal illness besides *E.coli*, since *E.coli* is just an indicator organism, and no other pathogens are considered in the risk assessment. There are also many other exposure pathways for diarrheal illness including food consumption and sanitation practices. Additionally, the dose-response information is generally formulated using healthy adults, and it is mostly children that suffer from diarrheal illness. Therefore, this risk assessment is not a complete assessment of the risk of diarrheal illness, but it is included because it demonstrates the methodology for quantifying microbial risk and provides a framework for future work.

8.6 Prioritization of Management Options

The fifth and final stage of risk assessment is the prioritization of management options. The risk of a population can be compared to a reference level of risk or locally developed tolerable risk, which may be determined with additional social, economic, and cultural information. Because the risk calculation was not complete for all pathogens in waterborne disease, this step cannot be completed at this stage of the analysis. However, water and sanitation related disease appears to be a significant burden on the population in the Northern Region of Ghana based on PHW survey results and GSS data displayed in Table 9.

CHAPTER 9:

CONCLUSIONS AND RECOMMENDATIONS



CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 Epidemiological Study Conclusions

There is a great need for safe water and sanitation in the Northern Region of Ghana, with 36% of the PHW survey population lacking access to an improved water source and 54% lacking access to an improved sanitation facility. Diarrheal illness prevalence is 5% for the population surveyed and 16% for children under five, underscoring that children under five are more at risk for waterborne illness. Though diarrheal illness is caused by a number of exposure pathways, clean drinking water is one key element that has the potential to improve public health of the Ghanaian communities. The surveyed population was fairly well educated about the importance of hand-washing, with 86% of the cohort practicing appropriate hand-washing. Additionally, there is great need for safe storage in the home, since water testing of improved water sources detected contamination. The cross-section epidemiological surveys were extremely well received within the communities, with 100% participation of the households.

The households were very pleased with the PHW technologies, with 100% of customers reporting that they would recommend the products to other households. Of the households without PHW products, 94% responded that they would be interested in treating their drinking water. The presence of filters in the home was found to reduce diarrheal illness by 88% for the household, though significant diarrheal illness reductions were not observed for children under five. These results can be explained by the many other factors of exposure, particularly for children. The public impact from improved drinking water may not be fully realized because of the many other factors for pathogen exposure. In order to substantially reduce diarrheal illness, a complete reform of sanitation and hygiene practices needs to be adopted in addition to improved drinking water. However, the PHW products are a significant step along the way to reduce waterborne disease.

It was found that the greatest need for clean water was in traditional communities. The traditional communities lacked improved water sources and adequate sanitation facilities more prominently than modern communities. Ninety-five percent of modern communities had access to sanitation facilities, while only 7% of traditional communities had access. Eighty-two percent of modern communities had access to an improved water source, with only 50% having access in traditional communities. Additionally, the traditional communities have a higher diarrheal prevalence for children under five, at 5% for modern communities and 18% for traditional communities. None of the mothers in traditional communities had received education; mothers' education level has been found to be a factor of diarrheal illness for children under five in Ghana (Gyimah, 2003).

Though the greatest need for household drinking water treatment products is in traditional communities, it is difficult for PHW to sell products to traditional communities because of the generally lower socioeconomic status; price was the most common response when respondents were asked why more households had not bought the PHW products. After consulting with the business students, it was discovered that it was not feasible to significantly lower the price and still maintain a sustainable business. Therefore, it is recommended that cheaper water treatment technologies be explored, such as solar disinfection or household chlorination, for households

that cannot afford the current PHW products. Additionally, ceramic filter manufacturing closer to Tamale is being investigated as a way to reduce product costs.

The continuation of PHW surveys would be beneficial as a method of monitoring product use in the home. To examine sustained use, households could be surveyed approximately one year after they had purchased the PHW technology to observe the durability and maintenance of the products. A more formal comparison study between households with and without PHW products could potentially examine the outbreaks of waterborne illnesses over time, such as in a six-month or one-year trial. Additionally, surveyed households that had not purchased the technologies during the implementation of this study could later be surveyed and compared if they purchase a PHW technology at a later date. Another potential investigation would be to perform a multi-variable analysis to examine the different exposure factors for diarrheal illness, particularly the effects of drinking filtered water. Epidemiological studies help to evaluate the health impacts of the PHW products on the consumers, and should be continued as part of the PHW business.

9.2 Engineering Team Conclusions

Similar to John Snow's pivotal work combining epidemiology, mapping, and microbial testing which showed the correlation between cholera infection and certain wells within London in the early 1800s, the MIT Master of Engineering team has combined these fields of epidemiology, mapping, and microbial testing to gain a better understanding of the drinking water situation in the Northern Region of Ghana. The following are some of our major conclusions:

- In the Northern Region, 56% of the population does not have access to an improved source of drinking water and 92% does not have access to improved sanitation.
- In communities surveyed, the diarrheal prevalence in children under five is only 5% in the modern communities, while it is 18% in traditional villages. Traditional communities suffer most from diarrheal illness, inadequate sanitation, and unimproved drinking water sources.
- The Nnsupa filter does not perform up to the microbial standards of the Tamakloe and its sale has thus been discontinued.

The good news is that the CT Filtron has been shown by team member Claire Mattelet's thesis work (Mattelet, 2006) to be a highly effective technology in removing fecal bacteria. The household surveys also showed a high level of customer satisfaction and interest in the ceramic product. Hopefully, as the efforts of PHW continue, this technology can begin to make a significant impact on improving the health within the Northern Region of Ghana.

9.3 The G-Lab Business Team Conclusions

The business team adopted the strategy of the Four Ps: product, price, promotion, and place. The product agenda was to streamline the available products for marketing efficiency. Due to its higher cost and inadequate microbial removal, the Nnsupa product was discontinued and current efforts are focused on promoting the Tamakloe filter and safe storage products. After financial analysis, the price of the Tamakloe was increased from the equivalent of $16 to $20 out of necessity for PHW to function as a sustainable business. While in Ghana, the entire PHW team

participated in a market day to promote products awareness, which will be continued by Wahabu and Hamdiyah along with community meetings and other forms of marketing. Concerning place, the PHW office will be moving to a more central location in Tamale to improve customer accessibility. Though currently produced in Accra, the potential production of the Tamakloe filters in the Northern Region of Ghana is also being explored to reduce shipping costs and to offer a lower priced product to those who want it but cannot afford it at the present price.

9.4 Future Recommendations

Because the greatest need for clean water is within the traditional and rural communities, an effort needs to be made to price the treatment systems to meet the needs of these communities. One possible solution is to move the production of the CT Filtron from Accra to Tamale. This would cut down on costs due to transportation, packing materials, and breakage. Labor and material costs may also be cheaper within the Northern Region. Another option would be to pursue other treatment technologies besides ceramic filters. One low-cost solution would be to evaluate solar disinfection which relies on the UV light coming from the sun as a way to kill pathogenic bacteria. In other countries, this technology has been shown to cost less than a dollar per year since only clear bottles to contain the water are needed.

Another issue throughout the region is that there are more than one million people who lack improved water and these people are spread among many isolated rural communities. A marketing strategy needs to be created that can reach this population and teach them about the availability of household water treatment technologies. One method would be to work through other organizations. Currently the PHW Team is initiating the distribution of the filters through Shell gas stations in the region. Filters have also been given to a group of midwives for distribution through their patients (Figure 22). Other distribution methods could easily be explored including schools, clinics, and aid agencies.

Figure 22: Tamakloe Filters Given to Midwives for Distribution to their Patients
Photo courtesy of Tanja Odijk

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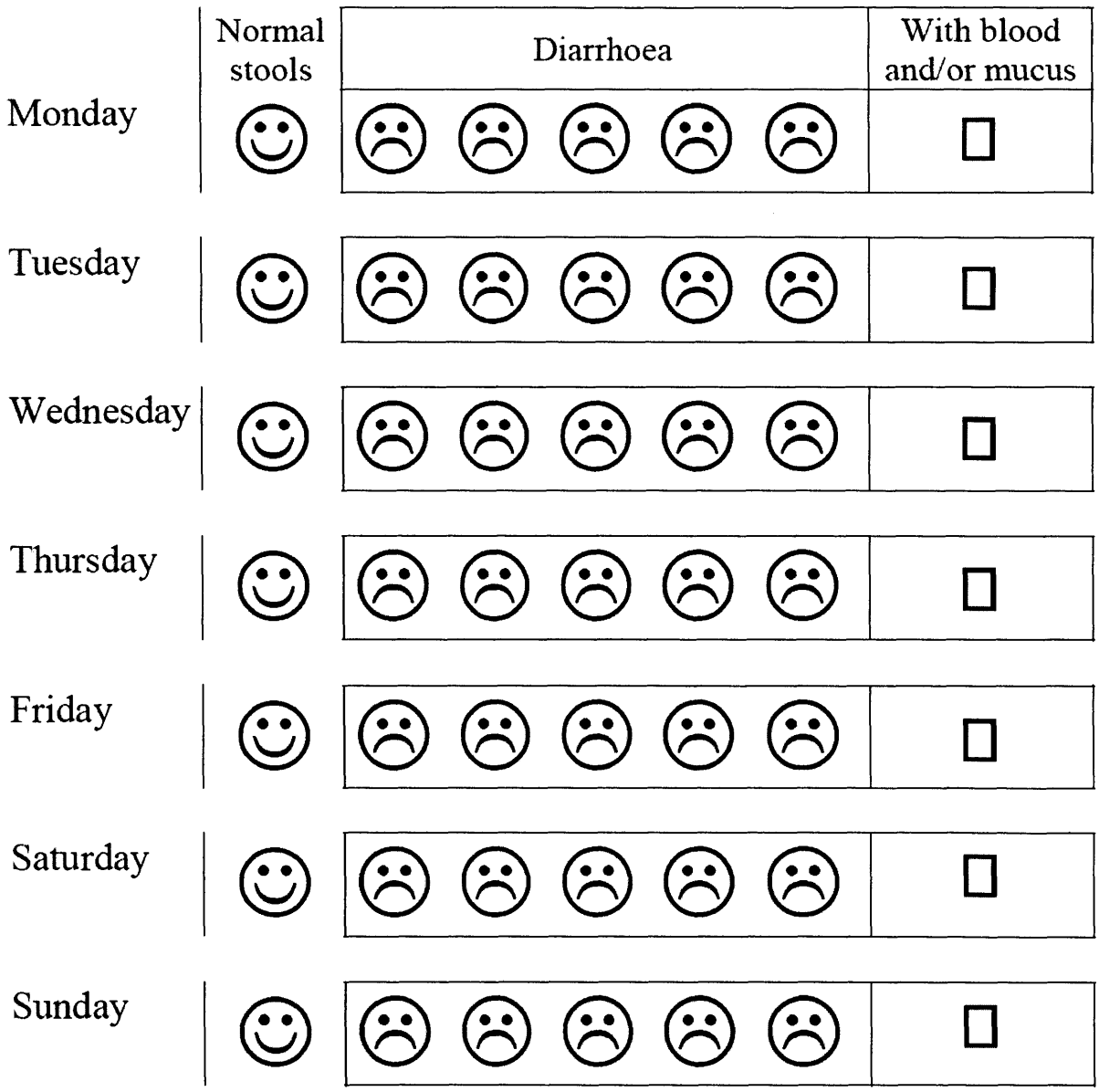
APPENDIX A: SMILIE DIARIES

AQUAPOL research project



Source: Wright, Jim and Stephen W. Gundry. AQUAPOL Research Project Principal Investigators. University of Southampton and University of Bristol.

APPENDIX B: PURE HOME WATER HOUSEHOLD QUESTIONNAIRE

Cross-sectional Survey

Hello, my name is Rachel Peletz and I am a student from the Massachusetts Institute of Technology (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 having children under 5 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)

When would be a good time to reach that person?

Date	
Time	

Interview background

Survey Number	
HWTS Technology	
Name	
District	
Community	
Address	

Date	
Start Time	
End Time	
Water test # (Claire)	
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	Other members
Children under 5		
Young children (6-12)		
Teenager (13-19)		
Twenties (20-29)		
Thirties (30-39)		
Forties (40-49)		
Fifties (50-59)		
Sixties (60-69)		
Seventies + (70+)		

1.3 Have you ever attended school?

Yes	
If so, how many years?	
No	

1.4 How much do you spend each month on the following?

Food	
Transportation	
Education	
Health	
Utilities	
Others	

1.5 Do you have _____?

Electricity	
Firewood	
Charcoal	
Gas	

1.6 OBSERVATIONS (socioeconomic)

House Type	
Floor Type	

Circle general socioeconomic category (1=poor, 3=wealthy)

Overall Rating	1	2	3

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)
Children under 5		
Children (6- 15)		
Adolescent (16-20)		
Young Adult (21-40)		
Middle Age (41-60)		
Elderly (61+)		

2.2 What do you think is the main cause of diarrhea? Do you think _____ is a cause?

	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	Cost (per year)
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 NOTE TIME)

In House	
Under 30 minutes	
Over 30 minutes	

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? (Follow up questions: Is water available throughout the year? Is another source used if first is unavailable?)

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 (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 2005)?

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, GO TO QUESTION 4.7

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		

4.7 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 (cost)			
Other (specify):				Other (specify):			

Water Storage

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

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

4.9 Are your storage vessels always covered?

Yes	
No	

4.10 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):	

4.11 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

4.13 Do you think the water is safe to drink (without treatment)?

Yes	
No	

IF YES, GO TO QUESTION 5.1

If not, why? (DO NOT READ LIST)

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

4.15 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?) ALSO, NOTE AWARENESS OF TECHNIQUE

	Always	Sometimes	Never	Awareness	Cost per month
Boil					
Chemicals (tablets/liquid)					
Filter:					
CT Tamakloe ceramic					
Nnsupa candle					
Biosand					
Cloth					
Other filter (specify):					
Settle					
Safe storage					
SODIS (solar)					
Other (specify)					

4.16 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	

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

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

Mother	
Father	
Grandfather	
Other(specify):	

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	
Cermanic candle Nsupa filter	
Plastic safe storage container	

B. Why did you select this technology?

Cost	
Ease of Use	
Other:	

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

Mother	
Father	
Other(specify):	

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

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

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

Better	
Worse	
The Same	

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

		When Not
Yes		
No		

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

Yes	
No	

H. 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. What do you do if it is broken?

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 C: DETAILED SURVEY RESULTS: GENERAL - Households 1-4

Interview Background	Survey Number	1	2	3	4
	Name	Faustina Bakah	Gifty Baba	Beatrice Amissoah Keteku	Diana Nuokyi
	District	Tamale	Tamale	Tamale	Tamale
	Community	Barracks	Barracks	Barracks	Barracks
	Date	7-Jan-06	7-Jan-06	7-Jan-06	7-Jan-06
	GPS N/S	N 09° 27.831'	N 09° 27.867'	N 09° 27.835'	N 09° 27.833'
	GPS E/W	W 000° 50.923'	W 000° 50.949'	W 000° 51.020'	W 000° 51.030'
	Technology	Nnsupa	Tamakloe	none	none
Household Information	Status of respondent	Mother	Mother	Mother	Mother
	Age of participant	32	33	29	20
	Years of education of respondent	12	9	9	9
	Age of child under 5	4	1, 5	4	2
	Number of children under 5	1	2	1	1
	Number of people in household	5	6	5	4
	Monthly expenses of household (cedis)- total	4,200,000	2,840,000	1,820,000	730,000
	Food	1,500,000	1,500,000	1,500,000	500,000
	Transportation	900,000	200,000	10,000	30,000
	Education	1,350,000	240,000	190,000	0
	Health	250,000	400,000	120,000	0
	Utilities	out of salary	out of salary	out of salary	out of salary
	Other	200,000	500,000	unknown	200,000
Diarrhea Knowledge	Diarrhea in past week (# of people)	0	0	0	0
	Causes of diarrhea				
	Dirty Water	Y	Y		Y
	Dirty food	Y	Y		Y
	Flies/insects	maybe		Y	Y
	Poor hygiene/ Environment	Y	Y		Y
	Diarrhea Treatment				
	Hospital	Y	Y		
	ORS (oral rehydration salt)			Y	
	Salt/sugar solution	Y	Y		
	Rice water		Y		
	Who cares for person with diarrhea	Mother	Mother, father	Mother	Mother, father
Sanitation and Hygiene	Handwashing				
	After the toilet	Y	Y	Y	Y
	Before eating	Y	Y	Y	Y
	Before cooking	Y	Y	Y	Y
	Use soap during handwashing	Y	Y	Y	Y
	Currently have soap in household	Y	Y	Y	Y
	Type of toilet facility	Flush	Flush	Flush	Flush
	Facility always availability?	Y	Y	Y	Y
	Public/Private/Shared Toilet	private	pubic	private	private
	Time to toilet facility	in home	in home	in home	in home
	Handwashing available at toilet facility?	Y	Y	Y	Y
Drinking Water Source Collection	Drinking Water Source (main)	Tap	Tap	Tap	Tap
	Other water source	none	tank	none	none
	Who collects the water	N/A	mother	N/A	N/A
	Time to collect water				
	Dry season	N/A	1 hr	N/A	N/A
	Wet season	N/A	0	N/A	N/A
	Water Source (away from home)	borehole	Sachet water	Sachet water	Sachet water
Water Storage	Drinking water storage vessel	plastic bottle	plastic bottle	plastic buckets and gallons	plastic buckets and drum
	Narrow mouthed vessels?	Y	Y	N	N
	Are storage vessels always covered?	Y	Y	Y	Y
	Method of taking water from the containers	pour directly	pour directly	Scoop with handle	Scoop with handle
Water Quality Perception	Is water safe to drink without treatment?	N	N	Y	Y
	Why is water not safe?	particles, metals	dirty/turbid		
	Treatment method used	Nnsupa	Tamakloe		
	Reason for method of choice		want clean water		

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 5-8

Interview Background	Survey Number	5	6	7	8
	Name	Marta Abusharaf	Angelina Gakpo	Grace Mills	Comfort Bratu
	District	Tamale	Tamale	Tamale	Tamale
	Community	Barracks	Barracks	Barracks	Barracks
	Date	7-Jan-06	7-Jan-06	7-Jan-06	7-Jan-06
	GPS N/S	N 09° 27.836'	N 09° 27.833'	N 09° 27.840'	N 09° 27.850'
	GPS E/W	W 000° 51.043'	W 000° 51.0533'	W 000° 51.047'	W 000° 51.027'
	Technology	Tamakloe	Tamakloe	Tamakloe	none
Household Information	Status of respondent	Mother	Mother	Woman	Mother
	Age of participant	32	28	28	35
	Years of education of respondent	9	12	12	6
	Age of child under 5	5, 1	1	none	4 months
	Number of children under 5	2	1	0	1
	Number of people in household	4	3	2	5
	Monthly expenses of household (cedis)- total	1,280,000	1,820,000	1,000,000	1,400,000
	Food	1,000,000	450,000	800,000	1,000,000
	Transportation	100000	450,000	100,000	60,000
	Education	80000	0	0	240,000
	Health	50000	500,000	0	60,000
	Utilities	out of salary	out of salary	out of salary	out of salary
	Other	50,000	420,000	100,000	40,000
Diarrhea Knowledge	Diarrhea in past week (# of people)	2	0	0	0
	Children under 5	1			
	Young Adult (21-40)	1			
	Causes of diarrhea				
	Dirty Water		Y	Y	Y
	Dirty food	Y	Y	Y	Y
	Flies/insects		Y	Y	Y
	Poor hygiene/ Environment		Y	Y	Y
	Other	pepper			
	Diarrhea Treatment				
	Hospital	Y			Y
	ORS (oral rehydration salt)			Y	
	Salt/sugar solution		Y	Y	
	Other (specify)		don't know		
	Who cares for person with diarrhea	mother	mother	husband and wife	Mother
Sanitation and Hygiene	Handwashing				
	After the toilet	Y	Y	Y	Y
	Before eating	Y	Y	Y	Y
	Before cooking	Y	Y	Y	Y
	Use soap during handwashing	Y	Y	Y	Y
	Currently have soap in household	Y	Y	Y	Y
	Type of toilet facility	Flush	Flush	Flush	Flush
	Facility always availability?	Y	Y	Y	Y
	Public/Private/Shared Toilet	private	private		private
	Time to toilet facility	in home	in home	in home	in home
	Handwashing available at toilet facility?	Y	Y	Y	Y
Drinking Water Source Collection	Drinking Water Source (main)	Tap	Tap	Tap	Tap
	Other water source	tanker truck	none	none	none
	Who collects the water	N/A	N/A	N/A	N/A
	Time to collect water				
	Dry season	N/A	N/A	N/A	N/A
	Wet season	N/A	N/A	N/A	N/A
	Water Source (away from home)	sachet water	carry water from home	carry water from home	sachet water
Water Storage	Drinking water storage vessel	plastic bottles	plastic bottles	plastic bottles	plastic buckets
	Narrow mouthed vessels?	Y	Y	Y	
	Are storage vessels always covered?	Y	Y	Y	Y
	Method of taking water from the containers	pour directly	pour directly	pour directly	scoop with handle
Water Quality Perception	Is water safe to drink without treatment?	Y	N	N	Y
	Why is water not safe?		particles	particles	
	Treatment method used	Tamakloe	Tamakloe	Tamakloe	settle, cloth filter, glucose
	Reason for method of choice		to clean water	make water safe	to stay healthy and remove particles

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 9-12

Interview Background	Survey Number	9	10	11	12
	Name	Fostina Lerty	Irene Shikabli	Francis Quagraine	Lucy Anane Ampradu
	District	Tamale	Tamale	Tamale	Tamale
	Community	Barracks	Barracks	Vitin Estates	Vitin Estates
	Date	7-Jan-06	7-Jan-06	10-Jan-06	10-Jan-06
	GPS N/S	N 09° 27.884'	N 09° 27.964'	N 09° 23.159'	N 09° 23.163'
	GPS E/W	W 000° 51.013'	W 000° 50.967'	W 000° 48.904'	W 000° 48.897'
	Technology	none	none	Tamakloe	none
Household Information	Status of respondent	Woman	Mother	Son	mother
	Age of participant	20	38	20	45
	Years of education of respondent	12	15	11	10
	Age of child under 5	none	4	none	6 months
	Number of children under 5	0	1	0	1
	Number of people in household	3	4	9	7
	Monthly expenses of household (cedis)- total	1,053,333	1,500,000	unsure	2,257,700
	Food	700,000	1,200,000		1,000,000
	Transportation	0	50,000		340,000
	Education	333333.3333	100,000		307700
	Health	0	150,000		300,000
	Utilities	out of salary	out of salary		160,000
	Other	20,000	0		150,000
	Information Sources			Radio, TV, newspaper	meetings, radio, market, tv, newspaper
	Water Information Sources			Radio, TV, newspaper	radio, tv
Diarrhea Knowledge	Diarrhea in past week (# of people)	0	0	0	0
	Causes of diarrhea				
	Dirty Water	Y	Y	Y	Y
	Dirty food	Y		Y	Y
	Flies/insects	Y		Y	Y
	Poor hygiene/ Environment	Y	Y	Y	Y
	Other				eating cold food
	Diarrhea Treatment				
	Hospital		Y		Y
	ORS (oral rehydration salt)			Y	Y
	Salt/sugar solution	Y			Y
	Who cares for person with diarrhea	husband and wife	Mother	Mother and father	mother and father
Sanitation and Hygiene	Handwashing				
	After the toilet	Y	Y	Y	Y
	Before eating	Y	Y	Y	Y
	Before cooking	Y	Y	Y	Y
	Use soap during handwashing	N	Y	Y	Y
	Currently have soap in household	Y	Y	Y	Y
	Type of toilet facility	Flush	flush	flush	flush
	Facility always availability?	Y	Y	Y	Y
	Public/Private/Shared Toilet	private	shared	private	private
	Time to toilet facility	in home	1 minute	In house	in house
	Handwashing available at toilet facility?	Y	Y	Y	N
Drinking Water Source Collection	Drinking Water Source (main)	Tap	Tap	Tap	Tap
	Other water source	none	none	public standpipe	neighbor's water tank
	Who collects the water	N/A	N/A	Father	Male child
	Time to collect water				
	Dry season	N/A	N/A	1 hour	30 min- 1hr
	Wet season	N/A	N/A	30 minutes	0
	Water Source (away from home)	bottled water	bottle water	sachet water	tied water
Water Storage	Drinking water storage vessel	plastic bottles	plastic buckets	plastic bottles	metal tank, metal drum
	Narrow mouthed vessels?	Y		Y	N
	Are storage vessels always covered?	Y	Y	Y	Y
	Method of taking water from the containers	pour directly	scoop with handle	Pour directly	scoop with handle, spigot on tank
Water Quality Perception	Is water safe to drink without treatment?	Y	Y	N	Y
	Why is water not safe?			dirty/turbid, impurities	
	Treatment method used		cloth filter	Tamakloe	Settling, clean container
	Reason for method of choice		water is dirty/cloudy	cholera prevention	clean out particles

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 13-15

Interview Background	Survey Number	13	14	15
	Name	Elizabeth Ahenkora	Mary Baidoo	Salamatu Mahama
	District	Tamale	Tamale	Tamale
	Community	Vitin Estates	Vitin Estates	Vitin Estates
	Date	10-Jan-06	10-Jan-06	10-Jan-06
	GPS N/S	N 09° 23.159'	N 09° 23.116'	N 09° 23.154'
	GPS E/W	W 000° 48.911'	W 000° 48.887'	W 000° 48.841'
	Technology	Tamakloe	Tamakloe	none
Household Information	Status of respondent	mother	mother	mother
	Age of participant	37	44	41
	Years of education of respondent	16	10	16
	Age of child under 5	5	4	4
	Number of children under 5	1	1	1
	Number of people in household	4	10	6
	Monthly expenses of household (cedis)- total	5,200,000	2,885,000	2,130,000
	Food	600,000	1,200,000	600,000
	Transportation	200,000	450,000	510000
	Education	3,300,000	735000	240000
	Health	500,000	100,000	100,000
	Utilities	400,000	150,000	180,000
	Other	200,000	250,000	500,000
	Information Sources	radio, tv, newspaper, friends	radio, tv	radio, tv, newspaper, people
	Water Information Sources	radio	radio, tv, person to person	meetings
Diarrhea Knowledge	Diarrhea in past week (# of people)	0	0	0
	Causes of diarrhea			
	Dirty Water	Y	Y	Y
	Dirty food	Y	Y	Y
	Flies/insects	Y	Y	Y
	Poor hygiene/ Environment	Y	Y	Y
	Diarrhea Treatment			
	Hospital	Y	Y	
	ORS (oral rehydration salt)	Y		
	Medicines			Y
	Person who cares for person with diarrhea	mother	mother	mother
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	N	Y
	Other	after eating		
	Use soap during handwashing	Y	Y	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	flush	flush	flush
	Facility always availability?	Y	Y	Y
	Public/Private/Shared Toilet	private	private	private
	Time to toilet facility	in house	in house	in house
	Handwashing available at toilet facility?	N	N	Y
Drinking Water Source Collection	Drinking Water Source (main)	Tap	Tap	Tap
	Other water source	public standpipe	public standpipe	none
	Who collects the water	Father	father	N/A
	Time to collect water			
	Dry season	1 hour	45 minutes (with car)	N/A
	Wet season	1 hour	0	N/A
	Water Source (away from home)	sachet water	sachet	sachet water
Water Storage	Drinking water storage vessel	plastic bottles	plastic bottles	Aluminum tank
	Narrow mouthed vessels?	Y	Y	Y
	Are storage vessels always covered?	Y	Y	Y
	Method of taking water from the containers	pour directly	pour directly	spigot
Water Quality Perception	Is water safe to drink without treatment?	N (unsure)	N	Y
	Why is water not safe?	microbial contamination, unclean pipes	particles	
	Treatment method used	Tamakloe	Tamakloe	
	Reason for method of choice	filter the water	it was recommended	

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 16-18

Interview Background	Survey Number	16	17	18
	Name	Husseina Haruna	Rebecca Darkey	Edith Leneugo
	District	Tamale	Tamale	Tamale
	Community	Vitin Estates	Jisonayili	Jisonayili
	Date	10-Jan-06	11-Jan-06	11-Jan-06
	GPS N/S	N 09° 23.202'	N 09° 27.021'	N 09° 27.021'
	GPS E/W	W 000° 48.915'	W 000° 50.957'	W 000° 51.262'
	Technology	none	Nnsupa	Nnsupa (broken)
Household Information	Status of respondent	mother	Mother	Mother
	Age of participant	32	35	37
	Years of education of respondent	14	12	9
	Age of child under 5	3	1, 4	none
	Number of children under 5	1	2	0
	Number of people in household	9	6	9
	Monthly expenses of household (cedis)- total	940,000	2,050,000	2,385,000
	Food	500,000	1,500,000	1,000,000
	Transportation	70,000	200,000	45,000
	Education	85,000	150,000	300,000
	Health	55,000	paid for by world vision	100,000
	Utilities	130000	200,000	400,000
	Other	100,000	unsure	540,000
	Information Sources	radio, tv	radio, husband	radio, tv
	Water Information Sources	radio	radio, tv, husband	radio, tv
Diarrhea Knowledge	Diarrhea in past week (# of people)	0	0	0
	Causes of diarrhea		No one ever gets it	
	Dirty Water			Y
	Dirty food	Y		Y
	Flies/insects	Y		Y
	Poor hygiene/ Environment	Y		Y
	Diarrhea Treatment		No one ever gets it	
	Hospital			Y
	ORS (oral rehydration salt)	Y		
	Medicines	Y		
	Who cares for person with diarrhea	everyone	mother	Mother and father
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	Y	Y
	Other	after eating		
	Use soap during handwashing	sometimes	Y	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	flush	flush	KVIP Latrine
	Facility always availability?	Y	Y	Y
	Public/Private/Shared Toilet	private	private	Public
	Time to toilet facility	in house	in house	under 30 minutes
	Handwashing available at toilet facility?	N	Y	N
Drinking Water Source Collection	Drinking Water Source (main)	Tap	Tap	Tap
	Other water source	none	sachet	none
	Days per week without tap water	4	0	0
	Who collects the water	N/A	N/A	Male and female children
	Time to collect water			
	Dry season	N/A	N/A	5 minutes each time
	Wet season	N/A	N/A	5 minutes each time
	Drinking Water Source (away from home)	bottled water, sachet	none	sachet water
Water Storage	Drinking water storage vessel	Plastic buckets, jerry cans	plastic bottles	barrels
	Narrow mouthed vessels?	Y	Y	N
	Are storage vessels always covered?	Y	Y	N
	Method of taking water from the containers	pour directly, scoop with handle	pour directly	scoop (with and without handle)
Water Quality Perception	Is water safe to drink without treatment?	Y	Y	don't know
	Why is water not safe?			dirty/turbid
	Treatment method used	none	Nnsupa, settling	Nnsupa (broken), settle
	Reason for method of choice		Told it's better (education)	get the dirt out

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 19-21

Interview Background	Survey Number	19	20	21
	Name	Rita Anai	Nasima Samed	Rose Naah
	District	Tamale	Tamale	Tamale
	Community	Jisonayili	Jisonayili	Jisonayili
	Date	11-Jan-06	11-Jan-06	11-Jan-06
	GPS N/S	N 09° 27.295'	N 09° 27.396'	N 09° 27.419'
	GPS E/W	W 000° 51.711'	W 000° 51.696'	W 000° 51.681'
	Technology	none	none	none
Household Information	Status of respondent	Mother	Mother	Woman
	Age of participant	32	26	33
	Years of education of respondent	12	13	13
	Age of child under 5	4	1, 3, 4	none
	Number of children under 5	1	3	0
	Number of people in household	4	12	1
	Monthly expenses of household (cedis)- total	1,470,000	6,250,000	355,800
	Food	200,000	1,500,000	200,000
	Transportation	20,000	unsure (husband has vehicle)	12,800
	Education	800,000	2,000,000	0
	Health	100,000	200,000	15,000
	Utilities	170,000	50,000	28,000
	Other	180,000	2,500,000	100,000
	Information Sources	tv	radio, market, tv, newspaper	radio, tv, people
	Water Information Sources	unsure	tv	people (coworkers, family)
Diarrhea Knowledge	Diarrhea in past week (# of people)	0	0	0
	Causes of diarrhea			
	Dirty Water	Y	Y	Y
	Dirty food	Y	Y	Y
	Flies/insects	Y	Y	Y
	Poor hygiene/ Environment	Y	Y	Y
	Other			fruit
	Diarrhea Treatment			
	Hospital	Y	Y	Y
	ORS (oral rehydration salt)	Y		
	Salt/sugar solution			Y
	Other (specify)		see pharmacist	
	Who cares for person with diarrhea	Mother	Father	friend
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	Y	Y
	Other		all the time	coming inside after being outside
	Use soap during handwashing	Y	Y	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	KVIP Latrine	KVIP Latrine	Flush, free range
	Facility always availability?	Y	Y	flush= no, free range=yes
	Public/Private/Shared Toilet	Shared	Shared	flush=shared
	Time to toilet facility	In House	In House	flush= 15 minutes
	Handwashing available at toilet facility?	Y	Y	flush= Y
Drinking Water Source Collection	Drinking Water Source (main)	Tap	Tap	Tap
	Other water source	none	none	none
	Who collects the water	N/A	Mother	N/A
	Time to collect water			
	Dry season	N/A	5 min	N/A
	Wet season	N/A	5 min	N/A
	Water Source (away from home)	sachet water	sachet water	sachet water
Water Storage	Drinking water storage vessel	plastic bottles	plastic bottles	cooler
	Narrow mouthed vessels?	Y	Y	N (but spigot)
	Are storage vessels always covered?	Y	Y	Y
	Method of taking water from the containers	pour directly	pour directly	spigot
Water Quality Perception	Is water safe to drink without treatment?	N	N	N
	Why is water not safe?	dirty/turbid and tap is close to toilet	dirty/turbid, looks different than treated water	dirty/turbid
	Treatment method used	none	none	Safe storage, cloth filter
	Reason for method of choice			Stay healthy; keep water cool

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 22-24

Interview Background	Survey Number	22	23	24
	Name	Phidelia Deyegbe	Ramatu Dawuni	Mamunatu Ibrahima
	District	Tamale	Tamale	Tamale
	Community	Jisonayili	Kaleriga	Kaleriga
	Date	11-Jan-06	12-Jan-06	12-Jan-06
	GPS N/S	N 09° 27.429'	N 09° 22.962'	N 09° 22.988'
	GPS E/W	W 000° 51.771'	W 000° 49.233'	W 000° 49.236'
	Technology	Tamakloe	none	none
Household Information	Status of respondent	Woman	Mother	Mother
	Age of participant	26	37	40
	Years of education of respondent	16	0	0
	Age of child under 5	none	2	1, 4
	Number of children under 5	0	1	2
	Number of people in household	1	8	12
	Monthly expenses of household (cedis)- total	1,750,000	975,000	881,667
	Food	800,000	750,000	250000
	Transportation	400,000	30,000	60,000
	Education	0	100000	150,000
	Health	0	33333.33333	275000
	Utilities	50,000	20000	80000
	Other	500,000	41666.66667	66666.66667
	Information Sources	meetings, radio, tv, sometimes newspaper	radio, market, friends	radio, market, tv
	Water Information Sources	work (Terrahydro Associates Ltd)	Meeting, radio, Watsan committee	radio, friends
Diarrhea Knowledge	Diarrhea in the past week (# of people)	0	2	3
	Children under 5		1	
	Young Adult (21-40)			2
	Middle Age (41-60)			1
	Elderly (61+)		1	
	Causes of diarrhea			
	Dirty Water	Y	Y	Y
	Dirty food		Y	
	Flies/insects			Y
	Poor hygiene/ Environment	Y	Y	Y
	Other			Dirty plates
	Diarrhea Treatment			
	ORS (oral rehydration salt)	Y		
	Medicines	Y	Y	Y
	Person who cares for person with diarrhea	Herself	Mother	Mother
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	N
	Before cooking	Y	Y	Y
	Use soap during handwashing	Y	Y	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	Flush	Free range	KVIP Latrine, free range
	Facility always availability?	Y	Y	N
	Public/Private/Shared Toilet	shared		public
	Time to toilet facility	In house	3 minute	5 minutes
	Handwashing available at toilet facility?	Y	N	N
Drinking Water Source Collection	Drinking Water Source (main)	Tap	Public standpipe	Public standpipe
	Other water source	none	Dam	dam
	Who collects the water	N/A	Mother	Children
	Time to collect water			
	Dry season	N/A	30 min	30 minutes
	Wet season	N/A	30 min	30 minutes
	Water Source (away from home)	tap at office	tied water	tied water
Water Storage	Drinking water storage vessel	plastic bottles	Ceramic vessels	Jerry can
	Narrow mouthed vessels?	Y	N	Y
	Are storage vessels always covered?	Y	Y	Y
	Method of taking water from the containers	pour directly	scoop without handle	pour directly
Water Quality Perception	Is water safe to drink without treatment?	N	Y	Y
	Why is water not safe?	particles		
	Treatment method used	Tamakloe	Cloth filter	Cloth filter, settling, alum
	Reason for method of choice	Improve health	remove particles	remove dirt

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 25-27

Interview Background	Survey Number	25	26	27
	Name	Berkisu Alhassan		Adisa Fuseini
	District	Tamale	Tamale	Tamale
	Community	Kaleriga	Kaleriga	Kaleriga
	Date	12-Jan-06	12-Jan-06	12-Jan-06
	GPS N/S	N 09° 23.005'	N 09° 22.951'	N 09° 22.990'
	GPS E/W	W 000° 49.207'	W 000° 49.183'	W 000° 49.170'
	Technology	none	none	none
Household Information	Status of respondent	Mother	Mother	Mother
	Age of participant	35	29	40
	Years of education of respondent	0	0	0
	Age of child under 5	7 children	1 child age 4	2 twins 2 years
	Number of children under 5	7	1	2
	Number of people in household	25	15	9
	Monthly expenses of household (cedis)- total	4,110,000	620,000	1,150,000
	Food	3,000,000	130000	650000
	Transportation	120000	50,000	120000
	Education	520,000	290,000	0
	Health	250,000	30,000	150,000
	Utilities	120000	60,000	150000
	Other	100,000	60,000	80,000
	Information Sources	radio, market	radio, market, taxi passengers	market, children
	Water Information Sources	meetings, radio	radio, market	meetings/presentations
Diarrhea Knowledge	Diarrhea in past week (# of people)	3	0	0
	Children under 5	2		
	Middle Age (41-60)	1		
	Causes of diarrhea			
	Main Cause	Sickness	Environment	
	Dirty Water	Y	Y	Y
	Dirty food	Y	Y	Y
	Flies/insects	Y	Y	Y
	Poor hygiene/ Environment	Y	Y	Y
	Other		too much boiled meats	
	Diarrhea Treatment		Y	
	Hospital			Y
	Medicines	Y		
	Who cares for person with diarrhea	Mother	Father	Father
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	Y	Y
	Use soap during handwashing	Y	Y	Y
	Currently have soap in household	Y	Y	N/A
	Type of toilet facility	KVIP, free range	KVIP latrine	KVIP latrine, free range
	Facility always availability?	N	Y	N/A
	Public/Private/Shared Toilet	public	public	
	Time to toilet facility	5 minutes	10 minutes	5 minutes
	Handwashing available at toilet facility?	N	N	N
Drinking Water Source Collection	Drinking Water Source (main)	Public Standpipe	Public standpipe	Public standpipe
	Other water source	dam	dam	dam
	Days per week without tap water	5	6	6
	Who collects the water	Everyone	Female adults	female children
	Time to collect water		5-10 min	
	Dry season	2 hours	30 minutes	1.5 hours
	Wet season	10 minutes	45 min to 1 hour	1 hour
	Water Source (away from home)	Tied water	Sachet and tied water	tied
Water Storage	Drinking water storage vessel	ceramic vessels	ceramic vessels	ceramic vessels
	Narrow mouthed vessels?	N	N	N
	Are storage vessels always covered?	N	Y	Y
	Method of taking water from the containers	scoop without handle	scoop with handle	scoop without handle
Water Quality Perception	Is water safe to drink without treatment?	Y	Y	Y
	Why is water not safe?			
	Treatment method used	Cloth filter	Cloth filter (for dam water)	Cloth filter
	Reason for method of choice	remove particles and guinea worm	dam water unclean	want children to stay healthy; don't have money for the hospital

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 28-30

Interview Background	Survey Number	28	29	30
	Name	Ayi Zekeria	Aishatu Iddrisu	Adishetu Ziblim
	District	Tamale	Savelugu	Savelugu
	Community	Kaleriga	Libga	Libga
	Date	12-Jan-06	14-Jan-06	14-Jan-06
	GPS N/S	N 09° 23.010'	N 09° 35.475'	N 09° 35.450'
	GPS E/W	W 000° 49.138'	W 000° 50.899'	W 000° 50.877'
	Technology	none	none	safe storage
Household Information	Status of respondent	Mother	Mother	mother
	Age of participant	30	32	25
	Years of education of respondent	0	0	0
	Age of child under 5	5 children	4 children	4 children
	Number of children under 5	5	4	4
	Number of people in household	19	31	18
	Monthly expenses of household (cedis)- total	1,201,333	955,000	649,000
	Food	900000	600000	450000
	Transportation	40,000	45000	14,000
	Education	83333.33333	180,000	0
	Health	30,000	40,000	80,000
	Utilities	24000	0	5,000
	Other	124,000	90,000	100,000
	Information Sources	market, friends	radio	radio
	Water Information Sources	meetings/presentations	meetings, radio, watsan chairman	meetings, radio, watsan committee
Diarrhea Knowledge	Diarrhea in the past week (# of people)	1	2	0
	Children under 5	1		
	Adolescent (16-20)		1	
	Middle Age (41-60)		1	
	Causes of diarrhea			
	Main Cause		sickness	dirty water
	Dirty Water	Y	Y	Y
	Dirty food	Y	Y	Y
	Flies/insects	Y	Y	Y
	Poor hygiene/ Environment	Y	Y	Y
	Diarrhea Treatment			
	Hospital	Y	Y	Y
	Medicines			Y
	Who cares for person with diarrhea	Father	Father	Everyone
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	Y	Y
	Use soap during handwashing	Y	Y	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	Free range	free range	free range
	Time to toilet facility	3 minutes	10 minutes	8 minutes
	Handwashing available at toilet facility?	N	N	N/A
Drinking Water Source Collection	Drinking Water Source (main)	Public standpipe	Borehole	Borehole
	Other water source	dam, rainwater		
	Days per week without tap water	6	0	0
	Who collects the water	Adult females	Females	Adult females
	Time to collect water			
	Dry season	1 hour	15 minutes	15 minutes
	Wet season	10 minutes	15 minutes	15 minutes
	Drinking Water Source (away from home)	tied	tied water	tied water
Water Storage	Drinking water storage vessel	ceramic vessels	ceramic vessels	safe storage
	Narrow mouthed vessels?	N	N	N/A
	Are storage vessels always covered?	Y	N	Y
	Method of taking water from the containers	scoop without handle	scoop without handle	spigot
Water Quality Perception	Is water safe to drink without treatment?	Y	Y	Y
	Treatment method used	cloth filter (for dam water)	Cloth filter	Cloth filter, safe storage
	Reason for method of choice	Remove particles	Clean water (since hands touch the water)	Remove dirt

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 31-33

Interview Background	Survey Number	31	32	33
	Name	Abiba Tampuli	Fuseini Alhassan	Yatasu Saiyibu
	District	Savelugu	Savelugu	Savelugu
	Community	Libga	Libga	Libga
	Date	14-Jan-06	14-Jan-06	14-Jan-06
	GPS N/S	N 09° 35.528'	N 09° 35.523'	N 09° 35.526'
	GPS E/W	W 000° 50.887'	W 000° 50.875'	W 000° 50.829'
	Technology	safe storage	safe storage	none
Household Information	Status of respondent	mother	mother	Mother
	Age of participant	35	35	28
	Years of education of respondent	0	0	0
	Age of child under 5	1 child	4 children	5 children
	Number of children under 5	1	4	5
	Number of people in household	10	15	18
	Monthly expenses of household (cedis)- total	855,000	1,275,000	2,145,000
	Food	600000	900000	1500000
	Transportation	100000	30,000	260000
	Education	60,000	250,000	220,000
	Health	60,000	30,000	100,000
	Utilities	5000	5,000	5000
	Other	30,000	60,000	60,000
	Information Sources	radio	radio,	radio
	Water Information Sources	meetings, radio	meetings, radio	radio, meetings
Diarrhea Knowledge	Diarrhea in the past week (# of people)	2	1	2
	Children under 5	1	1	2
	Middle Age (41-60)	1		
	Causes of diarrhea			
	Main Cause		sickness	Sickness
	Dirty Water	Y	Y	Y
	Dirty food	Y	Y	Y
	Flies/insects	Y	Y	Y
	Poor hygiene/ Environment	Y	Y	Y
	Diarrhea Treatment			
	Hospital	Y	Y	Y
	Medicines	Y	Y	Y
	Who cares for person with diarrhea	Mother	Mother	mother
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	Y	Y
	Use soap during handwashing	Y	Y	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	Free range	free range	free range
	Time to toilet facility	10 minutes	10 min	10 minutes
	Handwashing available at toilet facility?	N	N	N
Drinking Water Source Collection	Drinking Water Source (main)	Borehole	Borehole	Borehole
	Other water source			
	Who collects the water	Mother and Aunt	adult females	Adult females
	Time to collect water			
	Dry season	10 minutes	15 minutes	15 min
	Wet season	10 minutes	15 minutes	15 min
	Water Source (away from home)	Tied water	carry water from home	tied
Water Storage	Drinking water storage vessel	safe storage	safe storage	ceramic vessel
	Narrow mouthed vessels?	N	N	N
	Are storage vessels always covered?	Y	Y	Y
	Method of taking water from the containers	spigot	spigot	scoop without handle
Water Quality Perception	Is water safe to drink without treatment?	Y	Y	Y
	Treatment method used	Cloth filter, safe storage	safe storage	none
	Reason for method of choice	Good health	prevents recontamination	

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 34-36

Interview Background	Survey Number	34	35	36
	Name	Damata Iddrisu	Abibata Iddrisu	Sanatu Ibrahim
	District	Savelugu	Savelugu	Savelugu
	Community	Libga	Libga	Libga
	Date	14-Jan-06	14-Jan-06	14-Jan-06
	GPS N/S	N 09° 35.502'	N 09° 35.505'	N 09° 35.556'
	GPS E/W	W 000° 50.843'	W 000° 50.819'	W 000° 50.815'
	Technology	safe storage	none	none
Household Information	Status of respondent	Mother	Mother	Mother
	Age of participant	30	27	30
	Years of education of respondent	0	0	0
	Age of child under 5	7 children	1 child	3 children
	Number of children under 5	7	1	3
	Number of people in household	46	4	27
	Monthly expenses of household (cedis)- total	1,957,000	865,000	1,925,000
	Food	1500000	600000	1200000
	Transportation	32,000	100000	100,000
	Education	100,000	0	300,000
	Health	200,000	100,000	200,000
	Utilities	5,000	5000	5,000
	Other	120,000	60,000	120,000
	Information Sources	radio	radio	radio
	Water Information Sources	meetings, radio	meetings, radio	meetings
Diarrhea Knowledge	Diarrhea in past week (# of people)	2	1	0
	Children under 5	2	1	
	Causes of diarrhea			
	Main Cause	Teething children	Ate dirt	
	Dirty Water	Y	Y	Y
	Dirty food	Y	Y	Y
	Flies/insects	Y	Y	Y
	Poor hygiene/ Environment	Y	Y	Y
	Diarrhea Treatment			
	Hospital		Y	Y
	Salt/sugar solution			Y
	Medicines	Y		
	Person who cares for person with diarrhea	Mother	Mother and father	everyone
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	Y	Y
	Other			
	Use soap during handwashing	Y	Sometimes	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	free range	free range	Free range
	Time to toilet facility	10 minutes	4 minutes	15 min
	Handwashing available at toilet facility?	N	N	N
Drinking Water Source Collection	Drinking Water Source (main)	Borehole	Borehole	Borehole
	Other water source			
	Days per week without tap water	0	0	0
	Who collects the water	Adult females	Mother	Females
	Time to collect water			
	Dry season	15 min	10 min	20 min
	Wet season	15 min	10 min	20 min
	Drinking Water Source (away from home)	sachet water	tied water	sachet water
Water Storage	Drinking water storage vessel	safe storage	ceramic vessel	ceramic vessel
	Number of vessels	1	1	6
	Size of vessels	10 gal	15 gal	20 gal
	Preferred?	Y	Y	Y
	Narrow mouthed vessels?	N	N	N
	Are storage vessels always covered?	Y	Y	Y
	Method of taking water from the containers	spigot	scoop without handle	scoop with handle
Water Quality Perception	Is water safe to drink without treatment?	Y	Y	Y
	Treatment method used	cloth filter, safe storage	none	Cloth filter
	Reason for method of choice	want clean water	Used cloth filters to clean dam water	Remove dirt

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 37-39

Interview Background	Survey Number	37	38	39
	Name	Sanatu Yakabu	Awabu Alhassan	Sanatu Iddrisu
	District	Savelugu	Savelugu	Savelugu
	Community	Bunglung	Bunglung	Bunglung
	Date	18-Jan-06	18-Jan-06	18-Jan-06
	GPS N/S	N 09° 35.704'	N 09° 35.720'	N 09° 35.693'
	GPS E/W	W 000° 47.730'	W 000° 47.785'	W 000° 47.801'
	Technology	none	none	none
Household Information	Status of respondent	Mother	Grandmother	grandmother
	Age of participant	30	70	50
	Years of education of respondent	0	0	0
	Age of child under 5	1 child	3 yrs	2 children
	Number of children under 5	1	1	2
	Number of people in household	10	12	20
	Monthly expenses of household (cedis)- total	534,000	792,000	604,000
	Food	300000	100000	340000
	Transportation	64000	200,000	32000
	Education	80,000	140,000	80,000
	Health	40,000	50,000	50,000
	Utilities	2000	2,000	2000
	Other	48,000	300,000	100,000
	Information Sources	radio	radio	radio
	Water Information Sources	meetings, radio	radio	meetings, radio
Diarrhea Knowledge	Diarrhea in past week (# of people)	0	0	3
	Children under 5			1
	Young Adult (21-40)			2
	Causes of diarrhea			
	Main Cause	Dirt	Dirt	Sickness
	Dirty Water	Y	Y	Y
	Dirty food	Y	Y	Y
	Flies/insects	Y	Y	Y
	Poor hygiene/ Environment	Y	Y	Y
	Diarrhea Treatment			
	Hospital	Y	Y	Y
	Medicines	Y	Y	Y
	Other (specify)			local treatment
	Who cares for person with diarrhea	mother, father	mother, father	mother
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	Y	Y
	Other			
	Use soap during handwashing	N	Y	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	Free range	Free range	Free range
	Facility always availability?			
	Public/Private/Shared Toilet			
	Time to toilet facility	5 min	5 min	5 min
	Handwashing available at toilet facility?	N	Y	N
Drinking Water Source Collection	Drinking Water Source (main)	Borehole	Borehole	Borehole
	Other water source			
	Who collects the water	Female children	Female children	Female children
	Time to collect water			
	Dry season	10 min	10 min	7 min
	Wet season	10 min	10 min	7 min
	Drinking Water Source (away from home)	tied	tied	tied
Water Storage	Drinking water storage vessel	ceramic vessel	ceramic vessel	ceramic vessel
	Narrow mouthed vessels?	N	N	N
	Are storage vessels always covered?	N	N	Y
	Method of taking water from the containers	scoop without handle	scoop without handle	scoop without handle
Water Quality Perception	Is water safe to drink without treatment?	Y	Y	Y
	Treatment method used	Cloth filter	Cloth filter	cloth filter
	Reason for method of choice	Remove particles	Remove dirt/particles	Remove guinea worm and other contaminants

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 40-42

Interview Background	Survey Number	40	41	42
	Name	Memuhatu Adana	Yapakya Yakubu	Aisha Abdulai
	District	Savelugu	Savelugu	Savelugu
	Community	Bunglung	Bunglung	Bunglung
	Date	18-Jan-06	18-Jan-06	18-Jan-06
	GPS N/S	N 09° 35.714'	N 09° 35.714'	N 09° 35.750'
	GPS E/W	W 000° 47.791'	W 000° 47.791'	W 000° 47.868'
	Technology	none	none	none
Household Information	Status of respondent	grandmother	grandmother	mother
	Age of participant	50	53	30
	Years of education of respondent	0	0	0
	Age of child under 5	3 children	5 children	3 children
	Number of children under 5	3	5	3
	Number of people in household	20	34	12
	Monthly expenses of household (cedis)- total	1,102,000	622,000	772,000
	Food	400000	300000	440000
	Transportation	200,000	40000	20,000
	Education	200,000	60,000	170000
	Health	100,000	100,000	100,000
	Utilities	2,000	2000	2,000
	Other	200,000	120,000	40,000
	Information Sources	radio	radio	radio
	Water Information Sources	meetings, radio	meetings, radio	meetings, radio
Diarrhea Knowledge	Diarrhea in past week (# of people)	1	0	1
	Young Adult (21-40)			1
	Middle Age (41-60)	1		
	Causes of diarrhea			
	Main Cause		Dirt	
	Dirty Water	Y	Y	Y
	Dirty food	Y	Y	Y
	Flies/insects	Y	Y	Y
	Poor hygiene/ Environment	Y	Y	Y
	Diarrhea Treatment			
	Hospital	Y	Y	Y
	Salt/sugar solution		Y	
	Medicines	Y	Y	Y
	Other (specify)		boil water	
	Who cares for person with diarrhea	mother and father	mother	mother, father
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	Y	Y
	Use soap during handwashing	Y	Y	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	free range	free range	KVIP latrine
	Facility always availability?			Y
	Public/Private/Shared Toilet			private
	Time to toilet facility	4 min	6 min	2 min
	Handwashing available at toilet facility?	N	N	N
Drinking Water Source Collection	Drinking Water Source (main)	Borehole	Borehole	Borehole
	Other water source	dam		
	Who collects the water	Female adults and children	female children	female adults
	Time to collect water			
	Dry season	10 min	20 min	15 min
	Wet season	10 min	20 min	15 min
	Drinking Water Source (away from home)	tied	tied	tied, sachet
Water Storage	Drinking water storage vessel	ceramic vessel	ceramic vessel	ceramic vessel
	Narrow mouthed vessels?	N	N	N
	Are storage vessels always covered?	Y	Y	N
	Method of taking water from the containers	scoop with handle	scoop without handle	scoop without handle
Water Quality Perception	Is water safe to drink without treatment?	Y	Y	Y
	Treatment method used	cloth filter	cloth filter	cloth filter
	Reason for method of choice	Was taught to use the cloth	water is contaminated while carried	removes dirt

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 43-45

Interview Background	Survey Number	43	44	45
	Name	Sanatu Karim	Salatu Iddrisu	Wahariyadu Ababukari
	District	Savelugu	Savelugu	Savelugu
	Community	Bunglung	Diare	Diare
	Date	18-Jan-06	19-Jan-06	19-Jan-06
	GPS N/S	N 09° 35.794'	N 09° 52.419'	N 09° 52.448'
	GPS E/W	W 000° 47.838'	W 000° 52.653'	W 000° 52.699'
	Technology	none	none	none
Household Information	Status of respondent	grandmother	mother	mother
	Age of participant	55	21	40
	Years of education of respondent	0	0	0
	Age of child under 5	2 children	3 children	7 children
	Number of children under 5	2	3	7
	Number of people in household	15	25	60
	Monthly expenses of household (cedis)- total	932,000	1,674,000	670,000
	Food	340,000	950000	200000
	Transportation	80000	40,000	70000
	Education	200,000	300,000	100,000
	Health	160,000	100,000	50,000
	Utilities	2,000	234,000	130,000
	Other	150,000	50,000	120,000
	Information Sources	radio	radio, market	radio
	Water Information Sources	meetings, radio	radio, meetings	meetings, radio
Diarrhea Knowledge	Diarrhea in past week (# of people)	2	3	4
	Children under 5	1	1	2
	Children (6- 15)		1	1
	Young Adult (21-40)	1		1
	Middle Age (41-60)		1	
	Causes of diarrhea			
	Main Cause		dirty water, dirty food	sickness
	Dirty Water	Y	Y	Y
	Dirty food	Y	Y	Y
	Flies/insects	Y	Y	Y
	Poor hygiene/ Environment	Y	Y	Y
	Diarrhea Treatment			
	Hospital	Y	Y	Y
	Medicines	Y		Y
	Who cares for person with diarrhea	mother, father, anyone	mother	mother
Sanitation and Hygiene	Handwashing			
	After the toilet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	Y	Y
	Other			
	Use soap during handwashing	Y	Y	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	free range	free range	free range
	Time to toilet facility	5 min	2 min	15 min
	Handwashing available at toilet facility?	N	N	N
Drinking Water Source Collection	Drinking Water Source (main)	Borehole	public standpipe	dam
	Other water source		dam, dugout	dugout
	Who collects the water	female children	adult females	adult females and children
	Time to collect water			
	Dry season	15 min	10-20 minutes	40 min
	Wet season	15 min	in household	in household
	Water Source (away from home)	tied	Tied water, go to a home and ask	sachet and tied
Water Storage	Drinking water storage vessel	ceramic vessel	ceramic vessel	ceramic vessel
	Narrow mouthed vessels?	N	N	N
	Are storage vessels always covered?	N	Y	Y
	Method of taking water from the containers	scoop without handle	scoop with handle	scoop without handle
Water Quality Perception	Is water safe to drink without treatment?	Y	Y	Y
	Why is water not safe?			
	Treatment method used	cloth filter	cloth filter	cloth filter
	Reason for method of choice	removes dirt	removes dirt	remove guinea worm and other bacteria

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 46-48

Interview Background	Survey Number	46	47	48
	Name	Laabi Adam	Ayishatu Ibrahim	Aiyishatu Mahama
	District	Savelugu	Savelugu	Savelugu
	Community	Diare	Diare	Diare
	Date	19-Jan-06	19-Jan-06	19-Jan-06
	GPS N/S	N 09° 52.465'	N 09° 52.378'	N 09° 52.211'
	GPS E/W	W 000° 52.775'	W 000° 52.720'	W 000° 52.638'
	Technology	none	none	none
Household Information	Status of respondent	mother	mother	grandmother
	Age of participant	30	25	66
	Years of education of respondent	0	0	0
	Age of child under 5	3 children	4 children	3 children
	Number of children under 5	3	4	3
	Number of people in household	60	23	29
	Monthly expenses of household (cedis)- total	1,600,000	1,050,000	910,000
	Food	200000	320000	460000
	Transportation	40,000	30000	100,000
	Education	60,000	50,000	150,000
	Health	400,000	200,000	100,000
	Utilities	400,000	300,000	60,000
	Other	500,000	150,000	40,000
	Information Sources	radio	radio	radio
	Water Information Sources	meetings, radio	meetings, radio	meetings
Diarrhea Knowledge	Diarrhea in past week (# of people)	0	2	2
	Children (6- 15)			1
	Young Adult (21-40)		1	1
	Middle Age (41-60)		1	
	Causes of diarrhea			
	Main Cause	Environment	Unsure	dirty water
	Dirty Water	Y	Y	Y
	Dirty food	Y	Y	Y
	Flies/insects	Y	Y	Y
	Poor hygiene/ Environment	Y	Y	Y
	Other	cold food		cold food
	Diarrhea Treatment			
	Hospital	Y	Y	Y
	Salt/sugar solution			Y
	Who cares for person with diarrhea	mother and father	mother and grandmother	mother and father
Sanitation and Hygiene	Handwashing			
	After the toliet	Y	Y	Y
	Before eating	Y	Y	Y
	Before cooking	Y	Y	Y
	Other			
	Use soap during handwashing	Y	Y	Y
	Currently have soap in household	Y	Y	Y
	Type of toilet facility	free range	free range	free range
	Time to toilet facility	5 min	10 min	15 min
	Handwashing available at toilet facility?	N	N	N
Drinking Water Source Collection	Drinking Water Source (main)	borehole	dam	borehole
	Other water source	dam, dugout	dugout	dam, dugout
	Who collects the water	adult females	females adults and children	female adults
	Time to collect water			
	Dry season	80 min	1 hour	2 hours
	Wet season	in household	0	0
	Water Source (away from home)	sachet and tied	tied, someone's home	tied water
Water Storage	Drinking water storage vessel	ceramic vessel	ceramic vessel	ceramic vessel
	Narrow mouthed vessels?	N	N	N
	Are storage vessels always covered?	Y	Y	Y
	Method of taking water from the containers	scoop (with and without handle)	scoop (with and without handle)	scoop with handle
Water Quality Perception	Is water safe to drink without treatment?	Y	Y	Y
	Treatment method used	cloth filter	cloth filter	cloth filter, boil
	Reason for method of choice	remove guinea worm and other living things	remove guinea worm	removes dirt

APPENDIX C: DETAILED SURVEY RESULTS: GENERAL - Households 49-50

Interview Background	Survey Number	49	50
	Name	Mari Alhassan	Damata Tufilu
	District	Savelugu	Savelugu
	Community	Diare	Diare
	Date	19-Jan-06	19-Jan-06
	GPS N/S	N 09° 52.228'	N 09° 52.256'
	GPS E/W	W 000° 52.566'	W 000° 52.521'
	Technology	none	none
Household Information	Status of respondent	mother	mother
	Age of participant	34	38
	Years of education of respondent	0	0
	Age of child under 5	3 children	1 child
	Number of children under 5	3	1
	Number of people in household	12	16
	Monthly expenses of household (cedis)- total	500,000	410,000
	Food	350000	250000
	Transportation	30000	30,000
	Education	0	30,000
	Health	55,000	40,000
	Utilities	10,000	20,000
	Other	55,000	40,000
	Information Sources	meetings, market	radio
	Water Information Sources	meetings	meetings, radio
Diarrhea Knowledge	Diarrhea in past week (# of people)	0	0
	Causes of diarrhea		
	Main Cause	sickness	environment
	Dirty Water	Y	Y
	Dirty food	Y	Y
	Flies/insects	Y	Y
	Poor hygiene/ Environment	Y	Y
	Diarrhea Treatment		
	Hospital	Y	Y
	Medicines		Y
	Who cares for person with diarrhea	mother and father	mother and father
Sanitation and Hygiene	Handwashing		
	After the toilet	Y	Y
	Before eating	Y	Y
	Before cooking	Y	Y
	Other		
	Use soap during handwashing	Y	N
	Currently have soap in household	Y	Y
	Type of toilet facility	free range	KVIP latrine, free range
	Facility always availability?		latrine=no
	Public/Private/Shared Toilet		latrine=public
	Time to toilet facility	5 min	latrine=5 min, free range=15 min
	Handwashing available at toilet facility?	N/A	N
Drinking Water Source Collection	Drinking Water Source (main)	borehole	borehole
	Other water source	dam, rainwater	dam
	Days per week without tap water	0	0
	Who collects the water	female adults	adult females and children
	Time to collect water		
	Dry season	10 min	20-25 min
	Wet season	10 min	in household
	Water Source (away from home)	tied	tied
Water Storage	Drinking water storage vessel	ceramic vessel	ceramic vessel
	Narrow mouthed vessels?	N	N
	Are storage vessels always covered?	Y	Y
	Method of taking water from the containers	scoop with handle	scoop with handle
Water Quality Perception	Is water safe to drink without treatment?	Y	Y
	Treatment method used	cloth filter	cloth filter
	Reason for method of choice	Wants clean water for good health	want clean water

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 1-3

Interview Background	Survey Number	1	2	3
	Name	Faustina Bakah	Gifty Baba	Beatrice Amissoah Keteku
	District	Tamale	Tamale	Tamale
	Community	Barracks	Barracks	Barracks
	Date	7-Jan-06	7-Jan-06	7-Jan-06
	Start Time	10:30 AM	11:10 AM	12:00 PM
	End Time	10:52 PM	11:40 AM	12:20 PM
	GPS Coordinates number	9	7	10
	N/S	N 09° 27.831'	N 09° 27.867'	N 09° 27.835'
	E/W	W 000° 50.923'	W 000° 50.949'	W 000° 51.020'
	Technology	Nnsupa	Tamakloe	none
Without Treatment Technology	Would you like to treat your water before drinking?			Y
	Why/why not?			remove dirt
	How much would you pay?			100,000
With Treatment Technology	Type of technology	Nnsupa	Tamakloe	
	How did you hear about it?			
	Reason for product selection	Saves time (instead of boiling)	Size	
	How many days a week do you use it?	7	7	
	Is water better/worse/same?	better	better	
	Do you treat all of the familiy's water?	Y	Y	
	Health improvements since treatment?	Y	Y	
	Who treats the water?	Mother	Mother	
	Are you happy with the technology?	Y	Y	
	Why/why not?	it's good		
	Is it easy to use?	Y	Y	
	Would you recommend it to others?	Y	Y	
	Have you had any problems with the technology?	N	N	
	What and how often:			
	Do you clean the technology?	Y	Y	
	How often?	every 3 days	clean container weekly, clean filter montly	
	What do you do if it breaks?	call Hamdiyah	call Hamdiyah	
	Do you have enough resources ($, info, skills) to keep it running?	Y	Y	
	If it was broken, would you buy a new one?	Y	Y	
	For how much? (cedis)	50,000	10,000	
	Would your neighbors buy one for this price?	Y	Y	
	Why haven't more people bought technology?			
Other Technology questions	Who in the family decides what to buy?			mother
	Interest in producing technologies?	Y	Y	Y
	Other comments	lower the price, want bigger technology; (This is Hamdiyah's sister)	This is Hamdiyah's sister	

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 4-6

Interview Background	Survey Number	4	5	6
	Name	Diana Nuokyi	Marta Abusharaf	Angelina Gakpo
	District	Tamale	Tamale	Tamale
	Community	Barracks	Barracks	Barracks
	Date	7-Jan-06	7-Jan-06	7-Jan-06
	Start Time	12:30 PM	1:05 PM	1:50 PM
	End Time	12:55 PM	1:35 PM	2:10 PM
	GPS Coordinates number	11	12	13
	N/S	N 09° 27.833'	N 09° 27.836'	N 09° 27.833'
	E/W	W 000° 51.030'	W 000° 51.043'	W 000° 51.0533'
	Technology	none	Tamakloe	Tamakloe
Without Treatment Technology	Would you like to treat your water before drinking?	Y		
	Why/why not?			
	How much would you pay?	20,000		
With Treatment Technology	Type of technology		Tamakloe	Tamakloe
	How did you hear about it?			
	Reason for product selection		Size	to clean water
	How many days a week do you use it?		7	7
	Is water better/worse/same?		better	better
	Do you treat all of the familiy's water?		Y	Y
	Health improvements since treatment?		N	Y
	Who treats the water?		mother	mother
	Are you happy with the technology?		Y	Y
	Why/why not?			
	Is it easy to use?		Y	Y
	Would you recommend it to others?		Y	Y
	Have you had any problems with the technology?		N	N
	What and how often:			
	Do you clean the technology?		not yet	N
	How often?		will after 1 month	
	What do you do if it breaks?		contact Hamdiyah	buy a new one
	Do you have enough resources ($, info, skills) to keep it running?		Y	Y
	If it was broken, would you buy a new one?		Y	Y
	For how much? (cedis)		50,000	100,000
	Would your neighbors buy one for this price?		unsure	Y
	Why haven't more people bought technology?			
Other Technology questions	Who in the family decides what to buy?	Mother, father		
	Interest in producing technologies?	Y	Y	Y
	Other comments	Husband was present and answered many questions; Wanted to know easy ways of treating water, Hamdiyah explained SODIS and cloth filter	Noticed child drinking water out of a cup that was on the ground outside	Very enthusiastic about the product; Noted that no slime formed in the filter (compared to storing water in buckets which formed a slime)

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 7-9

Interview Background	Survey Number	7	8	9
	Name	Grace Mills	Comfort Bratu	Fostina Lerty
	District	Tamale	Tamale	Tamale
	Community	Barracks	Barracks	Barracks
	Date	7-Jan-06	7-Jan-06	7-Jan-06
	Start Time	2:15 PM	3:15 PM	3:45 PM
	End Time	2:35 PM	3:35 PM	4:00 PM
	GPS Coordinates number	14	15	16
	N/S	N 09° 27.840'	N 09° 27.850'	N 09° 27.884'
	E/W	W 000° 51.047'	W 000° 51.027'	W 000° 51.013'
	Technology	Tamakloe	none	none
Without Treatment Technology	Would you like to treat your water before drinking?		Y	Y
	Why/why not?			
	How much would you pay?		20,000	100,000
With Treatment Technology	Type of technology	Tamakloe		
	How did you hear about it?			
	Reason for product selection	size		
	How many days a week do you use it?	7		
	Is water better/worse/same?	better		
	Do you treat all of the familiy's water?	Y		
	Health improvements since treatment?	Y		
	Who treats the water?	mother		
	Are you happy with the technology?	Y		
	Why/why not?			
	Is it easy to use?	Y		
	Would you recommend it to others?	Y		
	Have you had any problems with the technology?	N		
	What and how often:			
	Do you clean the technology?	Y		
	How often?	weekly		
	What do you do if it breaks?	buy a new one		
	Do you have enough resources ($, info, skills) to keep it running?	Y		
	If it was broken, would you buy a new one?	Y		
	For how much? (cedis)	100,000		
	Would your neighbors buy one for this price?	Y		
	Why haven't more people bought technology?			
Other Technology questions	Who in the family decides what to buy?		Mother	Woman
	Interest in producing technologies?	Y	Y	Y
	Other comments	Commented that the filters should be made cheaper so the less privileged could afford them; this family has no children	Reduce the filter cost	Decrease the price

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 10-12

Interview Background	Survey Number	10	11	12
	Name	Irene Shikabli	Francis Quagraine	Lucy Anane Ampradu
	District	Tamale	Tamale	Tamale
	Community	Barracks	Vitin Estates	Vitin Estates
	Date	7-Jan-06	10-Jan-06	10-Jan-06
	Start Time	4:10 PM	10:55 AM	11:35 AM
	End Time	4:30 PM	11:16 AM	12:12 PM
	GPS Coordinates number	17	23	22
	N/S	N 09° 27.964'	N 09° 23.159'	N 09° 23.163'
	E/W	W 000° 50.967'	W 000° 48.904'	W 000° 48.897'
	Technology	none	Tamakloe	none
Without Treatment Technology	Would you like to treat your water before drinking?	Y		Y
	Why/why not?			
	How much would you pay?	100,000		100,000
With Treatment Technology	Type of technology		Tamakloe	
	How did you hear about it?		Wahabu (neighbor)	
	Reason for product selection		easy to use and available	
	How many days a week do you use it?		7	
	Is water better/worse/same?		better	
	Do you treat all of the familiy's water?		N	
	Health improvements since treatment?		Y	
	Who treats the water?		Male child	
	Are you happy with the technology?		N	
	Why/why not?		the ceramic is breakable	
	Is it easy to use?		Y	
	Would you recommend it to others?		Y	
	Have you had any problems with the technology?		N	
	What and how often:			
	Do you clean the technology?		Y	
	How often?		once a month	
	What do you do if it breaks?		buy a new one	
	Do you have enough resources ($, info, skills) to keep it running?		Y	
	If it was broken, would you buy a new one?		Y	
	For how much? (cedis)		unsure	
	Would your neighbors buy one for this price?			
	Why haven't more people bought technology?		don't know about them	
Other Technology questions	Who in the family decides what to buy?	Mother	Father	Mother, Father
	Interest in producing technologies?	Y	Y	Y
	Other comments	none	More education is needed so the public knows about the product and will buy it	none

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 13-15

Interview Background	Survey Number	13	14	15
	Name	Elizabeth Ahenkora	Mary Baidoo	Salamatu Mahama
	District	Tamale	Tamale	Tamale
	Community	Vitin Estates	Vitin Estates	Vitin Estates
	Date	10-Jan-06	10-Jan-06	10-Jan-06
	Start Time	12:30 PM	1:05 PM	2:25 PM
	End Time	12:45 PM	1:40 PM	2:55 PM
	GPS Coordinates number	24	25	26
	N/S	N 09° 23.159'	N 09° 23.116'	N 09° 23.154'
	E/W	W 000° 48.911'	W 000° 48.887'	W 000° 48.841'
	Technology	Tamakloe	Tamakloe	none
Without Treatment Technology	Would you like to treat your water before drinking?			N
	Why/why not?			Not necessary, water is clean; too much work
	How much would you pay?			
With Treatment Technology	Type of technology	Tamakloe	Tamakloe	
	How did you hear about it?	door-to-door seller	Wahabu	
	Reason for product selection	easy to use, lasts a long time	price, size	
	How many days a week do you use it?	7	7	
	Is water better/worse/same?	the same	better	
	Do you treat all of the familiy's water?	Y	Y	
	Health improvements since treatment?	N	Y	
	Who treats the water?	female child	mother	
	Are you happy with the technology?	Y	Y	
	Why/why not?	works well, removes particles	water is cleaner since can get water directly from spigot	
	Is it easy to use?	Y	Y	
	Would you recommend it to others?	Y	Y	
	Have you had any problems with the technology?	N	Y	
	What and how often:		clay bits come off the top when the lid is opened and closed	
	Do you clean the technology?	Y	Y	
	How often?	once a week	once a week	
	What do you do if it breaks?	unsure, read the pamphlet	call Wahabu	
	Do you have enough resources ($, info, skills) to keep it running?	Y	Y	
	If it was broken, would you buy a new one?	Y	Y	
	For how much? (cedis)	same amount, 152,000	100,000	
	Would your neighbors buy one for this price?	Y	Y	
	Why haven't more people bought technology?	price	price	
Other Technology questions	Who in the family decides what to buy?	father	mother	Mother
	Interest in producing technologies?	Y	Y	
	Other comments	none	none	Interview was done at her store (and interrupted occasionally for sales)

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 16-18

Interview Background	Survey Number	16	17	18
	Name	Husseina Haruna	Rebecca Darkey	Edith Leneugo
	District	Tamale	Tamale	Tamale
	Community	Vitin Estates	Jisonayili	Jisonayili
	Date	10-Jan-06	11-Jan-06	11-Jan-06
	Start Time	3:05 PM	10:17 AM	11:17 AM
	End Time	3:20 PM	10:50 AM	11:45 AM
	GPS Coordinates number	27	1	2
	N/S	N 09° 23.202'	N 09° 27.021'	N 09° 27.021'
	E/W	W 000° 48.915'	W 000° 50.957'	W 000° 51.262'
	Technology	none	Nnsupa	Nnsupa (broken)
Without Treatment Technology	Would you like to treat your water before drinking?	N		
	Why/why not?	Not necessary, water is clean		
	How much would you pay?			
With Treatment Technology	Type of technology		Nnsupa	Nnsupa
	How did you hear about it?		Husband (World Vision)	Husband (World Vision)
	Reason for product selection		Appearance (color), size	easy to carry
	How many days a week do you use it?		3	0
	Is water better/worse/same?		the same	the same
	Do you treat all of the familiy's water?		no	No (broken)
	Health improvements since treatment?		Y	Y
	Who treats the water?		Mother	everyone
	Are you happy with the technology?		Y	N
	Why/why not?		Better water than bottled water	Flowrate so slow that it's not working
	Is it easy to use?		Y	Y
	Would you recommend it to others?		Y	Y
	Have you had any problems with the technology?		N	Y
	What and how often:			Low flowrate- doesn't work
	Do you clean the technology?		Y	Would have, but didn't have it for long
	How often?		Clean container every 3 days	
	What do you do if it breaks?		husband contacts PHW	Tell PHW
	Do you have enough resources ($, info, skills) to keep it running?		Y	N (not enough $)
	If it was broken, would you buy a new one?		Y	Y
	For how much? (cedis)		husband decides	20,000
	Would your neighbors buy one for this price?			Y
	Why haven't more people bought technology?		price, people don't wwant to change, no need for treatment	price
Other Technology questions	Who in the family decides what to buy?	grandfather and grandmother	Mother and father	Mother
	Interest in producing technologies?		would need to discuss with husband	Y
	Other comments	Interview done after Muslim festival celebration (woman peppering the meat)	Has had filter since 1st week of december	Husband also answered questions; asked why they have to pay for it since it's from World Vision (why isn't it free)

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 19-21

Interview Background	Survey Number	19	20	21
	Name	Rita Anai	Nasima Samed	Rose Naah
	District	Tamale	Tamale	Tamale
	Community	Jisonayili	Jisonayili	Jisonayili
	Date	11-Jan-06	11-Jan-06	11-Jan-06
	Start Time	12:17 PM	1:20 PM	2:00 PM
	End Time	12:35 PM	1:35 PM	2:20 PM
	GPS Coordinates number	3	4	6
	N/S	N 09° 27.295'	N 09° 27.396'	N 09° 27.419'
	E/W	W 000° 51.711'	W 000° 51.696'	W 000° 51.681'
	Technology	none	none	none
Without Treatment Technology	Would you like to treat your water before drinking?	Y	Y	Y
	Why/why not?			
	How much would you pay?	don't know	200,000	20,000
With Treatment Technology	Type of technology			
	How did you hear about it?			
	Reason for product selection			
	How many days a week do you use it?			
	Is water better/worse/same?			
	Do you treat all of the familiy's water?			
	Health improvements since treatment?			
	Who treats the water?			
	Are you happy with the technology?			
	Why/why not?			
	Is it easy to use?			
	Would you recommend it to others?			
	Have you had any problems with the technology?			
	What and how often:			
	Do you clean the technology?			
	How often?			
	What do you do if it breaks?			
	Do you have enough resources ($, info, skills) to keep it running?			
	If it was broken, would you buy a new one?			
	For how much? (cedis)			
	Would your neighbors buy one for this price?			
	Why haven't more people bought technology?			
Other Technology questions	Who in the family decides what to buy?	Mother	Father	Herself
	Interest in producing technologies?	Y	Y	Yes
	Other comments	Interview done in hair salon; seemed interested in purchasing a filter	Hamdiyah's neighbor	Using a safe storage cooler container with a cloth filter; wants safe water to stay in good health; interesting in learning more about safe water (she's a school teacher)

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 22-24

Interview Background	Survey Number	22	23	24
	Name	Phidelia Deyegbe	Ramatu Dawuni	Mamunatu Ibrahima
	District	Tamale	Tamale	Tamale
	Community	Jisonayili	Kaleriga	Kaleriga
	Date	11-Jan-06	12-Jan-06	12-Jan-06
	Start Time	2:55 PM	9:55 AM	10:45 AM
	End Time	3:10 PM	10:27 AM	11:30 AM
	GPS Coordinates number	5	8	9
	N/S	N 09° 27.429'	N 09° 22.962'	N 09° 22.988'
	E/W	W 000° 51.771'	W 000° 49.233'	W 000° 49.236'
	Technology	Tamakloe	none	none
Without Treatment Technology	Would you like to treat your water before drinking?		Y	Y
	Why/why not?			
	How much would you pay?		40000	25000
With Treatment Technology	Type of technology	Tamakloe		
	How did you hear about it?	Hamdiyah in a taxi cab (World Vision)		
	Reason for product selection	Size		
	How many days a week do you use it?	7		
	Is water better/worse/same?	Better (taste)		
	Do you treat all of the familiy's water?	Y		
	Health improvements since treatment?	Y		
	Who treats the water?	Herself		
	Are you happy with the technology?	Y		
	Why/why not?	it's a local technology for good water		
	Is it easy to use?	Y		
	Would you recommend it to others?	Y		
	Have you had any problems with the technology?	N		
	What and how often:			
	Do you clean the technology?	Y		
	How often?	once a month		
	What do you do if it breaks?	report to Hamdiyah		
	Do you have enough resources ($, info, skills) to keep it running?	Y		
	If it was broken, would you buy a new one?	Y		
	For how much? (cedis)	152,000		
	Would your neighbors buy one for this price?	Y		
	Why haven't more people bought technology?	they don't know about it		
Other Technology questions	Who in the family decides what to buy?	Herself	Everyone	Everyone
	Interest in producing technologies?	Y	Y	Y
	Other comments	Suggested that the old cleaning brushes should be exchanged for free; Interview was conducted at her work Terrahydro Associated Ltd	Respondent was the chief's wife; the chief was present and answered the questions as well	Interested in what we are going- what is the value to the community; Saturday community meetings 7-8 am

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 25-27

Interview Background	Survey Number	25	26	27
	Name	Berkisu Alhassan		Adisa Fuseini
	District	Tamale	Tamale	Tamale
	Community	Kaleriga	Kaleriga	Kaleriga
	Date	12-Jan-06	12-Jan-06	12-Jan-06
	Start Time	11:45 AM	12:45 PM	1:25 PM
	End Time	12:25 PM	1:10 PM	2:00 PM
	GPS Coordinates number	10	11	12
	N/S	N 09° 23.005'	N 09° 22.951'	N 09° 22.990'
	E/W	W 000° 49.207'	W 000° 49.183'	W 000° 49.170'
	Technology	none	none	none
Without Treatment Technology	Would you like to treat your water before drinking?	Y	Y	Y
	Why/why not?			
	How much would you pay?	100,000	70000	40,000
With Treatment Technology	Type of technology			
	How did you hear about it?			
	Reason for product selection			
	How many days a week do you use it?			
	Is water better/worse/same?			
	Do you treat all of the familiy's water?			
	Health improvements since treatment?			
	Who treats the water?			
	Are you happy with the technology?			
	Why/why not?			
	Is it easy to use?			
	Would you recommend it to others?			
	Have you had any problems with the technology?			
	What and how often:			
	Do you clean the technology?			
	How often?			
	What do you do if it breaks?			
	Do you have enough resources ($, info, skills) to keep it running?			
	If it was broken, would you buy a new one?			
	For how much? (cedis)			
	Would your neighbors buy one for this price?			
	Why haven't more people bought technology?			
Other Technology questions	Who in the family decides what to buy?	Father	Mother and father	Mother
	Interest in producing technologies?	Y	Y	Y
	Other comments	We had an audience of many children	Audience of about 20	

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 28-30

Interview Background	Survey Number	28	29	30
	Name	Ayi Zekeria	Aishatu Iddrisu	Adishetu Ziblim
	District	Tamale	Savelugu	Savelugu
	Community	Kaleriga	Libga	Libga
	Date	12-Jan-06	14-Jan-06	14-Jan-06
	Start Time	2:10 PM	9:02 AM	9:44 AM
	End Time	2:43 PM	9:32 AM	10:14 AM
	GPS Coordinates number	13	14	15
	N/S	N 09° 23.010'	N 09° 35.475'	N 09° 35.450'
	E/W	W 000° 49.138'	W 000° 50.899'	W 000° 50.877'
	Technology	none	none	safe storage
Without Treatment Technology	Would you like to treat your water before drinking?	Y	Y	
	Why/why not?			
	How much would you pay?	50000	30,000	
With Treatment Technology	Type of technology			safe storage
	How did you hear about it?			Promotion in community
	Reason for product selection			Price (cheaper than filter)
	How many days a week do you use it?			7 days
	Is water better/worse/same?			Better
	Do you treat all of the familiy's water?			Y
	Health improvements since treatment?			Y
	Who treats the water?			Mother
	Are you happy with the technology?			Y
	Why/why not?			It's beautiful
	Is it easy to use?			Y
	Would you recommend it to others?			Y
	Have you had any problems with the technology?			N
	What and how often:			
	Do you clean the technology?			Y
	How often?			every 3 days
	What do you do if it breaks?			Tell PHW and buy a new one
	Do you have enough resources ($, info, skills) to keep it running?			Maybe
	If it was broken, would you buy a new one?			Y
	For how much? (cedis)			70000
	Would your neighbors buy one for this price?			Y
	Why haven't more people bought technology?			Don't know about it
Other Technology questions	Who in the family decides what to buy?	Entire household	Entire household	Mother and father
	Interest in producing technologies?	Y	Y	Y
	Other comments		Entire household answering	Yam reeds are put in water carrying container for balance; Lower the rpice so every hut can have one

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 31-33

Interview Background	Survey Number	31	32	33
	Name	Abiba Tampuli	Fuseini Alhassan	Yatasu Saiyibu
	District	Savelugu	Savelugu	Savelugu
	Community	Libga	Libga	Libga
	Date	14-Jan-06	14-Jan-06	14-Jan-06
	Start Time	10:25 AM	11:05 AM	11:45 AM
	End Time	10:55 AM	11:35 AM	12:10 PM
	GPS Coordinates number	16	17	18
	N/S	N 09° 35.528'	N 09° 35.523'	N 09° 35.526'
	E/W	W 000° 50.887'	W 000° 50.875'	W 000° 50.829'
	Technology	safe storage	safe storage	none
Without Treatment Technology	Would you like to treat your water before drinking?			Y
	Why/why not?			
	How much would you pay?			40,000-50,000
With Treatment Technology	Type of technology	safe storage	safe storage	
	How did you hear about it?	Promotion in community	presentation	
	Reason for product selection	price	prevents hand dipping	
	How many days a week do you use it?	7	7	
	Is water better/worse/same?	better	better	
	Do you treat all of the familiy's water?	Y	Y	
	Health improvements since treatment?	Y	Y	
	Who treats the water?	Mother	Mother	
	Are you happy with the technology?	Y	Y	
	Why/why not?	Don't have to dip hands in	children don't recontaminate the water with their hands	
	Is it easy to use?	Y	Y	
	Would you recommend it to others?	Y	Y	
	Have you had any problems with the technology?	N	N	
	What and how often:			
	Do you clean the technology?	Y	Y	
	How often?	weekly	every 2 days	
	What do you do if it breaks?	Contact PHW	Contact local representative (to get to PHW)	
	Do you have enough resources ($, info, skills) to keep it running?	Y	Y	
	If it was broken, would you buy a new one?	Y	Y	
	For how much? (cedis)	50,000	40000	
	Would your neighbors buy one for this price?	Y	Y	
	Why haven't more people bought technology?	Price	Price	
Other Technology questions	Who in the family decides what to buy?	Entire household	Entire household	Entire household
	Interest in producing technologies?	Y	Y	Y
	Other comments	Father is the Watsan chairman; Would like additional safe storage containers; At meetings others are encouraged to buy safe storage to make sure people have clean water (and good health, so they can work)	Respondent wishes that she had more than one; she asked about if the tap breaks and Wahabu said then to bring it to him	She wanted to know who to contact to buy technology, local representative would contact PHW

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 34-36

Interview Background	Survey Number	34	35	36
	Name	Damata Iddrisu	Abibata Iddrisu	Sanatu Ibrahim
	District	Savelugu	Savelugu	Savelugu
	Community	Libga	Libga	Libga
	Date	14-Jan-06	14-Jan-06	14-Jan-06
	Start Time	12:25 PM	1:30 PM	2:00 PM
	End Time	12:55 PM	1:52 PM	2:25 PM
	GPS Coordinates number	19	20	21
	N/S	N 09° 35.502'	N 09° 35.505'	N 09° 35.556'
	E/W	W 000° 50.843'	W 000° 50.819'	W 000° 50.815'
	Technology	safe storage	none	none
Without Treatment Technology	Would you like to treat your water before drinking?		Y	Y
	Why/why not?			
	How much would you pay?		15000	50000
With Treatment Technology	Type of technology	safe storage		
	How did you hear about it?	Promotion		
	Reason for product selection	Price		
	How many days a week do you use it?	7		
	Is water better/worse/same?	better		
	Do you treat all of the familiy's water?	Y		
	Health improvements since treatment?	Y		
	Who treats the water?	Mother		
	Are you happy with the technology?	Y		
	Why/why not?	Prevents recontamination		
	Is it easy to use?	Y		
	Would you recommend it to others?	Y		
	Have you had any problems with the technology?	N		
	What and how often:			
	Do you clean the technology?	Y		
	How often?	every 2 days		
	What do you do if it breaks?	buy a new one		
	Do you have enough resources ($, info, skills) to keep it running?	Y		
	If it was broken, would you buy a new one?	Y		
	For how much? (cedis)	40000		
	Would your neighbors buy one for this price?	Y		
	Why haven't more people bought technology?	price		
Other Technology questions	Who in the family decides what to buy?	Entire household	Mother and father	Mother
	Interest in producing technologies?	Y	Y	Y
	Other comments	Child pooped on mother's lap mid-interview so we took a short break for her to clean up	none	none

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 37-39

Interview Background	Survey Number	37	38	39
	Name	Sanatu Yakabu	Awabu Alhassan	Sanatu Iddrisu
	District	Savelugu	Savelugu	Savelugu
	Community	Bunglung	Bunglung	Bunglung
	Date	18-Jan-06	18-Jan-06	18-Jan-06
	Start Time	10:00 AM	10:40 AM	11:10 AM
	End Time	10:32 AM	11:02 AM	11:36 AM
	GPS Coordinates number	22	23	24
	N/S	N 09° 35.704'	N 09° 35.720'	N 09° 35.693'
	E/W	W 000° 47.730'	W 000° 47.785'	W 000° 47.801'
	Technology	none	none	none
Without Treatment Technology	Would you like to treat your water before drinking?	Y	Y	Y
	Why/why not?			
	How much would you pay?	40000	50000	30000
With Treatment Technology	Type of technology			
	How did you hear about it?			
	Reason for product selection			
	How many days a week do you use it?			
	Is water better/worse/same?			
	Do you treat all of the familiy's water?			
	Health improvements since treatment?			
	Who treats the water?			
	Are you happy with the technology?			
	Why/why not?			
	Is it easy to use?			
	Would you recommend it to others?			
	Have you had any problems with the technology?			
	What and how often:			
	Do you clean the technology?			
	How often?			
	What do you do if it breaks?			
	Do you have enough resources ($, info, skills) to keep it running?			
	If it was broken, would you buy a new one?			
	For how much? (cedis)			
	Would your neighbors buy one for this price?			
	Why haven't more people bought technology?			
Other Technology questions	Who in the family decides what to buy?	Entire household	Entire household	Entire household
	Interest in producing technologies?	Y	Y	Y
	Other comments	Husband answered questions as well	none	Respondent said that we should bring filters (and prices) to the community so people can buy them if they can afford them

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 40-42

Interview Background	Survey Number	40	41	42
	Name	Memuhatu Adana	Yapakya Yakubu	Aisha Abdulai
	District	Savelugu	Savelugu	Savelugu
	Community	Bunglung	Bunglung	Bunglung
	Date	18-Jan-06	18-Jan-06	18-Jan-06
	Start Time	11:45 AM	12:20 PM	12:54 PM
	End Time	12:10 PM	12:45 PM	1:18 PM
	GPS Coordinates number	25	27	28
	N/S	N 09° 35.714'	N 09° 35.714'	N 09° 35.750'
	E/W	W 000° 47.791'	W 000° 47.791'	W 000° 47.868'
	Technology	none	none	none
Without Treatment Technology	Would you like to treat your water before drinking?	Y	Y	Y
	Why/why not?			
	How much would you pay?	20000	40000	80,000
With Treatment Technology	Type of technology			
	How did you hear about it?			
	Reason for product selection			
	How many days a week do you use it?			
	Is water better/worse/same?			
	Do you treat all of the familiy's water?			
	Health improvements since treatment?			
	Who treats the water?			
	Are you happy with the technology?			
	Why/why not?			
	Is it easy to use?			
	Would you recommend it to others?			
	Have you had any problems with the technology?			
	What and how often:			
	Do you clean the technology?			
	How often?			
	What do you do if it breaks?			
	Do you have enough resources ($, info, skills) to keep it running?			
	If it was broken, would you buy a new one?			
	For how much? (cedis)			
	Would your neighbors buy one for this price?			
	Why haven't more people bought technology?			
Other Technology questions	Who in the family decides what to buy?	Entire household	Entire household	Entire household
	Interest in producing technologies?	Y	Y	Y
	Other comments	Respondent said she bought the ceramic vessels for 140,000; family was drying kasava and rice	none	none

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 43-46

Interview Background	Survey Number	43	44	45	46
	Name	Sanatu Karim	Salatu Iddrisu	Wahariyadu Ababukari	Laabi Adam
	District	Savelugu	Savelugu	Savelugu	Savelugu
	Community	Bunglung	Diare	Diare	Diare
	Date	18-Jan-06	19-Jan-06	19-Jan-06	19-Jan-06
	Start Time	1:27 PM	9:25 AM	10:03 AM	10:40 AM
	End Time	1:50 PM	9:50 AM	10:28 AM	11:05 AM
	GPS Coordinates number	29	31	32	33
	N/S	N 09° 35.794'	N 09° 52.419'	N 09° 52.448'	N 09° 52.465'
	E/W	W 000° 47.838'	W 000° 52.653'	W 000° 52.699'	W 000° 52.775'
	Technology	none	none	none	none
Without Treatment Technology	Would you like to treat your water before drinking?	Y	Y	Y	Y
	Why/why not?				
	How much would you pay?	80000	200000	50000	20000
With Treatment Technology	Type of technology				
	How did you hear about it?				
	Reason for product selection				
	How many days a week do you use it?				
	Is water better/worse/same?				
	Do you treat all of the familiy's water?				
	Health improvements since treatment?				
	Who treats the water?				
	Are you happy with the technology?				
	Why/why not?				
	Is it easy to use?				
	Would you recommend it to others?				
	Have you had any problems with the technology?				
	What and how often:				
	Do you clean the technology?				
	How often?				
	What do you do if it breaks?				
	Do you have enough resources ($, info, skills) to keep it running?				
	If it was broken, would you buy a new one?				
	For how much? (cedis)				
	Would your neighbors buy one for this price?				
	Why haven't more people bought technology?				
Other Technology questions	Who in the family decides what to buy?	Entire household	Entire household	Entire household	Entire household
	Interest in producing technologies?	Y	Y	Y	Y
	Other comments	none	none	none	The borehole water is not enough for the community

APPENDIX D: DETALED SURVEY RESULTS: PHW PRODUCTS – Households 47-50

Interview Background	Survey Number	47	48	49	50
	Name	Ayishatu Ibrahim	Aiyishatu Mahama	Mari Alhassan	Damata Tufilu
	District	Savelugu	Savelugu	Savelugu	Savelugu
	Community	Diare	Diare	Diare	Diare
	Date	19-Jan-06	19-Jan-06	19-Jan-06	19-Jan-06
	Start Time	11:15 AM	12:00 PM	12:40	1:10 PM
	End Time	11:45 AM	12:25 PM	1:00 PM	1:35 PM
	GPS Coordinates number	34	35	37	39
	N/S	N 09° 52.378'	N 09° 52.211'	N 09° 52.228'	N 09° 52.256'
	E/W	W 000° 52.720'	W 000° 52.638'	W 000° 52.566'	W 000° 52.521'
	Technology	none	none	none	none
Without Treatment Technology	Would you like to treat your water before drinking?	Y	Y	Y	Y
	Why/why not?				
	How much would you pay?	400000	20000	20000	400000
With Treatment Technology	Type of technology				
	How did you hear about it?				
	Reason for product selection				
	How many days a week do you use it?				
	Is water better/worse/same?				
	Do you treat all of the familiy's water?				
	Health improvements since treatment?				
	Who treats the water?				
	Are you happy with the technology?				
	Why/why not?				
	Is it easy to use?				
	Would you recommend it to others?				
	Have you had any problems with the technology?				
	What and how often:				
	Do you clean the technology?				
	How often?				
	What do you do if it breaks?				
	Do you have enough resources ($, info, skills) to keep it running?				
	If it was broken, would you buy a new one?				
	For how much? (cedis)				
	Would your neighbors buy one for this price?				
	Why haven't more people bought technology?				
Other Technology questions	Who in the family decides what to buy?	Entire household	mother and father	Entire household	Entire household
	Interest in producing technologies?	Y	Y	Y	Y
	Other comments	They are farmers, so they don't have a lot of money during the dry season	Borehole water is not enough for community-crowded and may take up to 5 hours to get water	none	none

APPENDIX E: WATER QUALITY TESTING RESULTS

	Sample		H_2S		Membrane filtration			
Community	Number	Description	24 hrs	48 hrs	E. coli	Total Coliform (per plate)	Total coliform (per sq)	Total Coliform, calculated
Kamina Barracks	1A	Nnsupa filtered	-	-				
Kamina Barracks	1B	Tap water	-	-				
Kamina Barracks	2A	Tamakloe filtered	-	-				
Kamina Barracks	2B	Tap water	-	-				
Kamina Barracks	3	Tap water	-	-				
Kamina Barracks	4	Tap water	-	+				
Kamina Barracks	5A	Tamakloe filtered	-	-				
Kamina Barracks	5B	Tap water	-	-				
Kamina Barracks	6A	Tamakloe filtered	-	-				
Kamina Barracks	6B	Tap water	-	-				
Kamina Barracks	7A	Tamakloe filtered	-	-				
Kamina Barracks	7B	Tap water	-	-				
Kamina Barracks	8	Tap water	-	-				
Kamina Barracks	9	Tap water	+	+				
Kamina Barracks	10	Tap water	-	-				
Vitin Estates	11A	Tamakloe filtered	-	-				
Vitin Estates	11B	Tap water	-	-				
Vitin Estates	12	Tap water	-	-				
Vitin Estates	13A	Tamakloe filtered	-	-				
Vitin Estates	13B	Tap water	+	+				
Vitin Estates	14A	Tamakloe filtered	-	-				
Vitin Estates	14B	Tap water	-	-				
Vitin Estates	15	Tap water	-	-				
Vitin Estates	16	Tap water	-	-				
Jisonayili	17A	Nnsupa filtered	-	-	0	0	0	0
Jisonayili	17B	Tap water	-	-	0	1		1
Jisonayili	18	Tap water	+	+	28	TNTC	10	785
Jisonayili	19	Tap water	-	-				
Jisonayili	20	Tap water	-	-				
Jisonayili	21	Tap water	-	-				

APPENDIX E: WATER QUALITY TESTING RESULTS, CONTINUED

	Sample		H_2S		Membrane filtration			
Community	Number	Description	24 hrs	48 hrs	E. coli	Total Coliform (per plate)	Total coliform (per sq)	Total Coliform, calculated
Libga	29	Borehole	+	+				
Libga	30	Safe storage (borehole)	+	+	23	TNTC	6	471
Libga	31	Safe storage (borehole)	+	+				
Libga	32	Safe storage (borehole)	-	-	0	TNTC	7	549.5
Libga	33	Borehole	-	-	2	TNTC	5	392.5
Libga	34	Safe storage (borehole)	-	-	0	TNTC	4	314
Libga	35	Borehole	-	-	18	TNTC		
Libga	36	Borehole	-	-				
Bunglung	37	Borehole	-	-	1	TNTC	7	549.5
Bunglung	38	Borehole	+	+	0			1000
Bunglung	38 5x	5 times dilution			0	50		
Bunglung	38 50x	50 times dilution			0	20		
Bunglung	39	Borehole	-	-	0	TNTC	8	628
Bunglung	40	Borehole	-	-	0	TNTC	10	785
Bunglung	41	Borehole	+	+	2	TNTC	6	471
Bunglung	42	Borehole	-	-	8	TNTC	6	471
Bunglung	43	Borehole	-	-	46	TNTC	8	628
Diare	44	Public standpipe	+	+	14	TNTC	8	628
Diare	45	Dam water	+	+	140			23300
Diare	45 100 x	100 times dilution			2	233		
Diare	45 10 x	10 times dilution			8	TNTC		
Diare	46	Dam water	+	+	135			7697.5
Diare	46 100x	100 times dilution			2	99		99
Diare	46 10x	10 times dilution			7	TNTC	7	549.5
Diare	47	Dam water	+	+	515			15307.5
Diare	47 100x	100 times dilution			4	TNTC	3	235.5
Diare	47 10 x	10 times dilution			63	TNTC	9	706.5
Diare	48	Dam water	+	+	105			4320
Diare	48 100x	100 times dilution			1	55		55
Diare	48 10x	10 times dilution			11	TNTC	4	314
Diare	49	Dam water	+	+	105			8955
Diare	49 100 x	100 times dilution			0	132		132
Diare	49 10x	10 times dilution			21	TNTC	6	471
Diare	50	Dam water	+	+	0	TNTC		

6913 - 51