SIX-MONTH FIELD MONITORING OF POINT-OF-USE CERAMIC WATER FILTER BY USING H_2S PAPER STRIP MOST PROBABLE NUMBER METHOD IN SAN FRANCISCO LIBRE, NICARAGUA

By

Rebeca Eun Young Hwang

B.S. Chemical Engineering
Massachusetts Institute of Technology, 2002

Submitted to the Department of Civil and Environmental Engineering in Partial Fulfillment of the Requirements for the Degree of

MASTER OF ENGINEERING IN CIVIL AND ENVIRONMENTAL ENGINEERING
at the
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

June 2003

Signature of Author:____
Rebeca Eun Young Hwang
Department of Civil and Environmental Engineering
February 28th, 2002

Certified by:____
Susan E. Murcott
Lecturer, Department of Civil and Environmental Engineering
Thesis Supervisor

Accepted by:____
Oral Buyukozturk
Chairman, Departmental Committee on Graduate Studies

Six-Month Field Monitoring of Point-of-Use Ceramic Water Filter Using H_2S Paper Strip Most Probable Number Method in San Francisco Libre, Nicaragua

by
Rebeca Eun Young Hwang

Submitted to the Department of Civil and Environmental Engineering
on February 28th, 2003 in partial fulfillment of the requirements for the degree of
Master of Engineering in Civil and Environmental Engineering

Abstract

Monitoring programs are an essential concomitant to household drinking water treatment. The author implemented a 6-month monitoring program to assess the performance of the Potters for Peace (PFP) water filter in San Francisco Libre, Nicaragua. Both analytical methods and surveys were used to study flow-rate, microbiological removal and user acceptance of 100 PFP filters.

Results for the 6-month monitoring by using hydrogen sulfide (H_2S) Paper Strip Most Probable Number (H_2S MPN) showed that an average of 80.4% of the sample population had less than 2.2 H_2S producing colonies per 100 mL after filtration through the PFP filter. Six percent of the visited households had more than 16 CFU/100 mL after filtration. Over the 6 months of the study, the level and pattern of contamination did not change significantly. Filtration rate measurements showed that the average PFP flow-rate was 1.7 L/hrs.

Membrane Filtration with mColiBlue24® tests were conducted for half of the sample population in the final month of the study. Total Coliform results showed that 30.6% of the studied families had less than 2.2 CFU/100 mL, and 27% had 0 CFU/100 mL for *E-coli* when initially present. Approximately 45% of the households had more than 16 CFU/100 mL after filtration for Total Coliform. Yet even so average removal rates for the PFP filter overall were 97.6% for *E-coli* and 89.3% for Total Coliforms.

Users mainly complained about the filter's small capacity (20L), and they requested a ceramic instead of a plastic recipient vessel. Filter breakage was appreciable, since 15% of the filters broke by the end of the study. Recontamination of filtered water due to contaminated receptacles was in 33% of cases. Multiple barrier solutions, such as chlorination after filtration, are recommended for PFP filter users.

The H_2S MPN method's relevance for long-term monitoring programs in developing countries is evaluated in this report. The use of H_2S MPN is recommended for rural areas where there are cost constraints in conjunction with a validation system. Validation of H_2S MPN may be given by performing parallel tests with other Standard Methods, such as Membrane Filtration (MF). The report also includes a discussion of lessons learned and recommendations for future monitoring programs of household drinking water systems.

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

Acknowledgements

I must thank Ms. Susan Murcott for her infallible motivation and encouragement. Her passionate example has been and will continue to be my role model. She inspired me to find my passion in life, and she supported me with her maternal guidance in good and bad times. I owe her this degree.

I would like to wholeheartedly thank Dr. Eric Adams and the Department of Civil and Environmental Engineering for their never-ending flexibility. Dr. Adams sincere interest in accommodating my concerns and needs has made the impossible true. I hope to be able to emulate his love for advising and guiding some day with my own students or children. Thanks to Cynthia Stewart for always answering my difficult questions promptly, and for supporting me.

Special thanks to Prof. Nicholas Ashford for his superb oratory and knowledge. He has revived in me my love for humanities and opened a new window with thrilling perspectives on the numerous possibilities we have to make a difference in life. His lectures were so inspiring that I was never able to fall asleep during his classes even if I tried!

So many students and professors contributed to this work. Prof. Martin Polz, Prof. Harry Hemond, Prof. Raul Lejano, Prof. Jennifer Davis, Prof. Charles Caldart, Daniele Lantagne, Jason Low and Luca Morganti have enlightened me with knowledge and supported me generously.

Ron Rivera and Ivania from Potters for Peace are living examples of dedication and fighting spirit. They taught me that the ability to dream and pursue our ideals is our most valuable treasure. Their hospitality has made this project possible.

Thanks to the IDEAS Competition Committee and the Lemelson Foundation. Special thanks to Sandi Lipnoski, who was always creative to find ways of solving my last minute problems. It was a pleasure to work with Teresa, Kate, Jon and Bruno.

Thanks to MIT and the Chemical Engineering Department for these 4 unforgettable years.

My humble thanks to my family. Jin Yi with her continuous cheering, Juan with his unusual wisdom and good sense of humor, Vicky with the biggest selfless heart in the world, Dad for always being there, and most importantly, my deepest thanks to my sweet Mom, whose unconditional love, motivation, and example has enabled me to feel the purest and eternal feelings of gratitude and love. Mom, you are truth and honesty personified. There is nobody like you in this world. Thank you forever.

Thanks to all my friends in Boston and Buenos Aires who never let me forget who I am.

Last but not least, Chunkito gracias por aguantarme todos estos años. Por hacerme sufrir y disfrutar como nunca. Por hacerme sentir viva. Sos el morenito que va a malcriar a mis hijos. Qué te puedo decir. Sos el único en la lista con el que no necesito este papel para comunicarte mi gratitud. Porque siempre estuviste y siempre vas a estar cerquita mío par que te lo susurre en la oreja. Te amo.

Table of Contents

List of Tables

List of Tables (cont.)

List of Figures

List of Figures (cont.)

PREFACE

Monitoring programs are an essential concomitant to household (point-of-use) drinking water treatment in developing countries. Although, at present, household drinking water treatment is not widely practiced in developing countries, yet it is one obvious solution to addressing the 2.4 million deaths each year from diarrhoeal diseases (WHO, 1999).

As one potential component of an overall water safety plan, household drinking water treatment requires not just a sound technology, but other key elements, including social acceptability, training and education, proper operation and maintenance plusa monitoring plan. While system assessments and surveillance plans by government agencies, community groups, aid organizations and NGOs are sometimes in place in developing countries, programs to regularly monitor household drinking water systems are almost non-existent.

This thesis presents the first effort on the part of the Massachusetts Institute of Technology water/sanitation group to conduct a medium-term (6 months) monitoring program as distinct from site or short-term system assessment water quality testing. Because it represents one of only few efforts of its sort, and because of the various constraints of this particular project, many mistakes were made, but at the same time, many lessons were learned.

This report documents the set-up, outcomes, lessons and mistakes that will hopefully enable improved monitoring programs in the future.

Chapter 1: INTRODUCTION

1.1 Nicaragua and Potters for Peace

During the World Summit on Sustainable Development in Johannesburg in September 2002, leaders from all nations committed themselves to halve the proportion of people without safe drinking water and without access to sanitation by 2015[1]. According to UNICEF (2000),[2] 1.1 billion people worldwide lack access to potable water and 2.2 children under 5 years old die of diarrhea every year. The lack of access to drinkable water is a serious problem that has recently gained wider public and political awareness. This thesis project was inspired by the obvious need for sustainable solutions to realize the human right of water for health (UN, 2002).

People in Nicaragua are especially suffering from the lack of safe water and sanitary conditions. Nicaragua is located in Central America with an area of 130,682 km^2 (PAHO, 1999). From the three topographical regions – the Pacific, Atlantic, and Central- the majority of the population lives in the Pacific coast. The total population is about 5 million. After Hurricane Mitch hit Central America in 1998, the water situation in Nicaragua was severely affected. The damage to water and wastewater systems was estimated to be over US$560 million, which had a negative impact on 800,000 people served (USAID, 2001). Most people in the urban areas have some degree of access to water and sanitation, but people in rural areas generally lack these resources. According to PAHO (1999), only 12% of the rural population has access to safe drinking water. Infant mortality under 5 years old, which is frequently linked to waterborne disease, is 66 per 1000 live births. Over 60% of the population lives in poverty (PAHO, 1999) and the illiteracy rate is 40% (PAHO, 2000). The twin disasters of Hurricane Mitch and the coffee industry crash have generated famine and misery for a large percentage of the population[3]. Unemployment, malnutrition and lack of access to basic health care have made the poorest even more prone to illnesses, such as water borne diseases. Therefore, affordability is a main constraint, which

---

[1] http://www.johannesburgsummit.org/ Accessed 02-2003

[2] http://www.childinfo.org/eddb/water/current.htm Accessed 02-2003

[3] http://www.nicanet.org/coffee.html, Accessed 02-2003

restricts the number of alternatives for water treatment.

A wide variety of technologies may be used to treat contaminated water. These may be applied on the household level, at a community level, or in a centralized drinking water treatment system. However, limited resources in developing countries constrain the number of options to those that are economical, sustainable and socially acceptable. In Nicaragua, especially after the devastation caused by Hurricane Mitch, the re-construction and establishment of a reliable centralized drinking water treatment system has not been feasible in the short-term. Therefore, household level filter treatment of water is potentially an efficient way of bringing a prompt solution to the immediate needs of the Nicaraguan population. The main benefits are the low cost, availability of raw materials, increased control of contamination by users and the ease-of-use. For these reasons, this thesis has focused on evaluating a "point-of-use" water treatment system promoted by an NGO named *Potters for Peace*.

1.2 Background on Potters for Peace Filter

Potters for Peace (PFP) is an independent, non-profit, international network of potters that manufacture water filters and other ceramic products. Their mission statement does justice to their name: "PFP seeks to build an independent, non-profit, international network of potters concerned with peace and justice issues. We will maintain this concern principally through interchanges involving potters of the North and South. PFP aims to provide socially responsible assistance to pottery groups and individuals in their search for stability and improvement of ceramic production, and in the preservation of their cultural inheritance."

Figure 1-1 PFP filter

PFP found a way of both fostering pottery activities and improving access to potable water for low-income families at the same time: a ceramic filter. The small pore size (0.6-3.0 μm) of the ceramic filter component removes the main contaminating particles. Besides this physical separation, a disinfectant element is thought to play some role in inactivating the microorganisms present in polluted water sources, such as *E-coli*. The filter designed by PFP is coated with colloidal silver, a compound known to be effective and safe in reducing the bacteria present in water. This filter consists of a plastic bucket and a ceramic cylinder open on the top. The ceramic part performs the filtration, and fits perfectly in the plastic component (Figure 1-1). The design is simple and inexpensive, but unfortunately, field tests of the PFP filters currently in use have shown poor performance (Section 1.3)

1.2.1 History of PFP Filters

PFP filters' roots are in Guatemala. The InterAmerican Bank (1981) sponsored a comparative study designed to evaluate 10 different technologies for domestic water treatment. This study was led by the Instituto Centroamericano de Investigación y Tecnología Industrial (Centroamerican Institute of Research and Technology, ICAITI), an industrial research institute in Guatemela. The ideal design would be a household unit made of locally available materials with sufficient flow capacity that in turn would foster artisan activity (ICAITI, 1994). The criteria for selection were based on filtration flow, bacteriological efficiency, ease of manufacture, availability of materials, final cost, contribution to artisan activity, and ease of distribution. Fernando Mazareigos, an ICAITI researcher in charge of conducting extensive studies, concluded that the PFP filter was the most appropriate of the evaluated technologies.

The field implementation of the ICAITI filter presented manufacturing and transporting difficulties, which remain unsolved today. The variability of the composition of clay in different geographical locations effects product standardization and quality control. Moreover, colloidal silver is not readily available in the required concentrations in the developing world. Another disadvantage is the filter's fragility –ceramics break easily with transport-, which inhibits efficient shipping and delivery to distant rural areas.

During the 1980s, Ron Rivera, a ceramics consultant, joined this project to lead further developments. Cooperative ceramic filter factories were organized in several countries, one of which is located in Managua, Nicaragua. Currently, the Managua factory produces thousands of filters annually. These are sold mainly to NGOs, who subsidize and distribute them to the end-user. For more details on the history of the PFP filter, see Lantagne (2001).

Currently, the main market for PFP filters in Nicaragua are non-profit and non-governmental organizations (NGO). With the economic downturn, and scarcity of funding, the PFP cooperative in Managua has experienced difficulties in maintaining its economic viability.

1.2.2 Filter Description

The PFP filter consists of two components, a ceramic and a receptacle. The filtration unit is made of locally available terracotta clay, is 24 cm high, 31 cm wide and has a conical shape. The receptacle that stores the filtered water is usually a 20 L plastic bucket or a ceramic container. On the filtration unit's upper section, it has a thin ceramic rim that serves as an anchor for the filter to stay suspended inside the plastic container (Figure 1-2).

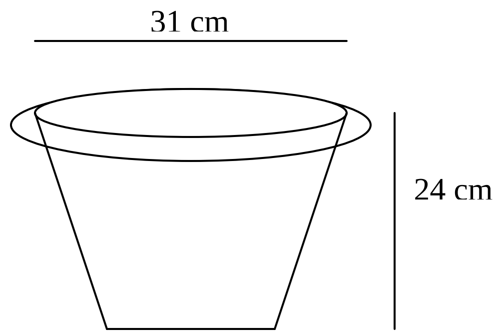


Figure 1-2 Filter Dimensions

The variables that define the technical and engineering aspects of the PFP filter are listed as follows:

1. Manufacturing conditions
2. Pore size
3. Flow rate
4. Maintenance requirements
5. Concentration of colloidal silver applied to filter

<u>*Manufacturing Process*</u>

In Nicaragua, a small cooperative manufactures the PFP filters by using a semi-automated process. Clay is ground and mixed with sifted sawdust, after which the whole mixture is kneaded and pressed into a mold. The filter is dried and fired at around 890°C. Finally, colloidal silver at 0.026% concentration is painted on both the interior and exterior surfaces of the filter.

The manufacturing process of the PFP filter have been extensively described in Appendix B of the Masters of Engineering Thesis of C.S. Low (2002), and in Chapter 2 of Lantagne (2001). This process can be summarized as follows:

1. 60 percent dry pulverized terracotta clay (including brick scraps that are not acceptable to bricklayers) and 40 percent screened sawdust (approx. 40 mesh) are mixed together in a mixer;
2. Water is added to the mix to obtain the correct consistency;
3. The filters are then formed by hand, turned on a potter's wheel, or press-molded. In the Managua factory, filters are press molded using a 10-ton hydraulic jack;
4. Filters are fired at about 890°C in a brick kiln using wood scraps from industry as the fuel source;
5. Filters are allowed to cool;
6. Filters are soaked for 24 hours to saturate the filter before flow testing;
7. The flow rate of each filter is tested to ensure a rate of between 1and 2 L/hr– filters outside this range are discarded;
8. Filters are allowed to dry again;
9. 2 mL of 3.2 percent colloidal silver in 250 mL of filtered water are applied with a brush to each filter (0.026% colloidal silver in solution);
10. Filters are dried and sold.

Pore Size

The pore size of the filter was measured by using s Scanning Electron Microscope (SEM) and reported by Lantagne (2001). The range of pore sizes was determined to be 0.6 microns to 3 microns (1.0 micron or less is necessary for efficient removal of *E-coli*). However, the presence of cracks up to 130 microns in length gives the filter a heterogeneous composition. The chemical components are mainly silicon, oxygen and aluminum. Iron, sodium, magnesium, sulfur and potassium were found in trace amounts.

Flow-rate

The flow rate is a function of the duration and temperature of firing, and the pore size. PFP units that filter slower than 1 L/hr or faster than 2 L/hr are discarded under the assumption that higher filtration rates will not enable enough contact time between colloidal silver and the microorganisms. Filtration rates lower than 1 L/hr are not distributed because filters that slow would not be able to supply enough drinking water for an average-size family. However, it has not been shown that 2 L/hr is the correct maximum allowable rate.
A mathematical model by Sten Eriksen (Red Cross International) includes variables that affect flow rate of the PFP filter . Using Darcy's Law, Eriksen found that:

$$Q_s = (k \Pi D) / 2a * x^2$$

where:

Q_s	the flow through the sides of the filter
k	the hydraulic conductivity of the filter wall
D	the diameter of the filter
a	the width of the ceramic on the sides of the filter
x	the height of the water within the filter

Maintenance Requirements

Maintenance of the filter is recommended to be performed once a month, by scrubbing the filter with a clean toothbrush. A recoating of colloidal silver is also suggested once a year. The filter has a sticker with instructions on these measures (Figure 2-1).

Concentration of Colloidal Silver

a) Chemistry of colloidal silver

Silver is naturally present in the environment in small concentrations up to the milligram level, however, it has not been proven to be essential to animal or plant life (Lantagne, 2001). This soft and malleable metal is stable in water and oxygen, but in water it forms a colloid, instead of a solution.

Colloids are defined as any particle that has some linear dimension between 10^{-9} and 10^{-6} meters. Colloids may assist in the transport of pollutants from bed sediments, due to colloids' large affinity to hydrophobic substances (Hiemenz, 1997). The hydrophobic nature of cell membranes may assist bacterial attachment to colloidal silver, which facilitates its removal from water.

Three mechanisms were proposed to explain the disinfectant action of silver (Russell, 1994):

- by reacting with thiol (sulphydryl, SH) groups in the bacterial cell
    - in structural groups
    - in functional proteins
- by producing structural changes in bacterial cell membranes
- by interacting with nucleic acids

Oxygen has been identified as an important co-factor for the bactericidal activity of silver (Heinig, 1993). Silver is not the only metal known to inactivate SH groups, since other metals such as mercury, arsenite, cadmium, iodine, fericyanide, and permanganate have been known to possess similar inactivating properties. For more detailed information, refer to Chapter 4 of *Investigation of the Potters for Peace Colloidal Silver Impregnated Ceramic Filter* by Lantagne (2001).

b) <u>Benefits vs. Risks</u>

Silver's allegedly healing properties have been acknowledged since the antiquity. According to Russell, Aristotle advised Alexander the Great to boil water and store it in silver vessels to prevent waterborne diseases (Russell, 1994). Later in history, Crede used silver nitrate to prevent gonorrhea opthalmicum since 1881. Other benefits were proposed by Becker (2000) who hypothesized that silver ions had an active role in regenerating bone after trauma. Similarly, Tsipouras (1997) used silver sulfadiazine in acute burn wounds on the skin, for its antibacterial power. Another example of silver's use as disinfectant was reported by Lin (1997), who claimed that more than 30 hospitals in the United States use silver ionization to control *Legionella*, a disease that affects immuno-comprised patients.

Exposure to high concentrations of silver may lead to illnesses such as *Argyria* and even to death. *Argyria* is a "medically benign but permanent bluish-gray discoloration of the skin. *Argyria* results from the deposition of silver in the dermis and also from silver-induced production of melanin. [It is] more pronounced in areas exposed to sunlight due to photo-activated reduction of the metal," and "although the deposition of silver is permanent, it is not associated with any adverse health effects." (Lantagne, 2001). The lethal intake of silver is a minimum of 10 g, or 0.08 mg/day over a 70-year lifetime (WHO, 1993).

c) Applications in Industry

Besides its several applications in medicine, colloidal silver is currently used by filter manufacturers, such as Katadyn. Katadyn manufactures high quality water filters for military or specialized camping applications. Their filter has the shape of a candle, which is coated with colloidal silver. Its high performance is reflected in its price, which is in the range of US$159 to US$189. MIT Master of Engineering student Rob Dies (2003) has compared the Katadyn filter with other filters made of Kaolin or Terracotta clay in Nepal and Vietnam.

d) Application in the PFP Filter

A solution of 3.2 percent colloidal silver is diluted and applied to the filter (2 mL in 300 mL of purified water). Half of the solution is coated in the inner part and the rest is applied in the external area. This concentration of colloidal silver has been determined empirically, and there is no evidence showing that it is the optimal amount.
The concentration of silver in water samples after filtration through the PFP filter has reported to be well below both USEPA and WHO standards (Lantagne, 2001).

1.3 Previous Work

Three categories of previous work influenced this thesis:

1) Studies of ceramic water filters by Master of Engineering students and graduates;
2) Laboratory methodology studies of H_2S by itself and/or compared to MF;
3) Previous efforts to monitor household drinking water treatment systems in real world developing country contexts.

In terms of previous studies of ceramic water filters by Master of Engineering students, this project follows up on MIT Master of Engineering thesis work by Junko Sagara (MIT, 2000) on the efficacy of colloidal silver on ceramic candle filters, on the consulting work in Nicaragua by Daniele Lantagne (2001) on the field performance of Potters for Peace filters, on the ceramic clay studies of MIT Master of Engineering thesis work of Jason Low (2002) at Madyapur Clay Crafts in Thimi, Nepal.

In Sagara's work, 3 filter/purifier systems were tested: a Nepalese ceramic candle filter (with and without colloidal silver coating), an Indian ceramic candle filter, and the *Gift of W*ater purifier used in Haiti. The Nepalese filter coated with colloidal silver successfully removed all hydrogen sulfide producing bacteria. Comparing the Nepalese candle filter without colloidal silver, the Indian candle filter without colloidal silver and the Gift of Water purifier, no filters removed microbial contamination without the addition of chlorine. Colloidal silver was tested because of its known germicidal properties (Sagara, 2000) and because of the easy-to-use features. Chlorine must be measured and added properly to the water in order to avoid intoxication or incomplete treatment. On the other hand, colloidal silver is painted only to the filter during its manufacture, and thus the user does not need to be trained in a disinfection step. Ms. Sagara's results showed promising preliminary data on the effectiveness of colloidal silver as a disinfectant.

It was found that filter candles with silver loading of more than 10.2 mg produced filtered water with hydrogen sulfide producing bacteriological contamination below the detection limit of 1.1 bacteria per 100 mL. Two filters with 13.6 mg and 15.3 mg of silver coating were also tested for total coliform and E.coli by P/A test. The test results showed that both filters removed E.coli, however, neither removed total coliform. Despite the promising results, Ms. Sagara recommended further studies on higher concentrations of colloidal silver application. Moreover, she pointed out that no studies have been performed on the efficacy of filters with colloidal silver over long-time periods. Further research on the efficient life span of filters with colloidal silver was suggested.

In Lantagne's studies, it was determined that despite satisfactory laboratory tests (98-100% removal of organisms), field tests rendered inconclusive results. Out of a total of 33 homes visited, 24 were using the filter. The summary of the results is:

1. 4% removed total coliform (by using the Presence/Absence method)
2. 25% removed H_2O-producing bacteria (by using the Presence/Absence method)
3. 53% removed E.coli when initially present (by using the Presence/Absence method)
4. Flow rate in 14 out of the 24 homes did not meet 2L/person/day.

Laboratory results conducted by CIRA-UNAN (Managua, Nicaragua) for Lantagne on 5 PFP filters, 1 without colloidal silver and 4 with different concentrations of colloidal silver (3 of the 4 of which were coated with Microdyn colloidal silver) showed that without colloidal silver the PFP filter removed 98% total coliform, 97% fecal coliform and 82 % fecal streptococcus. E.Coli was not detected in the raw sample so no removal results were obtained for E.Coli. The 3 filters coated with different concentrations of Microdyn colloidal silver showed 100% removal of total coliform, fecal coliform and fecal streptococcus. In other words, colloidal silver was necessary for complete removal of bacteria.

These apparently contradictory results between the field and laboratory tests may indicate the incorrect usage of filters by users or the degradation of the efficacy of colloidal silver over long periods of use. On the other hand, the unsatisfactory field results may have be caused by contaminated storage recipients. In any case, the number of samples tested was not sufficient to infer conclusively the cause of the disparity of results. Therefore, further investigation was recommended.

Lantagne's results showed that households that use the PFP filter are still exposed to water born diseases. Currently, flow rate averages about 1.7 L/hr. The World's Water 2000-2001 report (Gleick, 2001) recommends a daily consumption of 4 L per person. Howard (2002) indicates that daily requirements are higher, a minimum of 7.5 L/person, if food preparation and lactating needs are taken into account. For a household of 5, the PFP filter capacity would be barely enough for the drinking needs of the family, assuming that filter is refilled constantly 12 hours a day. In other words, the current flow rate of the filter would not be sufficient for cooking or hygienic purposes. Some of Lantagne's key conclusions and recommendations include:

- NGO's follow-up of filter-owning families increased sustained usage rates;
- Breakage of filter was recognized as one of the most common problems;
- A general lack of education on safe water practices was identified in the families that possessed the filter;
- Families indicated good taste and ease-of-use as important factors for liking the PFP filter
- Scrubbing of the filter proved to rejuvenate the filtration rate
- Plastic receptacles should be encouraged over ceramic containers, because plastic is easier to clean
- NGOs should be informed about the factors that affect the success and failure of the filter

The terracotta ceramic filters without colloidal silver studied by Low (2002) showed high percent of microbial removal (Table 1-1). However, he concluded that in some cases additional disinfection (pre or post chlorination) may be necessary. Low' results on the relationship between flow rate and performance of the filter were interesting. Curiously, his two TERAFIL filters had flow rates of 1-2 L/hr and 5-7 L/hr respectively. Nevertheless, despite the large difference on filtration rate, their turbidity and total coliform removal rates were comparable. These results contradicted the expected outcome of a slower rate being related to a smaller pore size of the filter and therefore to better removal. Table 1-1 shows a summary of Low's results. Figure 1-3 shows pictures of the different ceramic filters.

Table 1-1 Low's results on TERAFIL filters

	TERAFIL MIT	TERAFIL ENPHO	2 THIMI filters
Flow rate	1-2 L.hr	5-7 L/hr	0.2-0.3 L/hr
Turbidity Removal	83-93 %	97-99%	56-84%
Total Coliform Removal	96-99.9%	94-99.5%	96-99.6%
Fecal coliform/E.coli Removal	NA	96-100%	96-100%

In one preliminary experiment, Low also observed a slight drop in removal efficiency after the addition of colloidal silver. He suggested that the initial water samples contained higher levels of microbial contamination, and that may have caused the decreased performance. Low's results suggest that some of the most accepted assumptions, such as lower flow rate related to higher performance and colloidal silver application to higher removal rate must be tested more thoroughly in order to determine the real mechanism of action of the ceramic filters studied.

Figure 1-3 MIT TERAFIL, ENPHO TERAFIL and THIMI filters (Low's pictures).

Low also compared Presence/Absence (P/A) with Membrane Filtration (M/F) methods. Low concluded that P/A Total Coliform testing was appropriate for monitoring microbial quality of drinking water in rural areas, due to its low cost and simplicity. On the other hand, MF were much more efficient for quantitative analysis of water samples, such as to assess removal efficiencies of point-of-use water filters, however, significantly more expensive.

In terms of pervious work regarding laboratory methodology studies of H_2S, we know of Ivan Lira's (undated) comparison of H_2S P/A with MF in Nicaragua and we know of Scott Stoller's work in Nepal comparing H_2S MPN with MF.

Ivan Lira (undated) is a researcher at the national water utility in Nicaragua, Empresa Nicaragüense de Acueductos y Alcantarillados Sanitarios (ENACAL) performed parallel Membrane Filtration (MF) tests by using Millipore mFC broth and H_2S Presence/Absence (P/A) tests using HACH's Pathoscreen medium in Nicaragua. From a total of 215 samples, 53% had 0 fecal coliforms by the MF method and 47% were Absences. The correlation level was calculated to be 86%. His results suggested the appropriateness of using H_2S P/A as a more affordable water quality analysis method in the rural areas of Nicaragua.

University of California in Berkley Master of Engineering student Stroller compared H_2S P/A with H_2S MPN, H_2S P/A with MF and H_2S MPN with MF. His results were:

- H_2S P/A matched H_2S MPN results in 73% of the samples (out of 15);
- H_2S P/A was in agreement with MF in 58% of the samples (out of 24);
- H_2S MPN had a correlation of 90% with E-coli and 93% with total coliform (by using MF with Chromocult media in a total of 48 samples).

In terms of previous efforts to monitoring household drinking water treatment systems in developing country contexts, one of the best examples we know of is the Gift of Water Program in Haiti. This program has been well documented in the MIT Master of Engineering theses of Lantagne (2001), Vanzyl (2001) and Varghese (2002). The reader is referred to these documents for the details on the Gift of Water monitoring programs.

1.4 Objectives of Study

Based on previous work, the objectives of this thesis were to:

1) Implement and evaluate success and failures of a 6-month long monitoring program of 100 households using the PFP filter;
2) Assess performance of the PFP filter in those 100 households by measuring flow rate and microbiological contamination before and after filtration through the PFP device;
3) Identify variables that affect performance of the filter in those 100 households, such as common sources of contamination and cultural practices;
4) Survey user’s impressions on filter’s benefits and drawbacks;
5) Investigate the relevance of the H_2S-Paper Strip Most Probable Number method (H_2S MPN) as a useful approach in monitoring PFP filter performance in the challenging context (from the point of view of laboratory conditions) of Nicaragua;
6) Qualitatively compare H_2S – Paper Strip Most Probable Number (H_2S MPN) method with Membrane Filtration method;
7) Transfer knowledge on filter manufacturing to local potters.

1.5 Project History

The project came about because of a research interest in the PFP filter's problems and the need of more in-depth studies. A team led by the author submitted a proposal to the IDEAS competition outlining this 6-month monitoring project:

IDEAS is a competition started last year [2002] at MIT to promote student innovation and inventiveness for community needs. The IDEAS Competition provides an opportunity for members of the MIT community to develop their creative ideas for projects that make a positive impact in the world. Participants work in teams to develop designs, plans, strategies, materials and mechanisms that benefit communities, locally, nationally or internationally. Using $20,000 in cash prizes, as well as additional materials grants, the teams can take an effective step toward resolving pressing individual and community challenges.

The author's IDEAS proposal included a thorough evaluation of the PFP filter through a 6-month monitoring program to allow specific design modifications over time. One of the most creative innovations of the proposal was the use of an iterative feedback loop that would enable prompt field tests of new prototypes by incorporating the experience and the resources of local partners into the study. Based on real-time implementation and feedback on the innovations, the problem statement could be re-defined along with the progress of the project.

The proposal won the competition, which granted US$ 5,000 to the project. A matching fund from the Lemelson Foundation and additional financial support from the Civil and Environmental Engineering Department at MIT covered the rest of the financial needs.

1.6 Monitoring Program

A 6-month monitoring program was thus established in June 2002 to assess the performance of the PFP filter in San Francisco Libre, Nicaragua. Hygienic habits and cultural factors were surveyed in order to identify the variables that had an immediate effect on the appropriate functioning of the filter. Five students from MIT, Bruno Miller (PhD candidate for Aeroastro and Aeronautics Engineering), Teresa Yamana (candidate for S.B. in Civil and Environmental Engineering), Jonathan Werberg (candidate for S.B. in Urban Studies and Planning), Katharine Ricke (candidate for S.B. in Earth, Atmosphere and Planetary Sciences), and the author participated in this field study during the Summer of 2002. The author also traveled to Nicaragua to work on this project on two other occasions in April 2002 and January 2003.

There were multiple aspects to the monitoring program. Monitoring was considered to be a necessary component to deliver information and training to PFP filter users who were just starting to use this new technology. Moreover, this monitoring could provide information to filter manufacturers and researchers on the empirical performance of the filter in the households and offered hints on the main characteristics of the filter that needed modification. The 6-month length of the study was intended to show the evolution of the filter conditions and efficiency over time. In fact, continuous and iterative feedback on the filter and users' satisfaction level changed the initial problem statement accordingly.

The monitoring program covered approximately 100 families who had received the filter within 2 months before the June 2002 starting date of these studies. The semi-random selection of the 100 families out of a set of 2,000 families who had recently received the PFP filter from an Italian NGO, Movimondo, was biased by the ease of access to their homes. Therefore, the communities of Pacora, San Roque, Madroñito and Laurel Galán were chosen because of their convenient location close to the town center of San Francisco Libre. The selected families were surveyed on different aspects of filter usage and hygiene. Samples from these households were analyzed for microbiological contamination. This report presents the results collected over the 6-month period.

Also in June 2002, a training program was set-up to transfer knowledge on filter manufacturing techniques to local potters. This workshop was organized so that replacement devices could be found in the local sites, and so that participating potters could eventually become sources of information on general water filtering methods.

Chapter 2: METHODOLOGY

This chapter on methodology covers the specific survey questions asked during each month, the two analytical methods used to assess the microbiological contamination of the source water and the filtered water, the method of flow-rate measurement, the materials required, and the training of local potters.

2.1 Survey

Starting from July 2002, all 100 families of the sample population in San Francisco Libre, Nicaragua, were surveyed about their hygienic practices, their opinion on the filter and about general demographic information. In July 2002, families were asked 7 questions, but in subsequent months, 3 or 4 questions were asked each month and every month the questions differed. Juan Carlos Zambrana, a field worker hired for this project, asked and recorded the answers to all the questions. Zambrana was assigned to perform the survey and water quality tests from July to December 2002. The questionnaires for each month are reproduced in this section.

2.1.1 Questionnaire for July – Sample Demographics

1. Name of person in charge of the PFP filter;
2. Age of person in charge of the PFP filter;
3. Size of household;
4. Number of children;
5. Age of each child;
6. Number of children under 5 years old;
7. Age of PFP filter;

The purpose of July's survey was to assign a member of the house as the contact person for the overall survey. During each subsequent visit, the same person would be called to ensure continuity and efficiency in the monitoring process. Size of the household, and number and age of children, were important parameters that could define the capacity demands of the filter. The number of children under 5 years old was tabulated since infants this young were presumed to be more susceptible to water-borne diseases. Finally, the age of the filter was asked in order to ensure that all filters had been distributed within the last two months.

Details of all the survey questions and responses are given in Appendices A-C. If the reader looks at, for example, Appendix A, Table A-1, she will see that there is certain level of relation between the sample code number of the household and the geographical location. In order to perform the surveys and sampling efficiently the household sites near to each other in number tended to represent houses in the same general neighborhood.

2.1.2 Questionnaire for August

The questions asked during August were as follows:

1. How many members of the family drink from the PFP filter?
2. How long does it take to fetch water?
3. In what type of container do you fetch water?
4. In what type of container do you store water?

The first question was included in the survey because casual conversations during the set-up of the monitoring program in June 2002 had revealed that some families only use the filter to treat water that will be consumed by the children in the house. The amount of time spent to fetch water by each household was asked in order to assess the relative importance of the time spent on waiting for the water to be filtered by the PFP device. Finally, the type of containers used to fetch and store water could provide hints on potential sources of contamination and re-contamination.

2.1.3 Questionnaire for September

In September, four different questions were asked to the participating households. They were:

1. How frequently do you clean the PFP filter?
2. Do you know how to read?
3. Are the instructions on the back of the PFP filter clear?
4. When you clean the filter, which water do you use?

The September survey questions assessed the level of maintenance of the filter. All PFP filters carry a colorful label on the plastic bucket, on the side opposite the faucet (Figure 2-1). This label provides instructions on how to clean the filter every month. By assessing the literacy rate of the sample population, the relevance of the label and the frequency of the cleaning were investigated. The first question was validated in November's questionnaire, by asking the surveyed households when the last cleaning had been performed. Finally, using contaminated water to wash the filter could potentially be a source of contamination for the filter, therefore Question 4 was added to the survey.

Figure 2-1 Label on the back of the PFP filter

2.1.4 Questionnaire for October

The survey for October investigated the market demands of the sample population for bottled water, as an alternative solution to increase access to safe water. Questions on basic sanitation were included in this set. The specific questions were:

1. Do you ever buy bottled water?
2. Does anybody in your home take PFP filtered water to work?
3. Where is your latrine? Is it near your house? Near your well?

The location of the latrine relative to the house or the well was meaningful to estimate the degree human-originated fecal contamination present in the communities studied.

2.1.5 Questionnaire for November

Three new questions were asked in the November survey.

1. When did you last clean the filter?
2. Did you notice any difference in the water taste or in the filtration rate over time?
3. Do you wash your hands before handling the filter?

The first question was included as a means of validation of the answers reported in the September survey. The second question investigated the perception of the user regarding any changes in filtration rate and/or water taste (related to water quality) over time. Finally, the last question assessed the hygienic habits that could potentially create contamination of the filter and its water.

2.1.6 Questionnaire for December

The December survey sought more detailed perceptions on the benefits, drawbacks, and desired modifications on the PFP filter:

1. What do you like the best about the PFP filter?
2. What would you like to see changed about the PFP filter?
3. If a neighbor offered you money to buy your PFP filter, how much would you charge?
4. Is the amount of filtered water enough for the whole family?

2.2 Flow-rate measurements

A protocol was designed by our team to measure flow-rate of PFP filters in their field site locations, as follows:

1. Empty recipient vessel (plastic bucket);
2. Fill completely the ceramic component of the filter to the very top;
3. Record time;
4. Return after exactly 1 hour and empty water collected in the plastic component into a graduated beaker;
5. Record filtered volume.

2.3 Hydrogen Sulfide Bacteria (H_2S) Testing

The H_2S Paper Strip Most Probable Number (H_2S-MPN, Standard Methods #9221A.) tests followed guidelines from *Module 7: Water Quality Control Techniques* published by Andrés Sánchez-Bain and Bernard Dutka at the Fundación Tecnológica de Costa Rica (Technological Foundation of Costa Rica) with funds from the International Development Research Center of Canada (Sanchez-Bain, 1998).

H_2S-Paper Strip tests are based on the principle that a wide number of bacterial species produce hydrogen sulfide (H_2S), which can be used as an indicator of the presence or absence of these microorganisms. Water quality is evaluated on the basis of this parameter - the growth of these indicator bacteria during a given incubation time when exposed to a culture medium. H_2S-Paper Strip tests were developed as Presence/Absence tests, which means that they do not offer quantitative measurements on the degree of contamination of the water samples. The presence of Iron (Fe) in the culture medium causes the precipitation of ferric sulfide (FeS) in presence of H_2S, which is noticeable because of its black color. Therefore, when H_2S producing bacteria are present in the water sample, after 2 days of incubation at room temperature (25 - 35°C), the sample turns black. When the H_2S-Paper Strip tests are combined with the Most Probable Number method (MPN), this technique becomes semi-quantitative. The H_2S MPN is a statistical estimate the number of colonies of H_2S producing bacteria present in the sample. By using different volumes of sample in repeated tests and/or in serial dilutions, it is possible to statistically determine the degree of contamination based on the number of presences and absences that are obtained. The main advantages of this method are its low-cost and its simplicity, since H_2S does not require incubation at high temperatures (higher than 35°C) if tropical climates in which one performs these tests have temperatures consistently in the proper 25-35°C range. For more details on this method, refer to Chapter 6 of this report and to Chapter 5, MIT Masters of Engineering thesis by Low (2002).

2.3.1 Materials

The list of materials we used for H_2S MPN tests in Nicaragua were as follows:

1. Hot-air oven (for sterilization)
2. 10 mL auto-clavable vials with caps (288)
3. Racks for vials
4. Scale
5. Pipette and dischargeable pipette tips
6. Chemicals for culture medium (potassium phosphate dibasic powder, sodium dodecylSulfate, sodium thiosulfate anhydrous).
7. Distilled water
8. Ethanol
9. Latex gloves
10. Tissue-paper, kimwipes
11. Thermometers

12. Tape
13. Markers

In this study, strips of Kimwipes were impregnated with 0.5 mL of culture medium in five 10mL autoclavable vials for each sample. The culture medium was prepared by using the following chemicals:

1. 40.0 g of bacteriologiacal peptone
2. 3.0 g of dipotassium hydrogen phosphate
3. 1.5 g of ferric ammonium citrate
4. 2.0 g of sodium thiosulphate
5. 0.29 g of sodium dodecyl sulfate (sodium lauryl sulfate)
6. 100.0 mL of distilled water

All ingredients were dissolved together by stirring into distilled water.

The vials were then loosely capped and autoclaved for 60 minutes at 160 ºC in a hot-air oven. The caps were then tightened and the vials stored in a clean place up to 1 week. A line indicating 10 mL was marked on each vial so that the technician collecting the sample could quickly fill the vials with the correct volume

Four days a week, Zambrana collected from participating families 100 mL of water sample before and 100 mL after filtration through the PFP filter. Whirlpack plastic sampling bags were used to transport the samples to the laboratory in San Francisco Libre. Samples were stored in a cooler bag with ice, transported back to the lab and analyzed within six hours of the time of recipient. A total of 50 mL of each sample was placed in five 10 mL vials, which were incubated at ambient temperature (25 – 33°C) and recorded at 24, 48 and 72 hours after the initiation of the incubation.

The contents of the vials were disposed by immersing them in a high concentration of chlorine for at least 30 minutes. Vials were then rinsed with tap-water. The chlorinated solution was discarded in a latrine.

To cover 100 families each month, an average of 5 families were visited per day, working 5 days a week. Each family's PFP filter was tested for water samples before and after filtration, and often samples from the well sources were also collected and analyzed. This was equivalent to at least 10 vials for each family monitored. The culture medium was prepared once a week. Therefore, at least 250 vials had to be available on any given week. Taking off Sundays and the 1 day for cleaning, there were only 4 days when experiments could be started, since no tests could begin on Thursday. Otherwise recording of results would be necessary on Sundays. The final schedule after all these considerations is shown in Table 2-1:

Table 2-1 Zambrana's weekly schedule.

<table>
<tr><th></th><th>Monday</th><th>Tuesday</th><th>Wednesday</th><th>Thursday</th><th>Friday</th><th>Saturday</th><th>Sunday</th></tr>
<tr><td>9AM-
1 PM</td><td colspan="2">Visit 8-10 families
Ask survey questions</td><td>Visit 6-8 families</td><td rowspan="3">CLEAN UP
Surface
Place paper into vials
Weigh out chemicals
Make Broth
Record Monday's results (DAY 3)
Record Tuesday's (DAY 2)
Record Wednesday's (DAY 1)</td><td>Visit 8-10 families</td><td rowspan="3">Sterilize Monday's, Tuesday's vials.
Record Friday's results (DAY 1).
Record Wednesday's results (DAY 3)
Clean Wednesday's vials</td><td rowspan="3">REST</td></tr>
<tr><td>1-2
PM</td><td colspan="3">Return to Lab
Place samples in fridge
LUNCH</td><td>Return to Lab
Place samples in fridge
LUNCH</td></tr>
<tr><td>2-4
PM</td><td>Pipette samples into vials and label
Record Friday's results and clean up the vials</td><td>Pipette samples into vials and label
Record Monday's results (DAY 1) and clean up vials</td><td>Pipette samples into vials and label
Record Monday's results (DAY 2)
Tuesday's results (DAY 1)
Sterilize tools and vials</td><td>Pipette samples into vials and label
Record Tuesday's results (DAY 3)
Record Wednesday's results (DAY 2)
Clean up Tuesday's and Monday's vials</td></tr>
</table>

2.4 Membrane Filtration Testing

Membrane Filtration (MF, Standard Methods #9222) tests enable quantitative analysis of water samples. The MF method is based on the detection and enumeration of acid-producing coliforms during lactose fermentation (APHA-AWWA-WEF, 1998).

2.4.1 Materials

The list of materials used for MF tests in Nicaragua were as follows:

1. Millipore portable MF setup
2. mColi Blue24® culture medium
3. 0.45 µm-filters
4. Disposable petri-dishes
5. Oxford pipette
6. Bunsen burner
7. lighter
8. tweezers
9. 35 ºC Millipore portable incubator

A summary of the main steps is listed as follows:

1. Sterilize portable Millipore MF filter holder for 15 minutes by combusting methanol
2. Label petri-dish, pour mColiblue24® culture medium into petri-dish and discard excess
3. Flush approximately 30 mL of distilled water through filter
4. Place 0.45µm filter paper on the filter support base using sterile tweezers
5. Pipette 100 mL of sample into funnel and swirl to stir thoroughly

6. Run filtration
7. Remove filter carefully by using sterile tweezers and place into petri-dish in a rolling motion
8. Invert petri-dish and place into incubator at 35ºC for 24hs
9. Count the number of coliform forming units (CFU)
10. Pour chlorine into petri-dish and discard appropriately

Different dilutions were made based on observations of the previous day concerning the level of contamination of the samples.

2.5 Training for manufacturing PFP filters by traditional methods

2.5.1 Materials

Materials used for PFP filter manufacturing training were as follows:

1. 12 13½ in. by 10½ in. Plastic Flowerpots (filter molds)
2. 10 wide plastic buckets (mixing)
3. 12 1-L measuring cups
4. Plastic bags
5. 12 sieves (for sawdust sifting)
6. Varnish (to prevent termites)

During this training, 12 ceramists from San Francisco Libre, La Paz Centro and San Juan Oriente were taught how to make PFP filters by using traditional methods, i.e., without the use of a filter press or a pottery wheel. The training was held on June 16th 2003 in La Paz Centro by Ron Rivera of PFP and facilitated by the MIT team. The outcome of this training was monitored, and further guidance to the trainees was offered by Ron Rivera. Participants Juana Reyes, Ignacia Petrón, Fátima del Rosario Valle, Benita Romero Cajina, Mercedes Vega, Reina Margarita Potosme, Juana Cano, María Benigna Herrero Rayo, Francisco Mesa, Juan Manuel Gutiérrez, Sergio Alfredo Cano,and José Simón Rivera Espinoza gathered in Mercedes Vega's house, where a workshop on water borne diseases preceded the PFP filter workshop. The interactive discussion is transcribed as follows (Figure 2-2):

Figure 2-2 Ron Rivera gives training to potters

<u>Ron Rivera</u>: *What kind of illnesses do your children suffer from?*

<u>Audience</u>: *From diarrhea, colds, viruses, respiratory problems, high temperature, "bad water", malaria, mosquitoes, allergies, dengue, asthma.*

<u>Ron Rivera</u>: *What causes diarrhea?*

<u>Audience</u>: *Water, unwashed fruit, lack of hygiene, flies, trash, dirty hands, parent's negligence, E-coli, latrines, contaminated meat.*

Figure 2-3 Step 1. Juana Reyes sifts sawdust

<u>Ron Rivera</u>: *The number-one killer of children is diarrhea. Most of the diseases that you mentioned originate from water. Now, how do you clean contaminated water? Mercedes, where do you get your water?*

<u>Mercedes</u>: *From the well, after I chlorinate.*

<u>Ron Rivera:</u> *There are good and bad things about chlorine. What are they?*

<u>Audience</u>: *It disinfects water, it harms our kidneys though. It is expensive, 3 córdobas (US$0.2) per week.*

<u>Ron Rivera</u>: *Can you buy it?*

<u>Audience</u>: *It's easy to use, but sometimes I don't have money to buy it.*

<u>Ron Rivera</u>: *Is it available everywhere?*

Figure 2-4 Step 1 . Participant sifts clay

Audience: Yes, besides, you can use it for the clothes. It damages your teeth.

Ron Rivera: Who likes chlorine's taste?

Audience: No – 9 responded

Yes- 3 responded

Ron Rivera: Do you like chlorine's odor?

Audience: Yes

Ron Rivera: What is another way of cleaning water?

Audience: Boiling the water. It kills the bacteria but I don't like the taste of the water afterwards

Ron Rivera: What about filters?

Audience: It has been proven that water is pure after filtration

Ron Rivera: Do you have to buy the filter? Does it break? Is it heavy? Can children use it?

Audience: Poor people do not have access to filters. When I was little, my grandparents used to make filters. Ceramic recipients are good because water is fresher.

This introduction to water and filters was followed by the training. Participants were asked to bring their own dry clay, so that potters could adjust the method to the characteristics of local materials. Sawdust, sieves and molds were provided, as well as refreshments and lunch. The program for the training was developed by Ron Rivera. The main steps of this training are listed as follows:

Step 1. Sift clay and sawdust (Figures 2-3 and 2-4)

Step 2. Mix 1:1 measures of clay and sawdust (Figure 2-5).

Step 3. Sprinkle water slowly while continuously kneading until dough becomes malleable (Figure 2-6)

Figure 2-5 Step 3. Ron sprinkles clay and mixes with sawdust

Figure 2-6 Step 3. Simón Rivera kneads dough

Step 4. Cut dough into strips approximately 1-inch thick and long enough to encircle once the inside of the mold

Step 5. Wrap inside of the mold with a plastic bag. Cover whole mold with the clay strips (Figure 2-7)

Step 6. Apply pressure to connect edges of the strips, so that a continuous mass covers the inside surface of the mold

Step 7. Carefully detach the clay filter from the mold

Step 8. Dry for 2 weeks (duration of drying phase depends on weather conditions)

Step 9. Fire at 890 ºC

Step 10. Test for flow rate, discard filters that flow outside of the 1-2 L/hr range.

Figure 2-7 Step 6. Participants cover inside surface of mold with strips of clay

Chapter 3: FIELD MONITORING SET-UP

3.1 Objectives

The specific goals of the 6-month field monitoring program were to:

1) Implement and evaluate successes and failures of a 6-month monitoring program in 100 households using PFP the filter;
2) Assess performance of the PFP filter in those 100 households by measuring flow rate and microbiological contamination before and after filtration through the PFP device;
3) Identify variables that affect performance of the filter in those 100 households, such as common sources of contamination and cultural practices.

3.2 Team members, Collaborators and Responsibilities

In April 2002, the author traveled to Nicaragua to set up the initial agreements with local partners. Ron Rivera from Potters for Peace hosted the arrangements. The goals of this visit were to identify problems to be solved; to find a collaborating organization that could share resources with the team; to select an appropriate partner community to collaborate with, to determine budgetary, laboratory supplies, and equipment needs; and to find potential students and faculty from local universities willing to participate in this study. Different rural villages were visited to choose target partner community. San Francisco Libre was chosen over Calle Real de Tolapa, San Juan de Oriente, and La Paz Centro because it presented the most pressing situation concerning access to water. The lack of a piped water system and the availability of hundreds of families who had recently received the PFP filter from Movimondo made San Francisco Libre's town center and surrounding communities ideal for this study.

Movimondo, an international non-profit with programs in Nicaragua and elsewhere, purchased over 2,000 PFP filters and distributed them for free to households in San Francisco Libre and surrounding areas in April 2002. During this April 2002 field visit, agreements were reached between the author and Movimondo to collaborate on the follow-up study of the delivered filters. Movimondo verbally agreed to provide office space and to rent to the team one of their motorbikes for sample recipient. One of their former field workers, Juan Carlos Zambrana, was hired by our team to perform the water quality tests from July to December 2002. Discussions were pursued with the local universities Universidad Nacional de Ingeniería (National University of Engineering, "UNI"), and Universidad Centroamericana (Centroamerican University, UCA), on potential venues for collaboration. Interaction between local engineering students and students from MIT was proposed as a way of ensuring the sustainability of the project. Unfortunately, agreements with the two universities were not reached due to the short length of the visit and because of lack of funding resources.

Finally, arrangements were made for a training program to transfer filter production technology to local rural potters.

The second visit was during June 2002, when MIT graduate and undergraduate students Bruno Miller, Jon Werberg, Teresa Yamana and Katharine Ricke joined the author in a second field visit to Nicaragua. Werberg was assumed the accounting role in the team. Miller explored alternative water treatment systems in Nicaragua, particularly the system known as Biosand Filter. Miller also retrieved Spanish translations of important manuals later used to train Zambrana. The author led the team by planning and designing the study. She supervised and assigned the all tasks, which results she collected in January 2003. The author's advisor, Ms. Susan Murcott visited the site in July 2003 to overview the project and to suggest adjustments. All team members participated in making key decisions for the project.

During this month, agreements were consolidated with Movimondo, and the 100 families participating in the study were identified and recorded. All subjects were personally consulted for permission to be included in the study, after a brief explanation of the study goals. One-hundred percent of the visited families agreed to participate in the study.

During the month of July, Yamana and Ricke undertook the task of training Zambrana for the field analysis. These two MIT students taught him general laboratory principles and designed a schedule for the tests. For the rest of the monitoring program, a German student with some scientific background, named Christian Jussen, who was fulfilling his civil service in San Francisco Libre, was hired by the author to supervise Zambrana during the broth-preparation day and to generally check on Zambrana's work. Each fortnight Zambrana reported to the PFP office, where he received his wage in exchange for the reports for the previous two weeks. PFP was trusted with Zambrana's wages and a small amount of funding to cover unexpected needs during the team's absence from Nicaragua (months of August through December, 2002). The reports were in turn electronically mailed to the author at irregular intervals. Ivania Jerez, general manager of the PFP filter cooperative, and personal assistant to Ron Rivera, cleaned-up the data reported by Zambrana and sent the files in EXCEL format to the author. This mode of communication was inefficient. The lack of regular fluid communication between the field worker and the final analyzer of the data left questions unresolved until the third field visit in January 2003. A more direct way of reporting and of providing feedback was necessary for a real-time iterative system to be feasible.

3.3 Selection Criteria of Water Testing Method

Four different water testing methods were considered before selecting the H_2S-Paper Strip Most Probable Number (MPN) method. Membrane Filtration (HACH's mColiBlue24®), Hydrogen Sulfide bacteria (H_2S) Presence/Absence (HACH's pathoscreen reagents, Standard Methods #9221D) and the Coliplate® technology developed by the Environmental Bio-detection Products Inc. (EBPI), and H_2S-MPN were evaluated and tested in Nicaragua during June 2002. The criteria of selection were cost, simplicity to learn and perform, incubation requirements and amount of waste generated. The latter was considered because of the lack of proper waste disposal systems in San Francisco Libre, where waste is generally incinerated.

MF was particularly appealing because of the amount of quantitative information MF tests could offer. By using Membrane Filtration, microbiological removal percentage by the PFP filter could be precisely calculated. Communication with Prof. Martin Polz at Parsons Laboratory at MIT as well as the Masters of Engineering Thesis research of S.C. Low (2002) indicated that the mColiblue24® MF method was reliable. Moreover, this method is incubated at 35°C and allows the identification both of total coliform and E-coli present in the sample. However, the need for precise incubation and therefore an expensive incubator and electricity, and the elevated costs per analysis were important drawbacks. Another drawback of the MF method was the need of extensive laboratory training for the test-performer. Our field partner, Juan Carlos Zambrana, was adept at visiting and monitoring families, but had no formal training in general laboratory techniques prior to the training we provided to him. Careful skills in maintaining overall sterile conditions and in interpreting the results are difficult for inexperienced people to acquire in a short period of time. Similarly, a reasonable degree of judgment was required to make decisions on the need of dilutions for each specific case. Finally, the amount of waste generated by using the MF method was significantly higher than by using other methods, since petri-dishes, filters and broths were not recyclable.

The second method, H_2S P/A (HACH's pathoscreen), is simple to handle especially if the reagent for the colonies are purchased ready-to-use. The downside of this methodology is the limited amount of quantitative information that it provides. H_2S P/A could be combined with MPN methods, at the expense of increasing the costs almost to the MF prices per test, if the pre-made reagents are used.

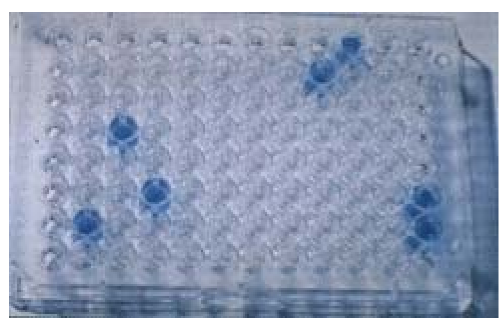


Figure 3-1 Picture of Coliplate®

The Coliplate® method is based on the principle of the MPN system, but with higher accuracy than the standard MPN because it has a larger number of repeated tests (96 wells for each test). In theory, application seemed straightforward, since the sample could be directly poured into all wells simultaneously. Field tests, however, showed this method to be inconvenient. While samples were being poured into the wells, several opportunities for contamination from the test performer were identified. Moreover, accidental dripping was frequent, which spoiled some of the tests performed. On the other hand, Coliplates® were easily stackable, but required incubation at 35°C. Figure 3-1 shows a picture of a Coliplate®. Finally, plates are not recyclable, which results in considerable amounts of waste.

H_2S-MPN can be used to obtain semi-quantitative data. Costs are significantly lower than the other three methods, and incubation may be performed at room temperature. As a result, limited budget, the unavailability of laboratory technicians to perform the tests, and the lack of a steady source of electricity for incubation, inclined the team to select the H_2S Paper Strip MPN method. Its simple interpretation, low cost and ease of performance were counteracted by the additional work that making the broth represented. The practical benefits and lower costs associated with this methodology outweighed the additional inconvenience of the self-prepared broth. Table 3-1 summarizes the benefits and drawbacks for each method.

Table 3-1 Benefits and drawbacks for MF (Total Coliform and E-coli), H_2S-P/A, Coliplate® and H_2S-MPN methods

Method	Type of information	Cost[4] US$	Ease of Performance	Incubation Requirements	Generation of Waste
MF for Total Coliform and E-Coli	Quantitative	2.48	Requires extensive lab training	35°C, 24 hrs	Abundant
H_2S P/A	Qualitative	~0.65	Does not require previous experience	Room T, 24-72 hrs	Minimal
H_2S-MPN	Semi-quantitative	0.25	Easy to use, but requires home-made broth	Room T, 72 hrs	Minimal
Coliplate®	Quantitative	4.03	Field tests were inconvenient	35°C, 24 hrs	Abundant

[4] The cost breakdown for each of these methods is in Appendix D.

3.4 Overall schedule – Timeline

Flow-rate and microbiological removal percentage of the PFP filter, and contamination sources were the focus of our study. Therefore, the plan for the 6 months was established as follows:

1) Monthly surveys assessing demographical data, hygienic habits and level of satisfaction on PFP filter;
2) One flow-rate measurement of each studied households' PFP filters, performed in July 2002;
3) One measurement of H_2S-producing bacteria contamination levels of the source-wells;
4) Monthly monitoring of H_2S-producing bacteria contamination before and after filtration for each participating family[5];
5) Cross-checking of results collected during the 6 months by performing additional Membrane Filtration analysis on half of the sample population's PFP filters during January 2003.

The overall timeline is summarized in Figure 3-2.

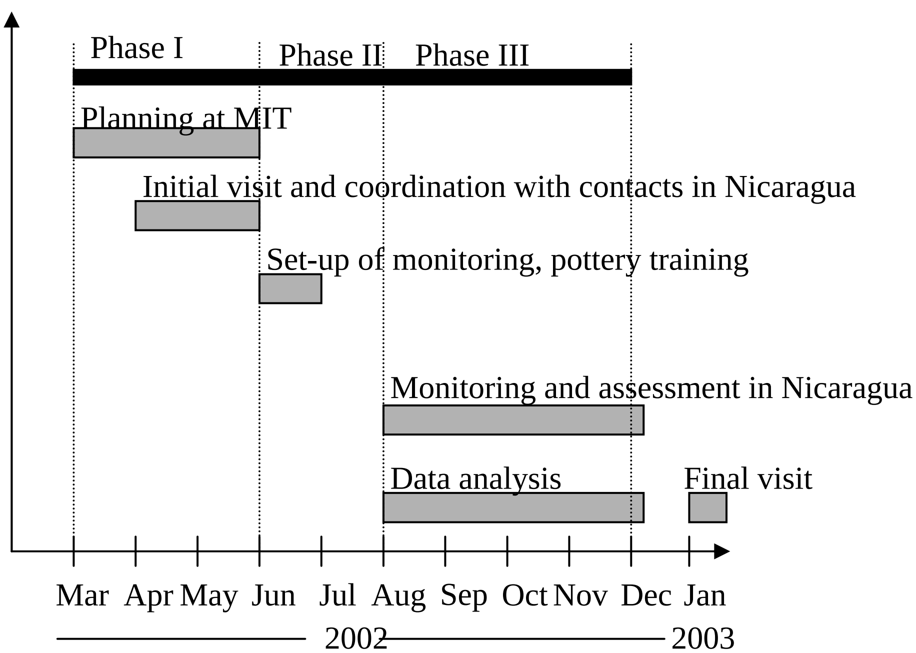


Figure 3-2 Timeline of project

[5] "Before" filtration samples differs from source-well samples because the first are taken from the filtering receptacle of the PFP filter, and the latter directly from the well.

Chapter 4: RESULTS AND DISCUSSION

4.1 Results for Surveys

4.1.1 July

All interviewees, except 3, in charge of supplying water in the family were female. The average size of the household was around 4.8, with a reported average of 0.8 children under 5 years old for each family.

The participants for this study had been selected so that the age of the PFP filter they possessed was not older than 2 months. The average reported age was 1.2 months.

The main demographic data is summarized in the Table 4-1

Table 4-1 Summary of Sample Demographics

Average age of person taking care of the filter	39.1
Average size of household	4.8
Average number of children per household	2.2
Average number of children under 5 years old per household	0.8
Average age of PFP filter	1.2 months
Dominant water supply system	Private and shared wells
Dominant source of energy for cooking	Fire-wood
Dominant source of power	Solar, no electricity
Dominant type of transportation	Horses and bicycles

An example of three responses for this questionnaire is shown in Table 4-2.

Table 4-2 Example of July survey

#	Name of Person in Charge of Filter	Age y.old	Size Hhld	# Children	Age of Children y=years, m=months	Children under 5	Age of Filter months
1	Marina Conde	52	2	1	13 y	0	1
2	Eloísa Ovando/Rosa María González	58, 28	8	4	N/A	N/A	1
3	Esperanza González	30	3	1	4 m	1	>1

The rest of the responses are shown in Appendix B, Table B-2.

During July, the filtration rate of 76 PFP filters were tested. The average flow rate was approximately 1.7 L/hr, which is within the allowed volumes of filtration per hour by the quality control criteria of Potters for Peace (Chapter 1). During the same occasion when flow-rates were measured, families were asked whether they used chlorine in combination with the filter. An appreciable percentage of 11% answered positively. This fact may have skewed the results of some samples, in which the role of the filter could not be distinguished from the action of the chlorine.

4.1.2 August

All interviewees except 6 responded that the whole family drank filtered water. Three of these exceptions indicated that only the children drank from the filter.

None of the families spent more than 15 minutes fetching their water and the average time spent collecting water was approximately 6½ minutes. In most cases, families had access to hand-pumped wells (Figure 4-2). Only 8 out of the 100 households who were surveyed claimed to use a closed container (bucket with a lid) to transport water to their houses. The majority of the sample households (98 out of 100) used buckets and/or plastic buckets to transfer water from the wells to the storage vessels at home. A minority of 2 families used ceramic vessels as carriers. In terms of storage, only 29% of the sample reported saving the water in the plastic recipient vessel of the filter. Almost half of the population (44%) transferred the filtered water from the plastic receptacle into a ceramic pot. Only 2 households had specialized containers with faucets for water storage.

The summary of the key results for this month's survey are in Table 4-3

An example of 3 responses for this questionnaire is shown in Table 4-4

Table 4-3 Summary of results for August survey

Percentage of households where all members drink from the PFP filter	97%
Average amount of time spent to fetching water	6½ minutes
Percentage of families transporting water in plastic buckets	92%
Percentage of families storing water in ceramic pots after filtration	44%
Percentage of households storing water directly in the PFP filter	29%

Table 4-4 Example of August survey

Sample #	How many members drink from the filter?	How long does it take to fetch water? [minutes]	In what type of container do you fetch the water?	In what type of container do you store the water?
1	entire family	3	plastic bucket	plastic bucket/filter
2	entire family	3	plastic bucket	plastic bucket/filter
3	entire family	3	plastic bucket	plastic bucket/filter

The rest of the responses are shown in Appendix B, Table B-4.

4.1.3 September

The sample population had an 88% literacy rate, sufficient for interpreting the instructions on the filter and following them accordingly. In those cases where the main filter care-taker could not read, family members, especially children, helped with the comprehension and execution of the instruction. All families indicated that the instructions were clear.

Finally, 30% of the sample population washed the filter with water collected from the well. A large proportion of wells presented at least 2.2 colonies of H_2S-producing bacteria (except #92 in July, #91 in August, #5 and #12 , #48, #75-#78, #85, #88, #89, #91-#94, #99 in September, #5, #73, #91, #92, #93 in October, #90, #92 in November, #15 , and #71 in December, out of a total of 145 tests on well water during the 6 months period). A similar fraction, 33 families, had at least 16 colonies per 100 mL of sample of Total Coliform bacteria after the July/August tests. These cases raised the suspicion that it may have been the contamination of the recipient vessel, which re-polluted the filtered water. To test this hypothesis, a health worker visited the families and cleaned the filter with uncontaminated water in front of the filter owners. After this measure, the level of contamination decreased substantially in subsequent monitoring. Besides decontaminating the recipient bucket, the health worker's visit served as additional training to the filter caretakers on the appropriate maintenance methodology. Contrary to expectation, only 7 of those 30% who confessed washing the filter with water from the well without adding chlorine matched the 33 families visited by the health worker.

A summary of the key findings is reported in Table 4-5.

Table 4-5 Summary of results for September survey

Average frequency of filter washing	Every 2.4 days
Literacy rate	88%
Reported clarity of instruction on the back of the filter	100%
Percentage of households washing the filter with well water in September	30%

An example of three responses for this questionnaire is shown in Table 4-6

Table 4-6 Example of September survey

Sample #	How frequently do you clean the filter?	Do you know how to read?	Are the instructions on the back of the filter clear?	When you clean the filter. which water do you use?
1	every 2 days	yes	instructions are clear	well water without chlorine
2	every 48 hours	yes	instructions are clear	well water without chlorine
3	every 2 days	yes	instructions are clear	filtered water

The rest of the responses are shown in Appendix B, Table B-6.

4.1.4 October

The answers for the previous questions showed that 76% of the sample never buys bottled water. A significant number of 19% purchase bottled water only during long trips to the capital, Managua. This low demand for commercially sold bottled water does not change for infants. Only 5% reported buying bottled water for babies and young children.

Almost half of the households (44%) pack water filtered from the PFP filter for the male members of the families who leave the house to fetch firewood or who work in the fields. Similarly, 31% of the families indicated that children take filtered water to school every day. On the other hand, a considerable 22% of interviewees declared that they never take filtered water out of their homes, and do not buy bottled water either.

The average distance of the latrine from the house was 19.3 m, whereas the average distance from the well was 40.3 m.

The results for this survey are presented in Table 4-7

Table 4-7 Summary of Results October Survey

Percentage of households who never buy bottled water	76%
Percentage of households who buy bottled water only while traveling	19%
Percentage of families who pack filtered water for their husbands and sons who leave the house to work	44%
Percentage of households who pack filtered water for children to take to school	31%
Percentage of families who never buy bottled water and never pack filtered water when out of their homes	22%
Average distance from house to latrine	19.3 m
Average distance from well to latrine	40.3 m

An example of three responses for this questionnaire is shown in Table 4-8

Table 4-8 Example of October Survey

Sample #	Do you ever buy bottled water?	Does anybody in your house take filtered water to work?	Where is your latrine? Is it near your house? Near your well?
1	no	yes. husband to the farm	at 13 m from the house
2	when I travel to Managua	yes. child takes water to school	at 17 m from the house
3	sometimes for my child	no	at 23 m from the house

The rest of the responses are shown in Appendix B, Table B-8.

4.1.5 November

The first question was included as a means of validation of the answers reported for the September survey ("How frequently do you clean the filter?"). Five out of 89 households (6%) had claimed in September that they washed their filter daily. When asked in November, a 6% of households responded that washing occurred every day. However, none of these families matched with the September group.

For the second question, the response was unanimously negative. None of the families noticed a change of taste of the filtered water or of the filtration rate. A reduced filtration rate due to progressive clogging of the pores is a potential factor that could decrease the performance of the filter. At least in the perception of the user, flow rates stayed roughly the same.

An interesting finding of this month's survey was the fact that the totality of the households washed their hands with soap and water from the well before handling the filter.

A summary of the findings for the month of November are presented in Table 4-9

Table 4-9 Summary of November survey

Percentage of families who noticed change of taste on water or filtration rate of filter	0%
Percentage of families washed hands with soap and well water before handling the filter	100%

An example of three responses for this questionnaire is shown in Table 4-10.

Table 4-10 Example of November Survey

Sample #	When did you clean your filter for the last time?	Did you notice any difference in the water's taste or in the filtration rate?	Do you wash your hands before handling the filter?
1	20 days ago	No changes	Yes. with well water and soap
2	15 days ago	No changes	Yes. with well water and soap
3	3 days ago	No changes	Yes. with well water and soap

The rest of the responses are shown in Appendix B, Table B-8.

4.1.6 December

PFP users' perception about the filter is summarized in Table 4-11. Respondents could choose more than one filter property, hence the percentages do not add up to 100%.

Table 4-11 User perception on best properties of the filter

Quality of the filter that was mentioned as the best property of the filter	Percentage
Water comes out "safer"	22%
Water comes out "cleaner"	35%
Improved health	9.4%
Water comes out "distilled"	9.4%
Hygienic improvement	3.4%
Decreased contamination	8.2%
Physical change of water ("lighter," "cooler")	5.9%
Maintenance and "protection" of water	5.9%
Purification and Filtration	2.4%

The full spectrum of answers is reproduced in Appendix B, Table B-9. The answers for the second question are reproduced in Table 4-12.

Table 4-12 Desired modifications to the filter reported by users

Desired modification	Percentage of answers
Larger filter	65.9%
Replace plastic recipient vessel	12.9%
Adopt ceramic recipient vessel	4.7%
No modifications	7.1%
Place cap on faucet	2.4%

Table 4-13 Responses to "Is the amount of water filtered enough for the family?"

Yes, enough, but still desire a larger filter	64%
Yes (without further comments)	18.8%

An example of three responses for this questionnaire is shown in Table 4-14

Table 4-14 Example of December Survey

Sample #	What do you like the best about the filter?	What would you like to see changed on the filter?	If a neighbor offered you you money to buy your filter, how much would you charge?	Is the amount of filtered water enough for the family?
1	Water comes out without contamination	nothing	I would not sell it	I feel it constantly as it starts emptying
2	Water comes out clean	That the recipient vessel were ceramic	I would not sell it because it woud be a mistake	Yes, it is enough for the whole family
3	Water is safer	That the recipient vessel were ceramic	I would not sell it	Yes, enough for everybody

The rest of the responses are shown in Appendix B, Table B-10.

4.2 Discussion for Surveys' Results

4.2.1 Background on surveyed communities

Figure 4-1 Urban town in San Francisco Libre

Water supply from a central treatment plant was non-existent in any of the monitored villages of Pacora, Madroñito, Laurel Galán and San Roque. Private and shared wells were the main source of drinking water in these villages (Figure 4-2). These communities can be reached only by horse, motorbike or a 4-wheel-drive vehicle, and are within an hour distance by motorbike from the small urban center of San Francisco Libre, also known locally as "the harbor" (Figure 4-1). Some houses in the urban center had access to a piped water supply, which was in theory chlorinated. This "harbor" faced Lake Managua, the receiving waters of the wastewater generated of Managua. There was no central waste discharge system in San Francisco and surrounding communities.

Most houses had their own latrines. Two small canteens were the meeting place for those sympathizing with either of the two main opposing political parties in Nicaragua, the "Liberals" and the "Sandinists," and were the only two places in San Francisco Libre where food and alcohol could be bought. Also in the town center, there was an elementary school that opened daily, and a secondary school that opened a few days a week, or only weekends, depending on the availability of teachers coming from Managua. A

Figure 4-2 A private well in Laurel Galán

small health center for urgent care, a police station and a few markets completed the picture of the urban center. Fresh milk was hard to find, and only the restaurants sold bottled water. Vegetables and fruits were never fresh in these markets, because of the dry weather of San Francisco Libre, which forced suppliers to bring most goods, even bread, from Managua.   A bus connected San Francisco Libre to the capital city, Managua, four times a day, three buses early in the morning and one in the afternoon.

Electric power was available sporadically in the town center, but never available in most of the villages. Power outages were frequent, and could last 2 or 3 days, especially in the rainy season of October and November. Waste was burned regularly in each house. The unstable power supply and the lack of a solid waste disposal system were critical factors to take into consideration during our laboratory set-up and experiments (Figure 4-3).

Figure 4-3 Laboratory set-up in San Francisco Libre

4.2.2 Observations

Following are some general but unrelated observations by the author of the physical and cultural conditions of our field site:

1. Living conditions in these villages were precarious, where dirt-floors and firewood based kitchens were the dominant resources (Figure 4-4). Children were usually in bare feet, and shared their living space with domesticated animals, such as dogs, pigs and hens (Figure 4-5). Most women appeared to work in house-chores, whereas the most frequent occupation for men seemed to be farming and firewood-cutting. Extended families seemed to be the common system through which one shared resources and duties. In fact, a large proportion of the interviewed families claimed to be related to some degree, which was reflected in recurrent last names.

Figure 4-4 A kitchen in Laurel Galán

Figure 4-5 Children and cattle share dirt floors in San Roque

2. In keeping with the original vision of the project (Section 1.4), the information flow was both from the villages to the researchers and vice-versa. Those families for which the microbiological tests after filtration were positive were notified and recommended a course of action to solve contamination problem. When a common unhygienic behavior was noticed, participants were informed and trained to be particularly cautious in those areas. For example, 33 families were identified

as having greater than 16 colonies of H_2S-producing bacteria per 100 mL of water sample after filtration. Zambrana recognized that the problem was mainly of recontamination of filtered water due to the utilization of a contaminated recipient vessel. The team hired Luis Manual Montiel, a field worker, so that recipient buckets for those families would be washed-out, after which results for the same families were negative.

3. Chlorination in the urban center was not implemented in practice every day. Since the piped system was thus unreliable, filters were also used in some houses with piped supply.

4. Several PFP filters had dusty faucets, which could have been contaminated due to contact with animals or dirty hands. Zambrana also observed users placing the ceramic components of the filters on unhygienic kitchen tables.

5. Some households were observed to store their PFP filter very close to the floor, at heights easily reachable by animals and children.

4.2.3 Discussion on July's results

The important role of women in water safety can be interpreted from the clear dominance of female filter caretakers over men. This fact should be taken into account when technologies and training programs are designed to solve the water problem. From the demographic data, it is possible to infer that the typical family in the area has approximately 2 children. Since there is close to 1 infant under 5 years old per family, approximately 50% of the children in the visited communities may be especially susceptible to waterborne diseases. In light of the results for August's and October's survey, when most families indicated the absence of a preferential treatment for young children in terms of drinking filtered water or buying bottled water, it might be reasonable to conclude that a large number of infants are in risk of exposure to water contamination.

The young age of the PFP filter in the sample population made possible the monitoring of the filter performance almost since the beginning. There was a general suspicion that the PFP filter could decrease its functionality over time, hypothesis that was discarded after analyzing the whole data set (refer to section 4.3).

Wells were the dominant source of water in the four communities where the monitoring program was conducted. This fact increases the relevance of studying the efficiency of a point-of-use treatment device in this case, since a central treatment system was unavailable. The lack of gas for cooking made boiling water especially inconvenient, since firewood was already becoming scarce in the region, and had to be fetched from far distances every day. Therefore, filtration seemed to be one of the few appropriate solutions for these communities, along with chlorination and solar disinfection. Nevertheless, in Chapter 2, the response of the attendants to the pottery workshop suggested that the taste and cost of chlorine may be an obstacle on its adoption as a water treatment alternative. Similarly, October's survey show that most people in the sample population (76%) never buys bottled water, which could be a problem to use solar disinfection (SODIS) to treat water, since there is no local availability of water bottles that could be recycled.

The main types of local transportation were horses and bicycles. The terrain was hardly accessible by other vehicles during the rainy season, which stressed the importance of the local availability of replacement filter components.

Filtration rate tests showed that for the average-size household of these communities, one PFP filter may not easily satisfy the drinking needs. The average filtration rate of 1.7L/hr was taken when the filter was completely full, which, according to Eriksson's model presented in Chapter 1, decreases along with the water level in the filter. In other words, when the filter is close to emptying, the flow rate is considerably slower. In any case, even if a member of the household filled the filter constantly so that the filtration rate was optimal, 12 hours of continuous refilling and filtering (12hs * 1.7 L/hr = 20.4 L) would be barely enough to provide the, 4L/day/person (Chapter 1), since the average family size was 5 members. Answers to the December survey show that the frequent refilling requirements were one of the main problems of the PFP filter for users.

4.2.4 Discussion on August's results

The fact that all except 6 interviewees responded that the entire family drank filtered water indicates that the PFP filter had a fairly large acceptance rate from filter owners.
The relatively short time spent on fetching water every day by the sample population may suggest that the limiting rate on availability of safe water is the filtration rate and not raw water supply.

Very few families (8 out of 100) used closed containers to carry water from the wells to the houses. The opportunities for contamination during the transfer may be high. A total of 145 tests were performed in wells during the 6 months. In approximately 50 of those cases (Appendix B), the degree of contamination of the well is smaller than the water sample taken immediately before filtration (already in the filtration receptacle in the PFP filter). These results suggest that contamination during transportation of water is significant.

Another opportunity for contamination may be during water storage. Close to half of the sample population transferred the filtered water into a ceramic vessel. The cooling effect of ceramic may be an important factor for this behavior. However, Lantagne (2001) indicated that ceramic containers are more susceptible to contamination than plastic buckets. On the other hand, plastic buckets are usually multi-functional, which may create opportunities for cross-contamination from sharing the bucket for different house-chores. Finally, another reason for the transfer of water may be the relatively low capacity of the PFP plastic bucket, which was perceived as too small by approximately 66% of the sample population during the December survey.

4.2.5 Discussion on September's results

The relatively high literacy rate suggests that labels and written documents attached on the filter may be efficient tools for spreading information on water safety and maintenance of the PFP filter. In cases when the filter caretakers cannot read, children seem to play a relevant role as interpreters, which shows the importance of the labels being simple and attractive for younger people. Users expressed that the current label was clear, but in July there were 33 cases of filter contamination that were solved as soon as those families were shown how to clean the filter by Montiel. Perhaps, users may need a live-demonstration that explains the information on the written instructions.

Results were not conclusive on whether using well water could contaminate the filter, since only 7 of those using well water to wash their PFP filters were part of the group of 33 people with filter contamination. Other opportunities for contamination of the filter and the recipient vessel may occur during the washing procedure itself, when the ceramic component of the filter may be rested on a dirty surface. In any case, after these cases in July, Zambrana encouraged the whole population to wash the device with filtered water, and the rates of contamination after filtration decreased substantially (Section 4.3).

There seems to be a pattern of similar or identical answers related to the respondent's close number assignments (Appendix B, Table B-6). In light of this fact, it is possible to notice a pattern of behaviors among those living close or next to each other. There is a possibility that the formation of clusters with similar answers may be due to imitation of peers'. If this were true, "peer-motivation" may be used as a valid tool for future projects in which training and information spreading are main goals.

4.2.6 Discussion on October's results

Large percentages of households packed water to drink outside of their houses, either in the fields or in school. This is a recommended practice, but may represent an additional strain in the already low capacity of the filter, since some amount of the available filtered water is used for outside consumption.

Almost a quarter of the population never buys bottled water or packs filtered water, which means that they may present higher risks of exposure to contaminated water when not at home.
The low demand for bottled water shows that point-of-use water treatment is essential to increase access to safe water.

Another potential path of exposure to contamination may be the proximity of the latrine to the well or the house, and the kitchen. In the visited communities, decent distances (19.3 and 40.3 m) separated the house and the well from the latrine. The risk of bacterial contamination from a single domestic latrine is normally minimal, and only a hazard if there is groundwater abstraction point within 15 m of the latrine infiltration system (Franceys, 1992).

4.2.7 Discussion on November's results

Filter users answered differently in September and November on the frequency of cleaning for the PFP filter. This might question the reliability of the self-reported answers to questions that address issues of hygienic practices. On the other hand, it may just indicate that hygienic habits change over time.

Performance of the filtered did not change noticeably, according to users' reports, which suggests that decreased filter performance over 6 months may not be a problem. However, informal interviews with filter owners during the field visit of January 2003 showed that at least 3 filter owners were complaining on an unpleasant odor and water taste originated from the filter. The degree of honesty of the interviewees may be dependent on the interviewer. When addressed by a foreigner, who may be conceived as a source of further financial and material contribution, individuals may tend to have second intentions on their complaints.

4.2.8 Discussion on December's results

The most popular answer (35%) on the best property of the filter was that water came out cleaner after filtration, which does not necessarily connote improved safety of health. There were 9.4% who directly linked the filter with better health, subtly implying that the filter could have a direct effect on preventing diseases. Another 22% alluded indirectly to increased health by saying that the filter provided "safer" water. It was interesting that some (8.2%) answered that the filter decreased contamination, which indicates that there was awareness about the fact that sources of raw water were contaminated. A total of 5.9% referred to physical changes on the water. An identical percentage of 5.9% households believed that the filter was efficient on preserving or "protecting" the condition of the water, in other words, the water was clean in the first place, and the filter served to successfully maintain that condition.

All these different answers may be efficiently used when devising training material and educational tools, by targeting the misconceptions and by informing that the main function of the filter is to remove the microbiological contamination. In this sample, the majority acknowledged that the filter played a role in removing dangerous agents in the water that may be harmful for them.

That 66% wanted a larger filter indicates that supply needs for clean drinking water were not being met (refer to 4.1.1 on flow rate measurements). There are, however, two possible interpretations. Filter users may be complaining on the fact that even when they do not mind re-filling the filter constantly, flow-rate is not fast enough to cover the needs of the whole family, for which a larger filter is necessary. The second interpretation could be that the existing flow-rate of the filter is adequate, but the total capacity of the storage vessel is small for the needs of the family, for which constant re-filling is required. This latter interpretations seems more probable, 64% percent of the households that indicated the need of a larger filter simultaneously reported that the filtered water was enough for the whole family, although it required constant filling (refer to Table 11, Appendix B-B). Users seem to feel annoyed that the filter has to be filled continuously because of low storage capacity, but families are not dissatisfied about the flow-rate per se. In this last question, only 18.8% of the sample population indicated that they were completely happy with the amount of water filtered by the device. All the other answers complained on the total capacity of the filter, even tough reported the amount of water to be enough.

The second most popular design modification was the change of the collection vessel material. Plastic was disliked by 12.9% of the sample, whereas 4.7% clearly indicated a preference for ceramic. A low percentage of 7.1% was completely satisfied with the status quo of the filter. A couple of answers were very specific, such as the cap on the faucet, which might indicate an understanding of the potential venues of contamination through the faucet. Another interpretation could be that spigots were leaking. A couple more interviewees requested free PFP filter replacements, which makes sense in light of a high breakage rate of 15% after 6 months of filter use. This concern about lack of local sources for replacement is reflected on the answers for question three. One-hundred percent of the sample population denied any possibility or desire to sell the filter, not even in a hypothetical situation of the interview. Four out of 85 referred specifically to the fact that they would be left without filter, implying that the lack of sources of replacement made selling the filter an inconceivable idea. When users declared that they would "never" sell the filter, the desire to appear trustworthy may have been operative (since the filters were given for free as a humanitarian gesture).

Overall, there seems to be a considerable amount of dissatisfaction with the capacity and the need to keep refilling the filter.

4.3 Results for H_2S Paper Strip Tests

A complete report on the results of all H_2S-Paper Strip MPN tests performed during the 6-month period is presented in Appendix B, Tables B-2,B-4,B-6,B-8 and B-10.

Major results are reproduced graphically in this section. Those families who had 5 Absences for their H_2S MPN test after filtration were counted and summarized in Table 4-16 and Figure 4-6.

A practical software package developed by Mr. Mike Curiale at U.C. Berkley that automatically calculates the number of colonies based on the mentioned input parameters was used to convert the data .[6] The conversion table is reproduced in Table 4-15.

Table 4-15 Conversion Table for H_2S Paper Strip MPN Method with Five 10 mL Vials with no dilutions

# of Positives	Number of colonies per 100 mL
5	> 16
4	16
3	9.2
2	5.1
1	2.2
0	< 2.2

Table 4-16 Summary of results for the 6-month monitoring

Month	Percentage of Families with less than 2.2 colonies per 100 mL of sample
July-August	52%
September	94%
October	83%
November	90%
December	83%

[6] Based on Hurley, A. H. and M. E. Roscoe. 1983. Automated statistical analysis of microbial enumeration by dilution series. J. Appl. Bacteriol. 55:159-164. Developer does not claim copyright or accuracy of this method. This method has been widely used by officials in the Canadian and Australian governments. (http://members.ync.net/mcuriale/mpn)

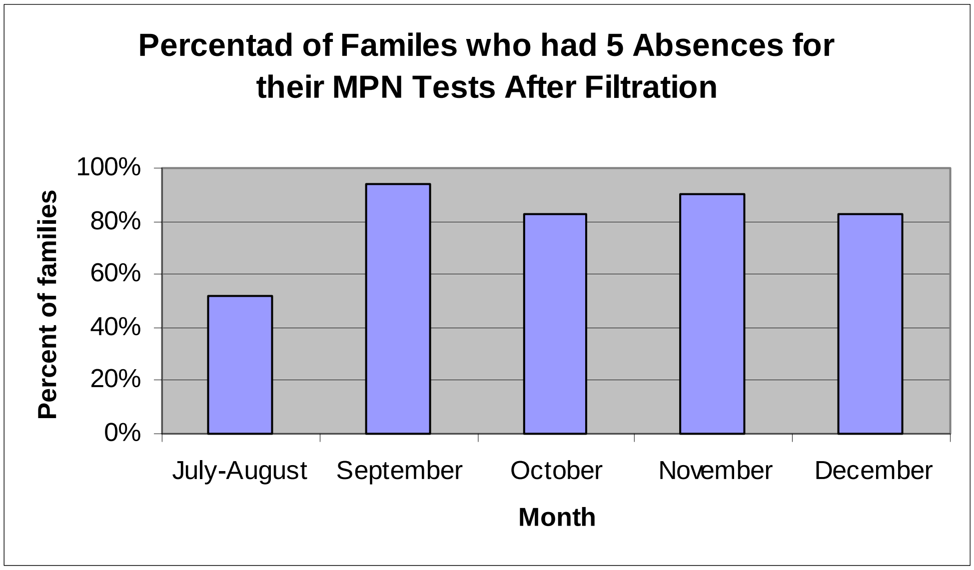


Figure 4-6 Summary of results for the six-months monitoring

The amount of households each month and the level of contamination of their samples before and after filtration have been graphed in Figures 4-7, 4-8, 4-9, 4-10 and 4-11. References indicate the number of H_2S-producing bacteria per 100 mL of sample.

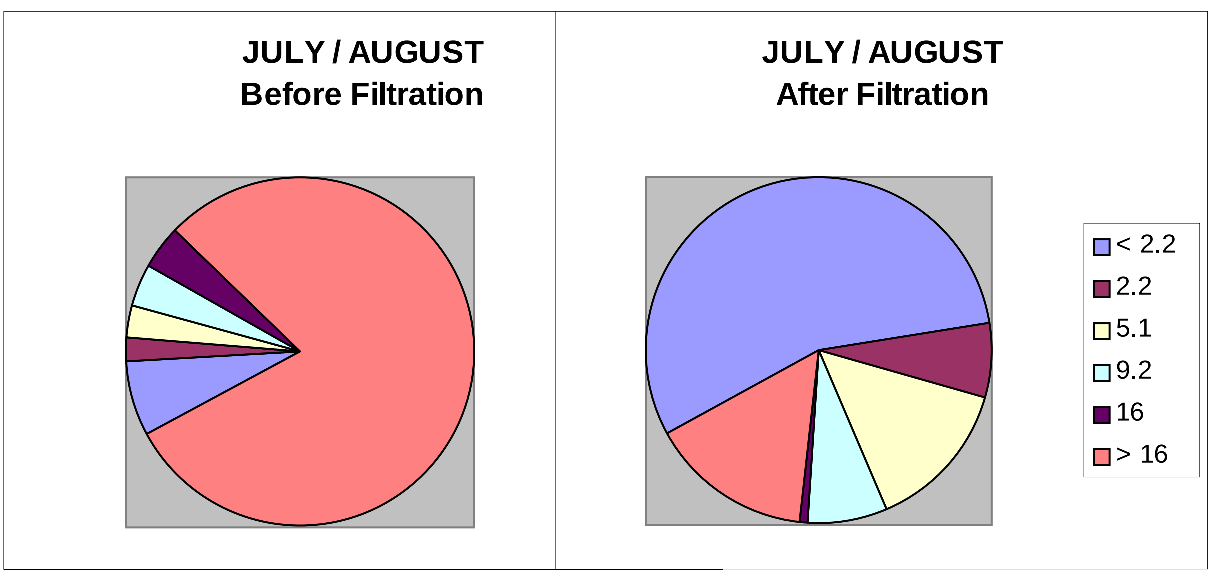


Figure 4-7 Results before and after filtration for July/August

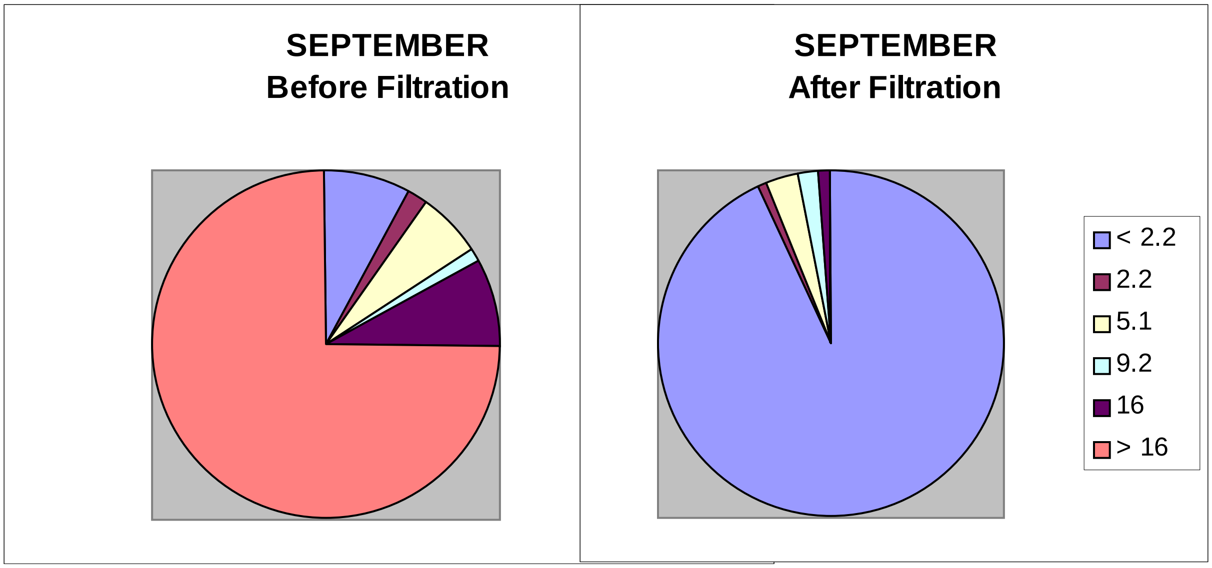


Figure 4-8 Results before and after filtration for September

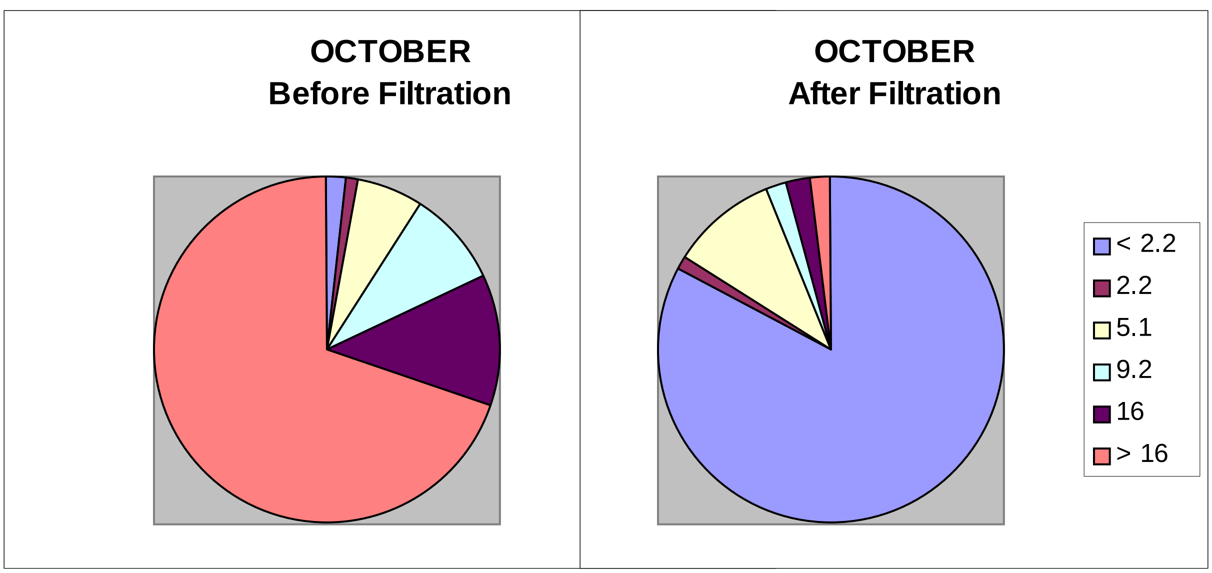


Figure 4-9 Results before and after filtration for October

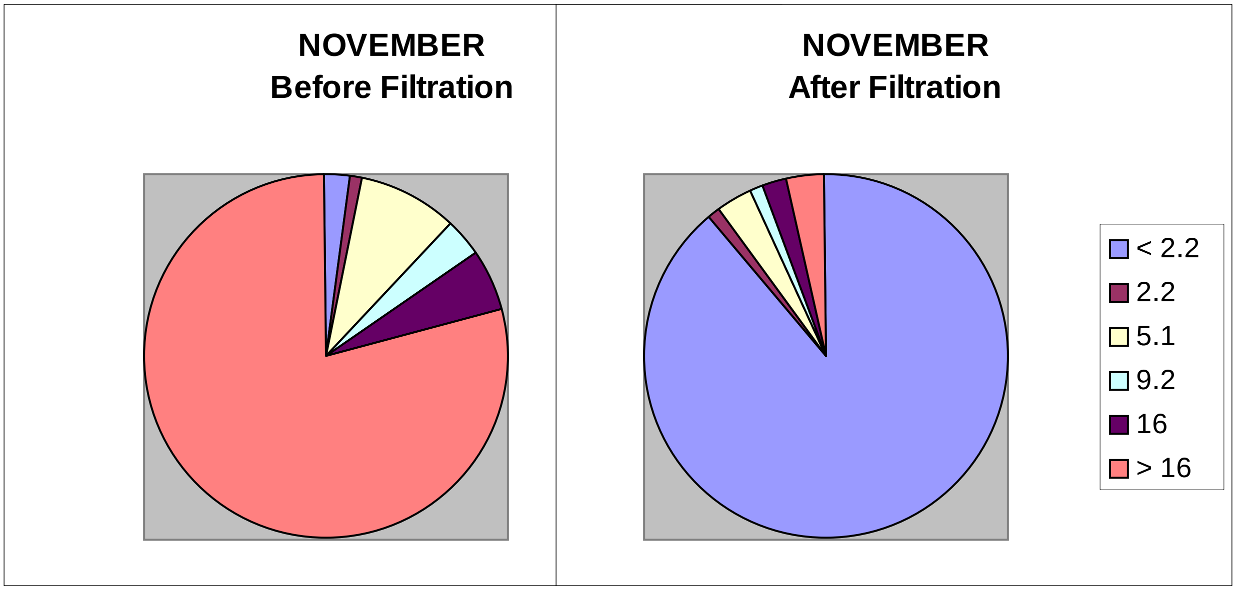


Figure 5-10 Results before and after filtration for November

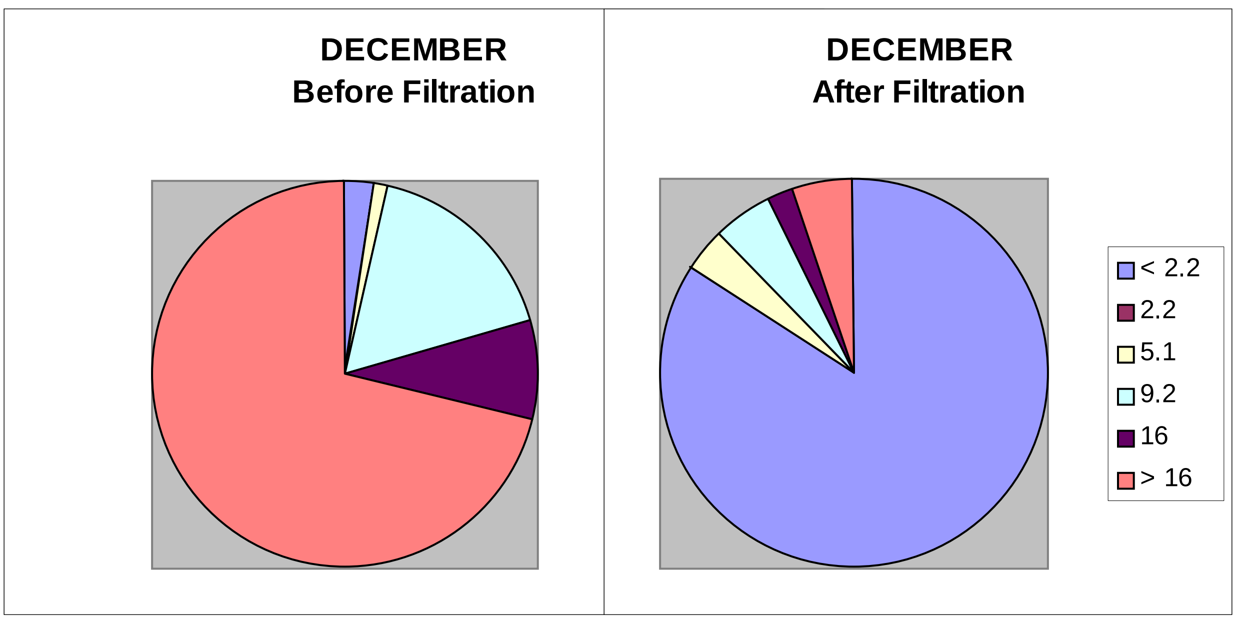


Figure 4-11 Results before and after filtration for December

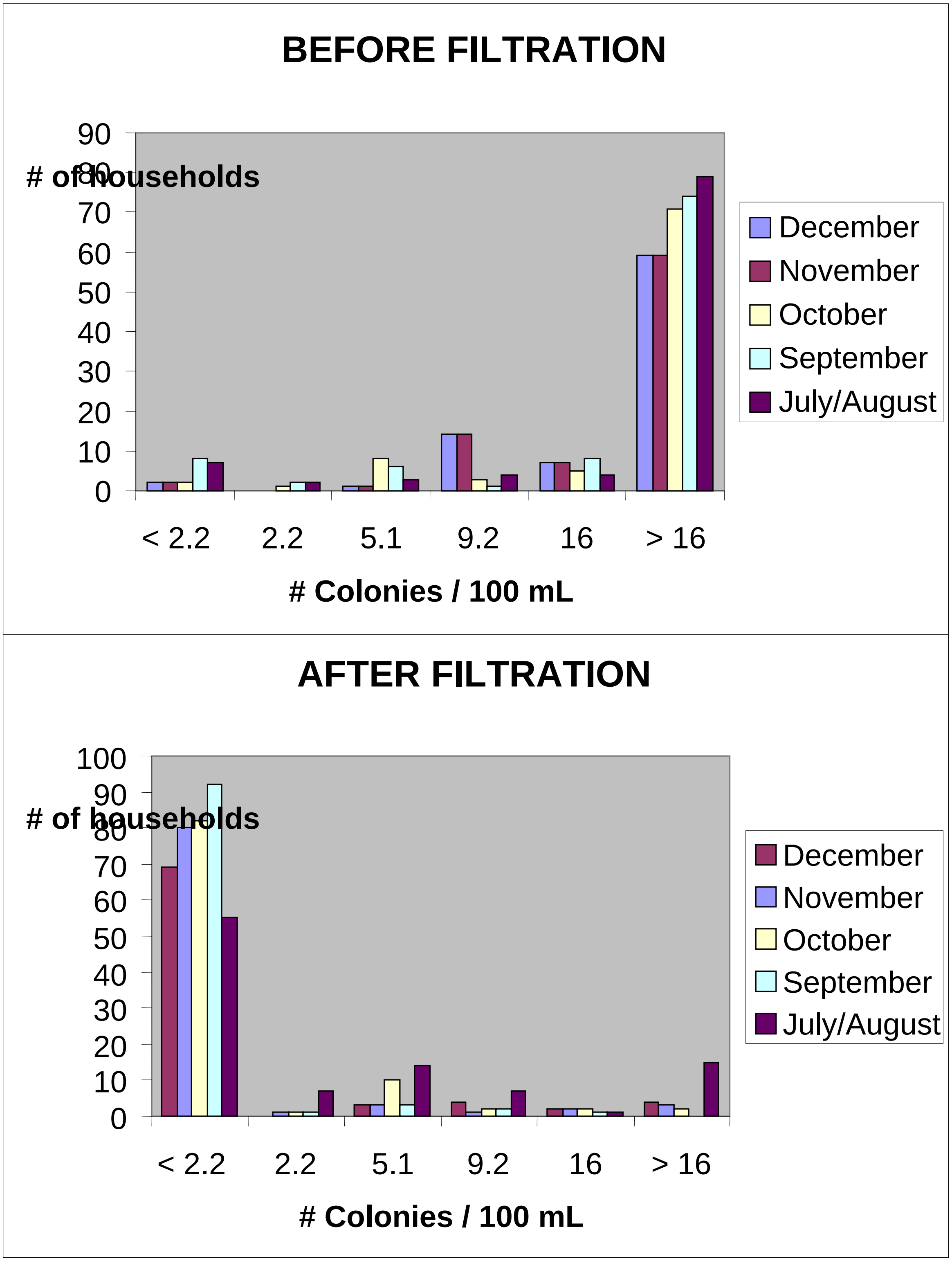


Figure 4-12 Results before and after for the whole study period

4.4 *Discussion for H_2S Paper Strip Test Results*

Table 4-16 shows a dramatic change in the percentages of families with <2.2 CFU/100 mL between August and September. This change may be mainly due to the de-contamination and the 33 filter collection containers and retraining of the households who used contaminated collection vessels. This work was performed by the health worker Montiel during the month of September. It is worth noticing, as well, that the MIT students Yamana and Ricke in charge of training and supervising Zambrana for the first 2 months left Nicaragua at the beginning of September, which left Zambrana without constant oversight.

Charts in Figures 4-7 to 4-11 show the different percentages for each level of contamination for each month. Except for July, all other months have similar results, except for September, which shows a slightly better performance.

All the curves were plotted in the same graph in Figure 4-12 enable comparative analysis. In the case of "before filtration," results reflect the level of contamination of the source or the contamination that took place during the transportation from the source to the filter. From the graphs, it is possible to infer that the distribution of contamination was basically unchanged during these 6 months, except for a peak in November and December, when some families who had 16 or more colonies per 100 mL of sample, seem to have decreased to 9.2 colonies per 100 mL of sample. Besides that unique case, trends seem to be fairly stable over the months. Trends for the results "after filtration" are even more constant during the 6 months. With the exception of July/August, the rest of the months seem to present almost identical distributions of contamination, which is indicative of the distribution of performance of the PFP filter. According to this set of results, it could be concluded that roughly 90% of the PFP filter that are manufactured may perform as expected, rendering undetectable levels of contamination (in this case, less than 2.2 colonies per 100 mL), whereas close to 10% of the filters may be defective. Another possible interpretation could be that specific cultural practices of this sample population affected the performance of the filter in 10% of the cases. However, the follow-up and personalized monitoring and re-training was performed every month by the same worker

Zambrana, which may indicate that the problem resides in the lack of robustness of the filter system. Sample numbers 22, 23, 26, 36 and 38 presented more than 2.2 colonies per 100 mL of sample both in September and October. Number 22 showed recurrent problems in all subsequent months. Another recurrent defective filter is number 36, which presented high levels of contamination in September, October and December. Three more filters presented some level of contamination above 2.2 colonies per 100 mL both in November and December. From the 33 filters that were followed up by a health worker after July/August, only household # 17, 20, 21, 43, 58 and 99 showed cases of re-occurance in the following months, but only once (not re-inciding in more than one month, except for 43). These results, although not conclusive, may indicate that the amount of filters that seem to malfunction are not distributed randomly among the sample population, since there could be found clear cases of re-occurance over the sutdy period. Similarly, the filters that were washed by the health worker in September seem to have maintained in most cases the good performance, a sign of the importance of monitoring and continous training.

These results should be considered by taking into account results from H_2S-MPN of less than 1 CFU/100mL of sample may indicate that water is safe to drink (WHO, 2002).

4.5 Reliability of data

Field conditions present unexpected challenges. Frequent power failures, non-optimal laboratory settings and extreme weather were detrimental to ensuring standard conditions. In this study, lack of efficient ventilation and easy access by insects and dust to the equipment were constant annoyances. Supplies were not always easy to find. For example, distilled water was brought from Managua in 5-gallon bottles, but the quality of the water was not checked by a laboratory. For autoclaving, a kitchen oven was utilized after a lab oven was blocked by US Aiport Security, which required external gas tanks which may not have been always perfectly sealed. In this particular study, an additional factor that decreased the reliability of the data was the inexperience of our technician. Zambrana was well trained in field visits and monitoring, but not in laboratory techniques. Team members supervised his first month of work and explained the principles behind each rule thoroughly to Zambrana. All essential material was translated to Spanish and left as a hard copy for later consultation. Despite all these precautions, the language barrier between trainers and trainee may have been an obstacle to proper transfer of knowledge. In addition, Zambrana himself proved to be an extra source of uncertainty in this study. He demonstrated capability and efficiency when he felt motivated, but tardiness and lack of discipline were observed by different collaborators in some occasions. Some days, it was reported that Zambrana would not show up to meetings or training sessions, which may be a reflection on the possible lack of dedication he applied to his later work. The lack of continuous supervision may have been a tempting opportunity to relax his strict schedule and the rigid laboratory sterility rules. When the author visited half of the sample population during January 2003, she observed that the filter-owners recognized and welcomed him, which is a proof of his activity during his independent work period. Christian Jung has also aknowledged having witnessed Zambrana's work. Therefore, there are no solid reasons to suspect Zambrana's performance, but due to the difficult field conditions and the technician's inexperience, this data must be taken under the specified context.

When the H_2S MPN results are compared to similar studies reported in the literature, our values are considerably different. Out of 145 tests on well water, 26 had Absence (i.e. 5 individual test vials) of H_2S producing bacteria (18%). Lira (undated) reported 47% of 215 wells studied in Jinotega and Matagalpa (neighboring regions to San Francisco Libre) had Absence (i.e. 1 individual test) of H_2S producing microorganisms. We used self-made broth, whereas Lira used the HACH Pathoscreen culture media. Besides these specific differences in self-made vs. pre-manufactured broth and in MPN vs. P/A, the type of wells tested and the general conditions of the field sites were quite similar. Lira's sites, Jinotega and Matagalpa, Nicaragua, are only 1.5 hours distant from SFL and the social and physical conditions are comparable. Similarly, when H_2S MPN results from our monitoring program are compared to Lantagne's P/A data after filtration, our results are again significantly more favorable as to the performance of the PFP filter. Lantagne reported that only 25% of the tested PFP filters removed H_2S producing bacteria under field conditions, much lower than our average of around 80%. Her sample population was much smaller (24), but that does not explain the wide discrepancy. The divergence of results may be due to procedural errors on account of Zambrana's inexperience, or lack of dedication to the project, or possible misrepresentation of the results (to please us? To please the filter useres?). On the other hand, the use five 10 mL vial-MPN with no dilutions may lack enough sensitivity to detect presence of H_2S MPN at low concentrations. A more positive interpretation that could explain the divergent results is the influence of the monitoring program itself as the reason of the improved performance of the filter. Membrane Filtration results in January 2003 seem to challenge this interpretation. Nevertheless, since no parallel tests were performed during the 6-month monitoring program, the reliability of data remains inconclusive.

4.6 Results for Membrane Filtration Tests

The author traveled to San Francisco Libre in January 2003 to evaluate the efficiency of the H_2S Paper Strip MPN methodology and to attempt to qualitatively validate the results obtained by performing membrane filtration analysis. A total of 49 families were visited, from whom water samples before and after filtration were taken. For the first 12 samples, duplicates were tested, but due to their consistency, and the limited resources, only single tests were run subsequently. Detailed information on the volumes tested, and the results for each of the samples are reproduced in Appendix C. Key results are presented in this section, and a deeper comparison between the H_2S MPN methodology and Membrane Filtration is performed in Chapter 6.

Contrasting to the previous months' results, only 30.6% of the sample families presented less than 2.2 colonies of Total Coliform per 100 mL of sample after filtration. Removal rates were appreciable, as Figure 4-13 shows. The average removal rate for 27 quantifiable samples was 89.1% for Total Coliforms. The equivalent rate for 19 quantifiable samples was 97.6% for E-coli . The values that reach 5000 colonies per 100 mL of sample correspond to those results that were too numerous to count (TNTC). Total coliform was abundant for the source water, but E-coli was not present in all samples. The PFP filter proved to be efficient in removing the blue colonies, which indicate presence of E-coli.

Table 4-17 shows the main results for the MF tests, and Table 4-18 compares these results to the H_2S results.

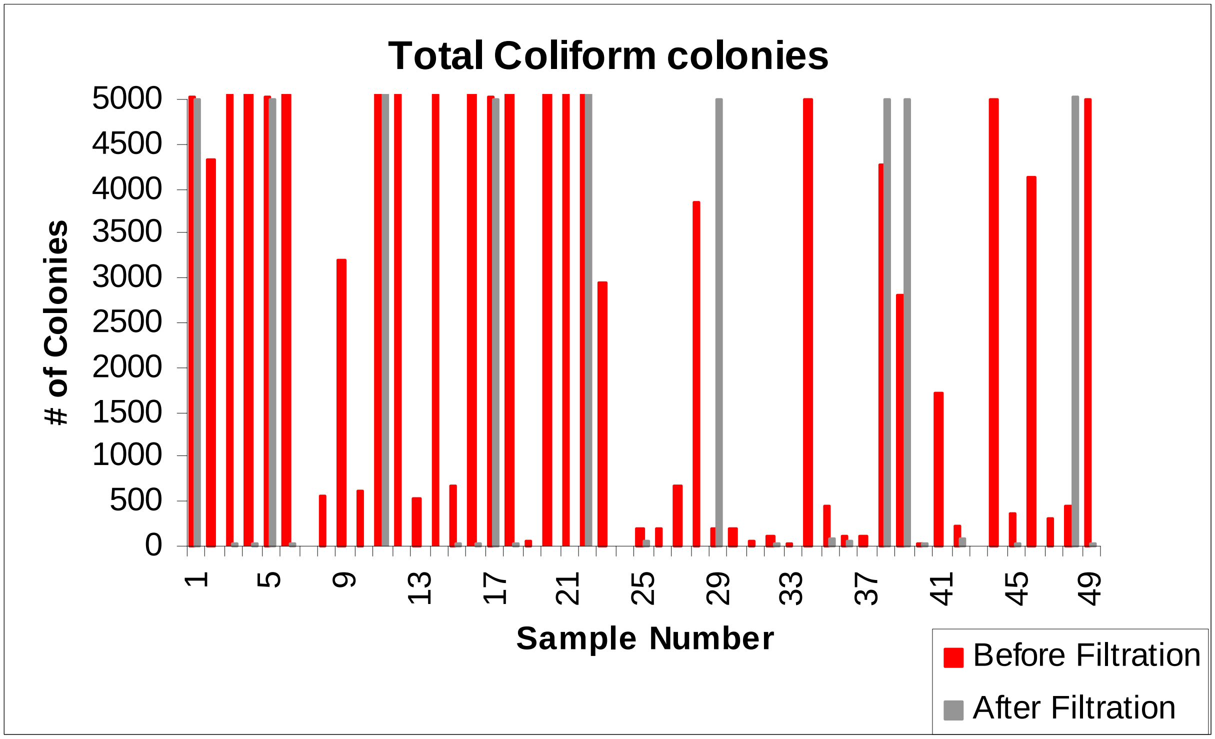
Table 4-17 Summary of membrane filtration results

Percentage of families with less than 2.2 colonies of Total Coliform per 100 mL of sample	30.6%
Average removal rate for E-coli	97.6%
Average removal rate for Total Coliform	89.3%

Table 4-18 Comparison between H_2S-MPN and MF results

	H_2S Method	MF Method
Average percentage of families with less than 2.2 CFU/100 mL	80.4%	30.6%
Average percentage of families with 0 CFU/100 mL (H_2S- producing bacteria and E-coli[7] respectively)	80.4%	27%
Average percentage of families with more than 16 colonies of Total Coliform per 100 mL of sample	6%	45%

[7] only when initially present for E-coli



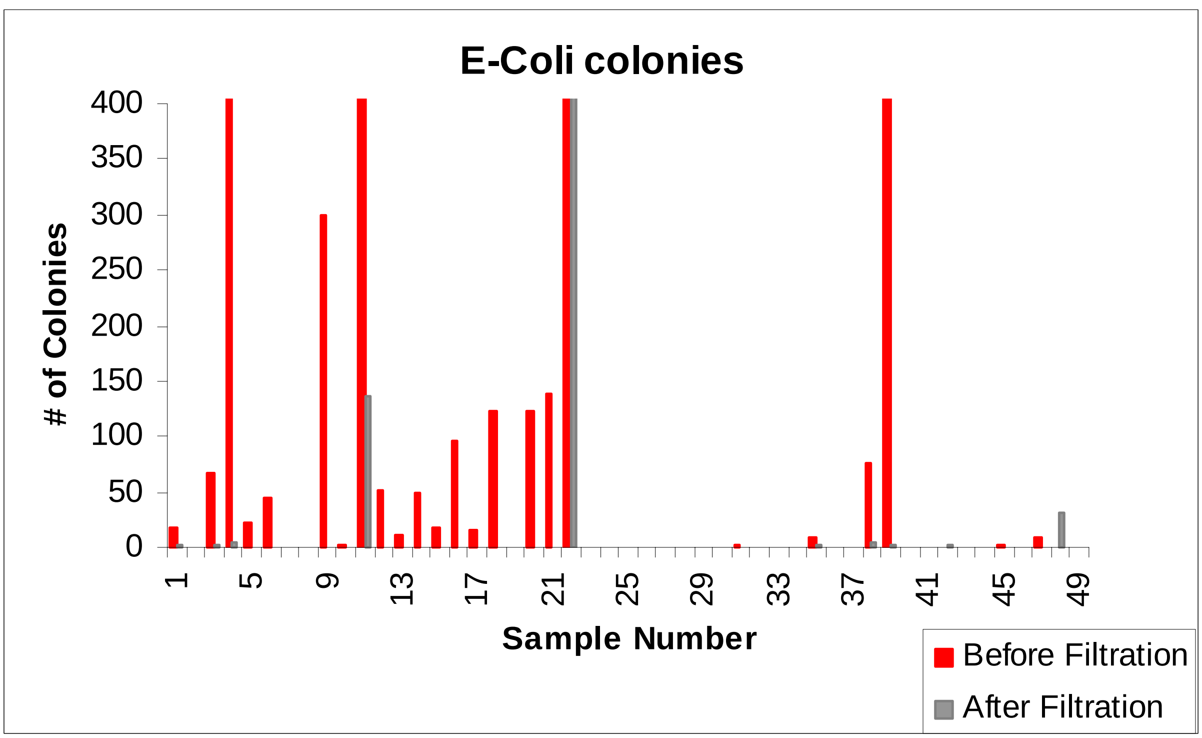


Figure 4-13 Count on Total Coliform and E-coli before and after filtration

4.7 Discussion for Membrane Filtration Tests' Results

The divergence between the H_2S MPN and the membrane filtration results may be due to human error or to the inherent sensitivity of the two methods. This topic will be further analyzed in chapter 6.

Lira (undated) reported MF results in the regions of Jinotega and Matagalpa (north of San Francisco Libre) in Nicaragua. Lira found 53% of the sample population (our of a total of 215 wells) to have 0 CFU/100 mL for Total Coliform. This value is slightly closer to our MF results (30.6%), but still inconclusive to show which of the two methods used in our study may be more reliable.

University of California in Berkley Master of Engineering graduate Scott Stoller compared the H_2S MPN to the H_2S P/A method in Lumbini, Nepal. His key findings were:

- <u>H_2S P/A vs. H_2S MPN</u>: H_2S Presence responses corresponded to H_2S MPN values between 8 and 16,000 CFU/100ml. Only one sample above 15 CFU/100ml failed to trigger a Presence response from the H_2S P/A. Comparing 15 samples, the P/A test was in agreement with the H_2S MPN test 73% of the time.
- <u>H_2S P/A vs. MF</u>: comparing the 24 H_2S P/A samples, the H_2S P/A showed a 58% agreement with both E. coli and TC. TC and E.coli values up 400 CFU/100ml sometimes failed to have a corresponding positive response for H_2S P/A. There was no relationship between the magnitude of the total coliform and E.coli concentration to the presence or absence of H_2S producing bacteria.
- <u>H_2S MPN vs. MF</u>: the H_2S MPN had a good correlation with E-coli (90%) and total coliform (93%) when 16 tube water samples were tested. When 48 tube well and treated water samples were tested, the H_2S MPN/total coliform correlation was still very high (97%), but the H_2S MPN E-coli correlation dropped significantly (57%).

Stoller's results suggest that there may be intrinsic divergence between MF and H_2S P/A results, since his agreements rates were as poor as 58%. H_2S MPN generally had high correlation with the MF method, but in same cases it could be as low as 57%. In light of these findings, the lack of correspondence between our H_2S MPN and MF results does not necessarily indicate that the results from one of the two methods is unreliable. On the other hand, other comparisons between the two methods reported in the literature rendered higher correlation rates above 71% (WHO, 2002). Therefore, the validity of H_2S MPN results from our study remains inconclusive.

Unfortunately, it is not possible to establish a correlation percentage of the two methods in our case, since tests were performed for different sets of samples. A qualitative comparison between the two methods is presented in Chapter 6.

Unreliable field conditions also challenge the validity of these results. Incubation was not successfully maintained at 35°C at all times, due to sudden power failures and to a malfunctioning incubator. The room temperature was around 35°C during the day, but it could reach much lower temperatures of 25°C during the evenings and nights. During sunrise, the temperature appeared to lower even more. These abrupt temperature changes may have had an effect on the performance of the incubator to maintain constant and undisturbed conditions. In some cases, the incubating samples had to be moved from the laboratory to the residence of the author, because of the need of constant temperature monitoring. These disturbances may have skewed the results to some degree. Another obstacle that was experienced was the lack of a proper waste disposal system . Membrane filtration generates a considerable amount of solid and liquid waste, which may involve environmental problems when not disposed properly. The need of refrigerating the broth was another inconvenience in the field, because of the aforementioned power instability.

PFP filter's removal rates for Total Coliform and E-coli are high, although still do not meet drinking water standards set by the World Health Organization's (WHO) *Guidelines for Drinking Water Quality* (2002), which require zero colonies of Total Coliform and E-coli per 100 mL of sample. The percentage of households that are close to meeting the standards (<2.2 colonies per 100 mL of sample) is as low as 31%. These results show the need of complementary technologies and solutions to the PFP filter in order to improve the water quality for the communities of Pacora, San Roque, Laurel Galán and Madroñito.

4.8 Summary for Six-Months Monitoring Experiments

This long monitoring program has shown that the PFP filter has potential to be an efficient tool to increase access to safe water in rural areas. One of the most important findings was a realization of the importance of continuous follow up in order to guarantee appropriate handling and maintenance of the filter. This monitoring should be a component of a holistic approach to solving water problems, which must include water quality analysis at the point of consumption (i.e. right before water is consumed), and regular collection of information for both engineering and health improvements. These programs should be targeted to a female population, since women are the dominant caretakers of the PFP filter, and this should include education, availability of sustainable and appropriate technologies, and cultural behavior as essential components. For example, hygienic practices play an important role in the microbiological removal rate of the filter.

The PFP filter did not present appreciable change in filtration rate and performance during the 6-month period studied. However, 15% of the filters were broken during the 6-month period, which raises the question of sustainability of this technology in the long-term.

Despite many positive qualities, the filter has shown to be vulnerable to several variables, which demand the existence of alternative solutions that could complement the performance of the filter. Two of these variables were identified to be breakage and necessity of frequent re-filling in order to provide average-sized household with sufficient water. Contamination during transportation of water from the source to the houses was significant. Similarly, results suggested that contamination during storage may be appreciable. Moreover, there are certain design modifications that must be performed to satisfy the user, who mostly complained about the capacity and the material of the filter.

4.9 Results and Discussion for Training Program of Local Potters

Every participant in the training program made at least one filter. All filters cracked after firing. Ron Rivera followed up on further trials performed independently by some of the participants. By January 2003, no working filters had been made by these potters. Some of the problems were identified to be the lack of easy access to sawdust in the rural villages, and the diversity on the quality of the clay that created variable requirements of water and sawdust, which could not be predicted during the workshop. Personal communication with Ron Rivera revealed that hand-made filters need several iterations before a working prototype and continuous supervision and guidance to potters until the correct parameters for each type of clay were determined. This close follow up was unfeasible remotely. Nevertheless, when the author left Nicaragua in at the end of January 2003, potters were still trying different prototypes, for which the final turn out of this program is currently unknown.

Chapter 5: SUMMARY OF FIELD EXPERIENCE AND GENERAL PRINCIPLES DERIVED FROM THE SFL MONITORING PROGRAMS

The results presented in the Chapter 5 show that monitoring programs may provide valuable information both as feedback to filter users to maintain or improve their filter usage, and to researchers such as our MIT team who are seeking to improve filter design. The data can be analyzed and used to support social, political, economical, environmental, administrative and cultural changes in order to improve the access to safe water to the monitored communities. However, organizing surveillance programs is a time-consuming and delicate task. There are many factors to take into account, and advance planning is required to ensure the appropriate collection, analysis and interpretation of data. This information is useless unless the right channels of knowledge-dissemination are established so that health officials and community members are able to comprehend and convert the information into a tangible improvement. Without a systematic methodology to regularly assess the water quality of a community and to provide education to users of water treatment technologies, projects will likely be unsustainable. This Chapter outlines general principles that should be kept in mind while designing the implementation of a monitoring program. Some of these guidelines were lessons learned during the 6-month monitoring program in San Francisco Libre, and others were based on principles presented by Guy Howard in *Water Supply Surveillance – a Reference Manual* (2002).

First, a summary of the learning and outcomes from our experience in San Francisco Libre is listed as follows:

A) <u>Positive outcomes of monitoring program:</u>

1. Statistical data was gathered on the performance of the PFP filter;
2. Sources of contamination and re-contamination were identified;
3. Feedback on contamination levels of water samples was provided to study participants during the course of the project and corrective actions were taken that appeared to result

in significant improvement (assuming we trust the data) at least during the subsequent months of September through December;

4. User needs were understood: larger filters are desired and ceramic recipient vessels were preferred over plastic;
5. Breakage rate was assessed through observation;
6. A foundation for future research was for future research was established;
7. This was the first time we had ever attempted to set-up a medium term monitoring program, as distinct from site assessment and technology water quality evaluations at given points in time and a lot of valuable lessons were learned.

B) Things that could have been improved:

1. Initial goals for the project were too ambitious;
2. A field worker lacking laboratory training and possibly lacking motivation was hired;
3. There was a lack of constant supervision of the field partners;
4. The analytical method used (H_2S Paper Strip MPN) was not validated or checked with parallel testing;
5. Time planning was deficient, since we run out of time;
6. We did not secure a partner with laboratory facilities;
7. Real-time feedback was not achieved, due to a deficient communication channel;
8. Surveys should have included more questions that cross-checked earlier ones;
9. The appropriateness of choosing 5 vials of 10 mL with no dilutions for the H_2S MPN method for our field site was not verified before starting the monitoring program;

The following section presents general guidelines that will prevent future researchers from making similar mistakes.

5.1 General Guidelines

- *Focus on a few basic parameters to be studied during the monitoring program*

Monitoring programs that have overly ambitious goals may fall short in gathering the most relevant data and create prohibitive costs for low-income communities, aid programs or government budgets. Howard recommends testing critical parameters only:

- quality
- quantity
- access
- cost
- use patterns

These variables should be assessed "up to the point of consumption." For the study of water quality, microbiological indicators, such as E-coli or fecal coliforms, may be used inexpensively for frequent and long-term surveillances. For chemical contamination, Howard suggests focusing only on nitrate, arsenic and fluoride levels, unless there is previous knowledge of other serious contaminants in the region. Water color, taste, odor and other factors that may cause rejection of water sources by users should also be included in the study, even if they do not represent a health risk. Cultural behavior may be as important or even more relevant than physical and microbiological parameters of general risk that affects a community.

Sanitation information may be coupled with water supply and quality studies, since in many cases these two variables are closely connected. Howard emphasizes the need of holistic studies: "Water quality alone is very unreliable measure of system performance and provides little or no information about risks in the long and short term and provides limited information about causes of water quality failures and sources of pollution. Furthermore, water quality analysis is inherently temporally and spatially constrained and, whilst results from small samples are used to predict quality for larger volumes, this entails a certain degree of inaccuracy and unreliability."

- *Setp-by-step improvement is more sustainable than radical change*

Howard asserts, "interim water quality objectives may be more effective in improving water quality progressively than trying to apply stringent standards." Further, he explains that these stringent standards, such as the guidelines promulgated by WHO, “are based on the risk to health from contaminant water supplies and do not address with issues of achievability. In general, these guideline values are only likely to be achieved by chlorinated water supplies.” Applying this concept to monitoring programs, data collected during such programs should be used to progressively increase the access to high quality water supplies, instead of aiming for perfect solutions, in particular when resources are not available for a central treatment system.

In this study, the PFP filter was effective in a monitored field context to decrease the contamination level of the source water, although not sufficient to reach ideal levels of water purity (WHO recommends 0 CFU/100 mL). Interim solutions were identified, such as specific design modifications (e.g. increase of capacity) and the addition of chlorine after filtration, which would significantly improve the quality of water accessed by villagers in San Francisco Libre, before radical changes such as a piped system or a more robust technology become feasible.

- *Surveillance should be designed to ultimately improve and maintain water supplies that represent a limited risk to the health of users*

Monitoring programs should be designed not only to identify and help clean up contaminated sources, but also to create general environmental consciousness that promotes conservation of safe sources of water. Oftentimes, only polluted wells may be scrutinized and frequently monitored, leading to inattention to risk-free sites, which consequently become contaminated.

Many of the households studied in the 6-month monitoring program in Nicaragua which did not have detectable levels of contamination had contaminated filtered water in later months. Every month, there were a number of new families with polluted samples who had not have contamination earlier in the study. Similarly, wells with no detectable contamination became contaminated in later months, without a significant change on maintenance level by the users. These examples show that contamination and re-contamination of clean sources should be actively avoided, along with remediation of polluted sites.

- *Decrease costs of surveillance by de-centralizing the system*

High costs are a major obstacle in the implementation of monitoring programs. Frequently, organizations and governments prefer to allocate funding to starting new projects, or to covering a larger number of beneficiaries, rather than spending resources in following-up fewer projects.

Our team experienced a general apathy from non-profit organizations to invest time and resources to support monitoring programs, since surveillance programs do not generally result in short term improvements and are not as marketable in funding proposal applications as other activities.

Therefore, costs should be kept to a minimum to increase the appeal of surveillance programs and to increase the affordability for health ministries and non-governmental organizations engaged in effective, long term monitoring.

De-centralizing the surveillance system may be efficient to decrease costs, since it will avoid most logistical problems due to long transport of samples, results and human capital. Moreover, an additional benefit of de-centralization is the promotion of local solutions to problems, by motivating local hygienic education and awareness of water problems.

- *Carefully select staff*

Surveillance staff should ideally have a basic science or engineering or public health background, ready to perform extensive field-work and have local experience. Staff members should be involved in all stages of the program (information collection, dissemination, and use).

In our project, the deficient application of this guideline caused reliability problems with respect to the data obtained during the 5 months of independent work by our field worker. The lack of previous health or laboratory science background raised questions as to the validity of those results.

- *Plan ahead and start with a pilot stage*

Howard proposes an iterative system that incorporates periodical feedback from workers and users (Figure 5-1):

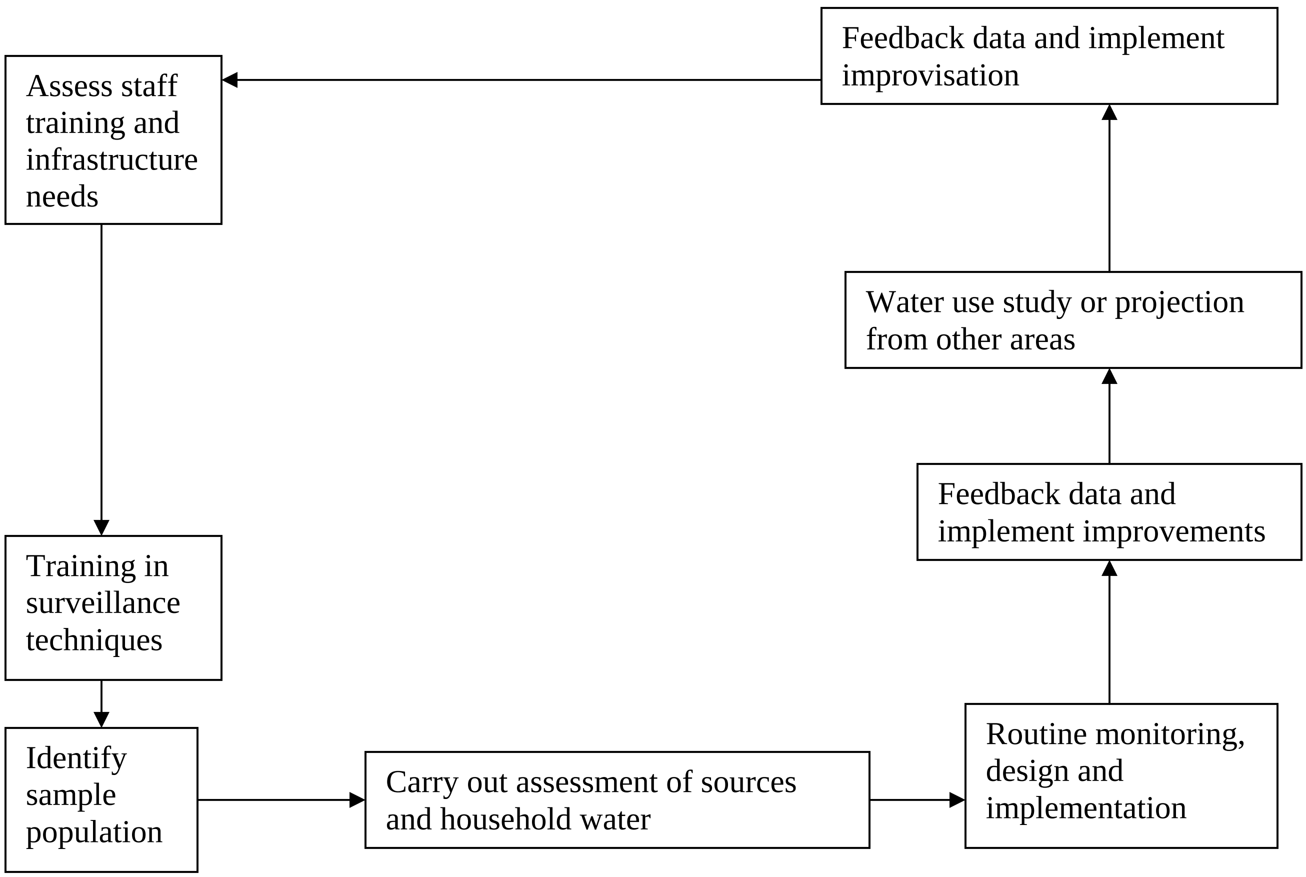


Figure 5-1 Steps to plan and implement monitoring programs (adapted from Howard, 2002)

Our project was based on a similar model. One of the lessons learned that could be added to Figure 5-1 is the timing of the feedback. Iterative feedback should happen in real-time, in other words, without an appreciable time lag from the feedback and the re-training of staff, re-organization of the infrastructure needs, and re-formulation of the problem statement. The time delays on data collection, analysis and report in our case added a large degree of inefficiency to our project.

- *Reporting of data should be frequent, comprehensible for non-technical readers and should incorporate community feedback.*

Without appropriate reporting, monitoring programs lose much of their power. The data collected must be understood and utilized for tangible changes, which cannot happen without frequent and adequate reporting.

- *In-situ analysis of data is recommended over remote analysis*

The analysis of the samples close to the field sites decreases the time lag between the feedback and the implementation of changes. In addition, the presence of staff and equipment in the field increases the interest and participation of the community, which in turn creates more opportunities for education.

In our study, this fact was corroborated. The presence of our team on site, and the ability to observe workers and equipment for water sampling and analysis, caught the attention of locals, especially children, who took the initiative to ask questions. This interaction occurred thanks to the data analysis *in-situ*, creating an excellent opportunity for informal health-education to local children.

The main drawback to this method is the possibility of increased contamination during analysis, due to the uncertain and unreliable conditions in the field (power outages, insects, dust, etc.). However, according to Howard, “for microbiological water quality testing, there appears to be little difference in the reliability of the results obtained, provided aseptic techniques are followed. The use of field-based approaches offers significant added benefits when working with low-income communities.” Nevertheless, quality assurance should be implemented to ensure reliability of data, by for example, using split samples or pre-prepared vials containing bacteria. Data that does not pass standards of quality assurance should not be necessarily discarded, but interpreted by noticing the special circumstances.

- *Data-entry and organization should be done systematically*

In surveillance programs, the final amount of data is often too large to handle manually. Since the outset of the project, an efficient software package or a well-designed data-entry system should be designed to avoid unnecessary additional work during the analysis phase.

In our project, data was entered manually on paper, then converted into an electronic file, which in turn was sent to the author in raw form. These EXCEL files had to be re-edited and re-organized several times before being ready for reporting. Therefore, it is important to establish a clear communication and data-reporting channel before starting the project.

- *Educational programs should complement monitoring programs*

Finally, monitoring must be accompanied by continuous education of users and health-workers. The results in Chapter 4 showed the importance of education in the maintenance of a successful improvement in water quality relative to the use of the PFP filter.

There may be several more factors that may be applicable to specific cases. Interaction and communication among stakeholders (government, health institutions, users, policy-makers, etc.) must increase and therefore increase collaboration, which will ensure the efficiency and sustainability of monitoring programs.

Chapter 6: COMPARISON BETWEEN H_2S-PAPER STRIP MPN AND MEMBRANE FILTRATION METHODS

6.1 Validity of H_2S-Paper Strip MPN and the MF Method

The mColiBlue24® MF method (HACH) has been certified by USEPA (method No. 10029) to be a valid and reliable technology to assess the degree of total coliform and E-coli bacterial contamination in water samples.[8]

The H_2S method has not been validated by the scientific community. Sobsey (WHO, 2002) declares that "the test has been in existence for two decades, it has been repeatedly modified, tested and field applied in many parts of the world, it is now widely promoted by some scientists and other authorities, and yet it has never been subjected to critical testing for its ability to fulfill or meet the essential criteria of a fecal indicator of drinking water quality."

The qualitative comparison between the H_2S-MPN method and the MF method has not been recognized as a valid approach to determine the appropriateness of the H_2S-MPN tests (WHO, 2002). However, the H_2S method has been widely used in a number of countries and thanks to its benefits (cost and practicality), this method deserves to be considered as an alternative technology at least for low-budgetary and isolated field conditions, i.e. the conditions of many developing countries. A practical way of determining the usefulness of the H_2S method may be through comparing it with other standard methods.

Several authors have used comparative methods to assess the validity of the H_2S tests: Manja et al (1982), Ratto et al. (1989), Kromredjo and Fujioka (1991), Venkobachar et al. (1992), Castillo et al. (1994), Martins et al. (1997), Nagaraju and Sastri (1999), Genthe and Franck (1999), and Rijal et al (2000). These authors covered a wide range of geographical areas, such as Peru, India, Indonesia, Chile, and South Africa. All the authors report agreement percentages ranging from 71% to 96% between the H_2S and validated standard methods (e.g. MF). These results were

[8] http://ecommerce.hach.com/stores/hach/pdfs/literature/L8170.pdf. Accessed on 02-24-03.

carefully analyzed by Sobsey and Pfaender in their *Evaluation of the H_2S Method for Detection of Fecal Contamination of Drinking Water (*WHO, 2002). Sobsey's compilation shows that the H_2S method is somewhat reliable, especially when the cases of disagreement with other methods are mainly based on false negatives. On the other hand, there are no standard criteria for comparison, or standard methods for H_2S-tests, which adds uncertainty to the conclusions.

Several different species of microorganisms produce H_2S, and the H_2S method does not measure the presence of either total coliform, fecal coliforms or fecal bacterium, as the MF method does (WHO,2002). Some coliform bacteria (e.g. *Citrobacter spp)*, enteric bacteria (e.g. *Clostridium perfringens)*, and other microorganism also produce H_2S, which could lead to false positives. Sobsey refers to several authors who have been able to identify some of these species: *Enterobacteriaceae, Clostridium perfringens, Enterobacter, Clostridia, Klebsiella, Escherichia, Salmonella, Acinetobacter, Aeromonas, Morganella,* and *Citrobacter,* among others. Not only microorganisms, but also abiotic chemical reactions can form sulfides (WHO, 2002). Therefore, the H_2S method has been shown to be a fairly reliable technology to assess H_2S-producing bacterial contamination in water, but cannot offer specific information as the MF method, which selectively counts the level of contamination by total coliform and E-coli, for example when using the mColiBlue24® culture media. As a consequence, when these two methods are used complementarily or independently, the analytical capacity of each method has to be taken into account to interpret the results

6.2 Field Implementation Considerations

For field implementation in isolated and challenging field sites, there are at least 3 factors that affect the appropriateness of a method:

1. Cost
2. Equipment, training and human resources requirements
3. Local availability of supplies

Cost

High costs make a test a method prohibitive in field implementation in developing countries. The large number of tests needed for a long-term monitoring program, coupled with the high costs of transportation may eliminate certain methods from most budgets. H_2S-Paper Strip MPN tests are relatively inexpensive compared to MF methods. The capital investment and the cost of supplies for H_2S MPN are far lower than those needed for MF. Table 6-1 shows estimated costs for both methods in a 6-month monitoring program based on the actual costs of the SFL 6-month monitoring program, in terms of H_2S MPN and the projected costs of MF based on 1 month's MF testing in January 2003. A more detailed breakdown of the costs is presented in APPENDIX D.

Table 6-1 Capital and variable costs for H_2S-MPN and MF methods[9]

Type of expenditure	H_2S-MPN [US$]	MF [US$]
Capital Investment	811[10]	2,210
Variable Costs (supplies every 1000 tests)	252	2,510
Cost per test (including capital investment)	0.66	4.72
Cost per test (without including capital investment)	0.25	2.50

We can see the significant advantage of H_2S MPN over MF as regards costs 6.3. The disadvantage, on the other hand, of the H_2S-MPN's are the additional effort of preparing the broth from raw ingredients represents. There may be higher opportunities of contamination during this preparation due to the unreliable sterile conditions of field laboratories. However, we did not observe any evidence of this in our 6-month monitoring program. Moreover, quality control protocols on self-made broths is generally lacking, whereas the strict quality assurance of

[9] In terms of this computation, one "test" with H_2S MPN represents 5 vials of 10 mL sample for each vial.
[10] The capital investment of H_2S MPN may be substantially decreased by purchasing a less expensive oven. Oven prices vary largely in different geographical locations (see Appendix D).

ready-to-use culture media manufactured by well-known laboratories such as HACH and Millipore are well established.

The capital investment of the MF method is reduced in practice when equipment is re-used in later programs. Most pieces of equipment that represent high costs are portable and thus easily transferable to other field sites. In any case, the variable costs for MF alone are substantially higher than the total costs for H_2S-Paper Strip MPN tests when pre-manufactured broths are used.

Low (2002) suggested that self-made broth for MF could decrease the costs for this method substantially. His results specifically show that the $2.50 cost per total coliform or E-coli test can be reduced to $0.70 - $0.75 per test if one prepares the broth. These are shown in Table 6-2.

Table 6-2 Comparison between pre-packed and self-made broth for E-coli, Total Coliform and Fecal Coliform detection by MF method (Low, 2002)[11]

Indicator Organism to be Detected by MF	Culture Medium	Total Cost for Sample [US$]
Total Coliform	m-ColiBlue24® (pre-packed)	2.50
Fecal Coliform	m-FC (self-made)	0.71
E-coli	EC with MUG (self-made) mColiBlue® (pre-packed)	0.74 2.50

Equipment, Training and Human Resources Requirements

In terms of expensive equipment, the MF method requires an incubator, a high-precision pipette, a refrigerator and a MF filtration kit. The H_2S-Paper Strip MPN method requires a kitchen oven for sterilization and a balance. Hence, MF requires electricity (or several replacement batteries that may be recharged during visits to the nearby cities), whereas H_2S-Paper Strip MPN needs propane gas or other fuel supply and commercially availably AA batteries for the scale. In Nicaragua, propane gas tanks for kitchen ovens are fairly available for low costs in case of

[11] Low's costs only include test cost (filter paper, broth, disposable petri-dish and pads)

absence of a gas utility in the area. On the other hand, generators of electricity are expensive and complex to run, and rare in rural settings. The alternative use of batteries to power incubators and refrigerators is inconvenient due to the need of frequent recharging. In addition, rechargeable batteries tend to be costly. In fact, Iván Lira (undated) from the national water utility Empresa Nicaragüense de Acueductos y Alcantarillados Sanitarios (ENACAL) , Nicaragua, asserted that the need of a stable source of electrical energy was the main drawback of using MF in the rural areas of Nicaragua. His team chose the H_2S P/A method to perform their water analysis.

In terms of space, MF barely requires any space, since the entire kit can be stored in a medium-size suitcase. Space requirements for H_2S-Paper Strip MPN methods are slightly higher, since numerous vials per tests must be stored during 72 hours of incubation, with the additional room that the oven may occupy. The space for the oven may be reduced if replaced by a pressure-cooker, where there is supply of electricity.

Generation of waste is another important factor for field implementations. H_2S Paper Strip MPN produces approximately a 10 L bucket of solid waste (used Whirlpack sampling bags and used paper strips), and a bucket of liquid waste (used broth with sample water) per 25 samples tested. Both types of waste are biodegradable, and can be disposed in latrines. The waste generated by MF is significantly larger in quantity. For each 10 samples analyzed, approximately 1 10 L bucket of solid trash is generated (used sampling bags, petri-dishes, pipette tips, filters and empty broth capsules), and another bucket for liquid waste (filtered water, rinsing water and surplus broth). The main drawback of the solid waste generated by the MF method is its non-biodegradability. In rural villages where there is no central waste disposal and treatment system, this factor may have detrimental environmental consequences.

Both methods require sterile conditions in the laboratories. Nevertheless, the use of methanol as the sterilizing agent for the MF kit adds one more requirement for MF analysis. Good ventilation and absence of flammable vapors in the environment of the lab is strictly advised. Two members of our team experienced a mild methanol-intoxication accident due to deficient ventilation in the laboratory room. Their only exposure to methanol was the presence of a small flame burning methanol (Bunsen burner) and the flame in the closed-container of the MF kit in intervals of 15 minutes every 30 minutes. This incident raised our team's consciousness on the special precautions required for the MF method.

The last factor to consider is the training and the previous experience required for the technician in charge of the water analysis. From our project's experience, we concluded that the MF method require additional training and higher levels of laboratory experience than the H_2S-MPN method. For the MF method, training in pipetting, on performing serial dilutions, and on judgment for interpreting results were essential. For the H_2S MPN method, techniques that had to be taught were weighting chemicals, cleaning vials, and sterile pouring of water samples into the vials. It seemed that the second set of skills would be more likely covered by basic laboratories in the secondary school level, whereas the first list of techniques were more specific for those with more extensive laboratory training.

Local Availability of Supplies

The broth, pipette tips, padded petri-dishes, and methanol required for MF tests are generally locally unavailable. Even suppliers in the capital cities may not have all of those materials. It is possible to order from large cities, but the usual time lag is at least 2 months. The H_2S MPN needs special chemicals for the broth. However, the rate of usage of these chemicals is substantially lower than the frequency of re-supply needed for the MF's materials. For example, 200 to 500 grams of each chemical for H_2S-MPN were purchased for the whole 6-month monitoring program. Only half of each container was used during that period (approximately for 600 water samples, equivalent to 6000 vials tested). On the contrary, about 200 petri-dishes, 150 broth ampules and 200 pipette tips were needed for only 50 water sample tests during January 2003. In other words, in the case of H_2S MPN method it is possible to stock at the beginning of a long-term field project enough materials for the whole duration of the program, but impossible to do so in case of the MF method, unless large and costly shipment is part of the investment used. Both methods require latex gloves, distilled water and chlorine, which are usually available in nearby towns, or even sometimes in rural areas.

These several advantages of the H_2S MPN method that were mentioned seem to outweigh some of its disadvantages especially for rural and isolated areas. Venkobachar et al (1994) reached the same conclusion, by asserting that the H_2S method is well suited for routine quality assessment of rural water sources because it is simple and requires little laboratory support. On the other hand, Kaspar et al (1992) concluded that the test (a modified version of the H_2S test) was not suitable for control of surface water and dug well water due to the frequent presence of non-fecal (total) coliforms presumed to arise from degradation of plant tissues and poikilothermic animals.

6.3 Sensitivity

The MF method gives a concrete quantitative number of colonies per 100 mL of sample that can corroborated by the use of the appropriate control and duplicate tests. As long as the number per plate does not exceed 20 to 80 colonies, the final count is certified to be reliable. The sensitivity of the method is claimed to be 1 CFU/100 mL (HACH, 1999).

H_2S-MPN is not quantitative, but semi-quantitative. In other words, this method enables an approximate estimation of the degree of contamination of the samples. Statistical algorithms are used to define a number of categories (based on the number of vials and dilutions used) of contamination, such as >16, 16, 9.2, 5.1, 2.2, and <2.2 colonies per 100 mL of sample.
The sensitivity for the H_2S-MPN depends on the number of vials, dilutions and sample volume used. In our case, we were not able to detect colony numbers below 2.2 /100 mL. Sobsey (WHO, 2002) on the other hand claims that the sensitivity (not necessarily to bacteria, but to H_2S production) of this method is high: "Given the low solubility product of iron sulfide, the test can detect even small amounts of sulfide formation or presence. Any source of H_2S in the sample can lead to a positive result." Sobsey (Who, 2002) believes that the H_2S method is not less sensitive than other standard methods: "when comparisons with other methods of detecting fecal contamination were done, the H_2S method appeared to have sensitivity similar to the other methods." According to Low (2002), this method has a sensitivity detection limit of 5 colonies per 100 mL of sample when using a 100 mL sampling volume.

Depending on the purpose of the experiments, the sensitivity of H_2S-MPN may or may not be sufficient. For example, to calculate the precise microbiological removal percent of a filter, MF is necessary. For generic surveillance programs, an assessment of an approximate level of contamination may be enough. For further details on the sensitivity of the H_2S method, refer to Chapter 4 of the MIT Master's of Engineering Thesis by Low (2002).

6.4 Reliability of Data

The data offered by the MF method is guaranteed by Millipore and HACH to reliable with the mentioned sensitivity as long as the standard methods are followed. On the other hand, several authors have questioned the validity of the H_2S methods in terms of the amount of false positives and false negatives this method renders.

Lira (undated) reports that 3.7% of a total sample of 215 wells tested were shown to be false negatives (test showed Absence when in fact there were of H_2S producing bacteria), whereas 10% were false positives (test showed Presence when in fact there were no H_2S producing bacteria). Lira performed a quantitative comparison between the H_2S (Manja et al, 1982) and the MF method (Millipore), and found that86% of the results matched. The "contingency table" is shown in Table 6-3.

Table 6-3 Comparison between MF and H_2S (P/A) (Lira, undated)

		H_2S producing bacteria		
		Presence	**Absence**	**Total [%]**
Millipore Method for Fecal Coliform	**Presence**	93 (43.3%)	8 (3.7%)	101 (47%)
	Absence	22 (10.2%)	67 (42.8%)	114 (53%)
	Total [%]	115 (53.5%)	100 (46.5%)	215 (100%)

Studies performed by Terry Hazen at the Lawrence Berkeley Laboratory have reported higher false positive percentages, which reached the 25% of the samples (WHO, 2002).

The generation of false positives is not as serious as the creation of false negatives. In most cases, false positives will promote slightly stricter preventive measures in the community, without significantly increasing the costs of prevention or remediation (if around 10%). On the other hand, false negatives are dangerous because contaminated sources may be labeled as safe. This is more harmful than no testing at all, since the population may stop their usual preventive measures due to this new piece of information. Even when results are not false negatives or false positives, Howard (2002) cautions that “care should be taken when interpreting the results of microbiological analysis based on such indicators as their absence does not provide complete proof of absence of pathogens, but rather that the risk of large number of pathogens being present is relatively low.” Therefore, the use of indicator-based methods such as H_2S-Paper Strip MPN should be considered under the appropriate constraints.

Chapter 7: SUSTAINABILITY CONSIDERATIONS OF FILTER MANUFACTURING AND DISTRIBUTION MODEL

7.1 Filter Manufacturing

The PFP filter is currently managed by a cooperative of 7 members: Juan Carlos Guevara, Ron Rivera, Ivania Jerez, Luis Román, Liliana Román, Henk Holstag and Sergio Martínez of which 4 have been workers. The details of the PFP manufacturing process have been presented in Appendix B of the Masters of Engineering Thesis of C.S. Low (2002). The small filter factory in Ciudad Sandino, about 40 minutes from Managua, is run by only one worker, Juan Carlos Guevara, who performs all the tasks related to the filter production, as follows:

1) purchasing raw materials: saw dust, clay (defect bricks) and colloidal silver
2) grinding the clay
3) sifting the saw dust
4) mixing saw dust with clay
5) kneading the mix
6) pressing under mold
7) drying
8) firing
9) coating with colloidal silver
10) testing for quality control (based on filtration rate)
11) packing
12) ensemble

These tasks were performed by four workers until the beginning of 2003, when an abrupt decrease of demand caused the resignation of three workers who were also members of the cooperative, which left Guevara alone in the factory. Except for the drying phase, all other activities have lately been performed daily by Guevara. The duration of the drying period is dependent on the weather conditions, and can last from 1 to 2 weeks or more. This is one of the two major limiting factors for the speed of production. The other major factor is the capacity of the sole filter press. This press, which is manually operated by one worker, allows production of about 20 filters per day. The factory has some room for storage in a recently built second floor for approximately 1200 filters, but not enough for long-term supply. In 2002, a consultant was hired to optimize the drying process including the space, after which filter drying was re-organized on shelves and production was planned in-line (figure 7-1).

Figure 7-1 Re-organized storage on shelves of PFP filters

Raw materials are acquired from changing suppliers, saw dust for free from a sawmill close by, and the clay from Ceramic Chilpetepe, a brick manufacturer. The quality of the materials is variable. For example, the size, moisture level and composition of the sawdust are varied depending on the type of wood, the water conditions and other variables. This affects the final composition of the media considerably. The pore sizes of the filter depend on the size and degree of moisture of the sawdust, which in turn affects the microbiological removal of the filter. The variability due to weather conditions makes long-term planning infeasible, and the lack of storage space makes difficult having large amounts of leftover filters in stock. Weather also causes inability to meet deadlines on some occasions. Therefore, the cooperative operates sporadically depending on orders, which have not been steady over the last 2 years. In fact, an abrupt decrease in sales forced the cooperative to decrease the number of partners from 10 to 7.

The efficiency of production, in other words, the amount of defective filters produced in each batch is approximately 17 to 20%. This high percentage of unusable filters may raise the cost of production and decrease the affordability of the end-user to purchase filters directly.

7.2 Cost

The cost of the ceramic filter component is practically doubled by the cost of the plastic recipient vessel and the plastic faucet, which together represent 48% of the total cost. Table 7-1 shows a cost breakdown, provided by Ron Rivera. This information indicates that a thorough optimization of the manufacturing process may provide a more reliable service to purchasers, but it will only have a minor effect on the final cost. Nevertheless, the process must be optimized in order to increase the quality control and the capacity of production, which will enable the factory to meet deadlines and to be able to react to seasonal orders.

Table 7-1 <u>Breakdown of the costs for the PFP filter</u>

ITEM	Cost per filter [US$]
Clay, Processing, Transportation	0.06
Labor	0.56
Firewood, Transportation	0.10
Sawdust, Transportation	0.01
Microdyn	0.13
Plastic Bags	0.30
Rent, utilities	0.38
Sticker	0.60
plastic recipient vessel (5-gallon)	1.86
Top for plastic recipient vessel	0.44
Faucet	1.00
Depreciation	0.02
Publicity	0.05
TOTAL	6.02

7.3 Distribution

Non-governmental and non-profit organizations that have leftover funding to spend, or who focus on poverty alleviation are the main customers of PFP filters. The allocation of funding by NGOs for water projects or for filter purchases is challenged by the overall economy and the competition of other development project priorities. In addition, there are other competing filter technologies available in Nicaragua such as the "bio-sand filter," which may take up potential resources that could be spent on the PFP filter. In general, orders by NGOs range from the hundreds to thousands of filters, which are generally distributed for free to low-income families in rural areas. To the author's knowledge, very few, if any, of these non-profit organizations perform monitoring or follow-up on filter beneficiaries, which disables a potential market for replacement purchases. The financial status of the cooperative fluctuates based on the economic health of non-profits and the variable interest of the latter on water projects in general and more specifically, on PFP filters.

Another factor of the distribution is shipping. Roads in Nicaragua may be irregular and stony, particularly in rural areas, where most of the filters are delivered. The natural fragility of the filter material, and its shape make stacking and packing tricky. Unfortunately, an appreciable proportion of these filters break before reaching destinations; sometimes even over 5%, of them may crack during delivery. Even when they reach the households, 15 out of 100 were observed to break at the end of 6 months since purchase, despite continuous monitoring. It may be reasonable to hypothesize that the breakage rates are higher for those cases in which no follow up was performed. Therefore, the actual number of filters that are appropriately used by families in the long-term may be significantly lower than the number of filters produced by the filter every year. Somewhat important may be the fact that filters are generally given for free or heavily subsidized, which may increase negligence in their maintenance. On the other hand, full coverage of the filter price may not be feasible for low-income families in Nicaragua, where average monthly salaries may be below US$ 100 a month.

The uncertainties in the manufacturing process, the relatively high cost of raw materials, the dependence on NGO's purchases and the lack of financial solidity to invest in larger scale production, are all factors that may harm the sustainability of this filter.

Chapter 8: CONCLUSIONS AND RECOMMENDATIONS

The objectives of this thesis were to:

1) Implement and evaluate success and failures of a 6-month long monitoring program.
2) Assess performance of the PFP filter in those 100 households by measuring flow rate and microbiological contamination before and after filtration through the PFP device.
3) Identify variables that affect performance of the filter in those 100 households, such as common sources of contamination and cultural practices.
4) Survey user's impressions on filter's benefits and drawbacks.
5) Investigate the relevance of the H_2S-Paper Strip Most Probable Number method (H_2S MPN) as a useful approach in monitoring PFP filter performance in the challenging context (from the point of view of laboratory conditions) of Nicaragua.
6) Qualitatively compare H_2S – Paper Strip Most Probable Number (H_2S MPN) method with Membrane Filtration method.
7) Transfer knowledge on filter manufacturing to local potters.

The first four objectives addressed the study of the PFP filter parameters and performance in San Francisco Libre, Nicaragua, by using analytical testing and surveying over a 6 months period. These two objectives were implemented by designing a field-monitoring program that allowed the exchange of information between the MIT team and one hundred PFP filter users at regular intervals from July 2002 to January 2003. Users' reports suggested practices that likely increased the opportunities for contamination of water and the filtering device. In addition, participants of the study expressed their perception on what the real *needs* were, i.e., technological modifications that were appropriate to fulfill needs for more water from the PFP filter. Objectives 3 and 4 were therefore fulfilled.

Objectives 5 and 6 were part of the technical component of this study, i.e. to evaluate the practical benefits and drawbacks of using the H_2S-Paper Strip Most Probable Number method for long-term monitoring in developing countries. This method's relevance in this setting was evaluated by comparing its results to information provided by using the Membrane Filtration (with mColiBlue24® as culture media) method on half of the sample population.

Finally, technological transfer of the PFP filter manufacturing technique was attempted during a pilot workshop in which 12 local potters participated. The PFP filter's manufacturing and distribution system were considered as parameters that affect the sustainability of this solution to improve access to safe water in rural areas in Nicaragua.

In this section, conclusions on each goal and recommendations on further work are presented.

8.1 PFP filter performance and sustainability

The results of the 6-month monitoring program showed that the PFP filter is an effective treatment system to decrease the contamination level of water consumed by households in the rural areas surrounding San Francisco Libre under the condition of a monthly monitoring program. An average of 80% of families had filtered water with less than 2.2 CFU/100 mL. Although this performance level does not reach the guideline of 0 CFU/100 mL recommended for drinking water (WHO, 1996), the PFP filter was successful as an interim solution until a reliable piped system becomes available for the rural populations of Nicaragua. These step-improvements are valid milestones if the ideal target is currently unachievable and are effective to decrease the amount of health risk due to water borne diseases (Howard, 2002). Nevertheless, results from this study suggest the need of a multiple barrier water treatment approach, such as inclusion of chlorination after filtration.

There were no noticeable decreases on the filter performance in terms of flow rate and microbiological removal during the 6-month period. The PFP filter seems to function consistently over the first 6 months after manufacturing, which may imply that when adequate maintenance recommendations are followed, there are no problems due to pore-clogging or colloidal silver wearing out. However, information on older filters is not available, for which further studies on the durability of the PFP filter's initial performance are recommended.

Despite the effective performance of the PFP filter under an adequate monitoring regime, this device is susceptible to several sources of contamination. Filtered water was shown to become re-contaminated when the recipient vessels were not cleaned properly. Washing with filtered water was recommended, but in light of the already low capacity of the filter, this requirement may not be practical for the user. Perhaps a sealed intersection between the filtering receptacle and the recipient vessel may result in a more robust system. Other possible sources of contamination were observed when animals or children touch the filter faucet with dirty hands, and the contact between the filtering ceramic component's bottom with contaminated areas, such as the floor or the kitchen table, for example when the filter unit is being removed for cleaning.

Certain user practices created opportunities for contamination. Filters were not always stored in hygienic places, and apparently, water was not transported from the well to the houses in clean vessels, since contamination during this transfer was evident. Similarly, there was a possibility of re-contamination seconds before consumption due to a contaminated glass, which suggests that glassware utensils for food and water should be washed with filtered or chlorinated water. This fact raises the issue of filter capacity, since currently, the PFP filter barely satisfies the drinking needs of an average-sized family.

Features of the PFP filter that must be improved are its relative fragility and its low capacity. Approximately 15% of the initial sample population's PFP filter units broke during the course of this study. Taking into account that households participating in this study were continuously monitored, this breakage rate is high, and may be higher in families where no monitoring was performed. Users complained mainly of the low capacity of the filter. The average filtration rate of the PFP filter was 1.7 L/hrs, which was insufficient to meet the basic water needs (7.5 L/person/day) of an average-sized family (5 members). A higher filtration rate could increase the quantity of water available to users, but constantly re-filling the filter seemed to be inconvenient for most users. Therefore, a larger filter should be designed for better user acceptance. In addition, the plastic material of the collecting receptacle was a source of complaint from the participants of this study. Many users preferred ceramic recipient vessels to plastic, probably because of the cooling effect of the ceramic material. Water temperature seemed to be a factor that could cause rejection of this technology, and thus further research on social acceptability studies of plastic vs. ceramic recipient vessels could be recommended.

Finally, the marketing strategy and manufacturing system that the PFP cooperative is currently implementing is not sustainable over the long-term. Attention should be paid to establishing solid market niches and decreasing the costs of the filter so that it becomes affordable to end-users. Moreover, the manufacturing process should be standardized as much as possible, to decrease variability on the quality of raw materials, which in turn will standardize the quality of the PFP filter.

8.2 Relevance of the H_2S Paper Strip MPN Method for long-term Studies in Developing Countries

The H_2S Paper Strip MPN method proved to be an inexpensive and convenient tool to conduct monitoring of water quality for long periods in developing countries. The major advantages were its low cost, low capital investment, easiness to perform, simplicity to interpret its results, and the minimal training and laboratory requirements. However, making the culture media was an additional burden and could be a source of contamination for the field test-performer. However, this did not appear to have been a problem in the case of this study. Despite this disadvantage, the method is valuable and likely the most affordable quantitative indicator organism for long-term monitoring programs. The information it provides allows enough quantitative data to prioritize the contamination problems of a community. Moreover, its simplicity allows local community leaders to be in charge of both sampling and analysis of water on-site, which empowers them to be more active in the development of appropriate and sustainable solutions.

According to the literature, the H_2S MPN method is comparable to other standard methods such as Membrane Filtration regarding the sensitivity to detect pathogens (WHO, 2002). However, the occurrence of false positives (10–25%) slightly decreases the reliability of this method. False positives are less of a concern than false negatives, from the point of view of the health risks that they may create. However, in our study, the divergence from the average results by using the

MF method and the H_2S MPN method suggests that false negatives, rather than false positives, may have affected our results. The MF tests showed substantially higher levels of contamination on the water after filtration compared to the H_2S MPN method, which was reflected mainly in the smaller percentage of households with less than 2.2 CFU/100 mL. These percentages were not larger for E-coli present after filtration. Although the H_2S MPN method and the MF method test for different indicators, the first is presumed to be able to detect presence of E-coli fairly sensitively (WHO, 2002). A couple of factors that may have skewed results is the unreliability of Zambrana and the difficult field conditions where the laboratory was set up. Moreover, our sample volumes and the lack of dilutions chosen for the sake of simplicity limited the sensitivity of our findings. Unfortunately, no parallel testing was performed with other methods after the initial selection of H_2S MPN, so it is not feasible to correlate the two methods in our case. Therefore, it remains inconclusive whether the method was appropriate in our field set-up, and whether H_2S MPN is generally much less sensitive than MF. However, other authors have been able to obtain high levels of correlation between those two methods (Lira, undated; WHO, 2002), and there was no evidence in our case that H_2S MPN was insufficient to provide acceptable amounts of information to prioritize those households or wells with the highest levels of contamination in the region. Therefore, the use of H_2S MPN is recommended for developing countries where resources are scarce, with the caveat that performing regular parallel tests with MF or other Standard Methods to validate results is needed.

8.3 Technology Transfer

Our experience showed that the PFP household water treatment technology must be transferred under appropriate supervision, and with on-going follow up. The local availability of each raw material must be checked for each location for the technology to be sustainable. The lack of sawdust in the rural communities surrounding San Francisco Libre jeopardized the correct transfer of the PFP filter manufacturing technique to local potters, since they could not afford to transport it from neighboring areas. If some materials are not available locally, the appropriate networks and resources must be provided so that iterations on prototypes may be possible before final products can be developed. Once these products become marketable, profits will allow the acquisition of unavailable supplies from neighboring towns.

8.4 List of Recommendations

8.4.1 Monitoring

- Monitoring of water quality should be a continuous communal effort and not dependant onforeign funding. Further research to find sustainable ways of designing and implementing frequent and long term-monitoring programs of household drinking water system for large distributed populations is recommended. For monitoring programs to be conducted by local communal groups, analytical methods must be inexpensive and practical. Frequent validation with other standard methods must be performed at regular intervals to ensure the quality of the data.
- Local universities and laboratories should be partnered with future MIT teams to facilitate research and later implementation of solutions.

8.4.2 Design modifications for PFP filter

- Further research to meet the WHO (2002) recommendation of 7.5 L/person/day by increasing flow-rate or increasing size of the PFP device is suggested;
- Materials or additional steps for the manufacturing process that increases the durability of the filter (and decrease breakage rates) should be studied;
- Multiple barrier techniques that complement the PFP filter to avoid contamination and re-contamination of water should be implemented and further researched;
- Alternative materials for the recipient vessel of the filter that insulates water from warm temperatures should be explored as an option if not as a substitute for plastic recipient vessels;

8.4.3 Research topics

- Research the durability and optimal concentration of the colloidal silver coating on the PFP filter;
- Assess performance of the PFP filter after the initial 6 months;
- Validate H_2S MPN by using comparative and parallel testing should be developed;
- Devise better communication channels that enable real-time iteration and feedback;
- Investigate optimal protocol to implement H_2S MPN tests in rural areas (number of vials, number of dilutions, volume of per vial);
- Design training and education programs that correct misconceptions and promote safe handling and usage of water Based on the results from the surveys of the 6-month monitoring program,;
- Design a sustainable model of filter production locally, by training local potters or motivating local entrepreneurs.

8.4.4 Recommendations for PFP users

- Use back-up technology to complement PFP filter, such as chlorine;
- Place a label on the filter indicating chlorine used in conjunction with the PFP filter will increase water safety;
- Perform live demonstrations on filter maintenance and washing, stressing the importance of avoiding re-contamination;

8.5 Recommendations for PFP cooperative

- Find a market niche that does not depend on NGOs and non-profits as main clients;
- Standardize the quality of the raw material to guarantee consistency of quality in the production.

REFERENCES

American Public Health Association (1998). *Standard Methods for the Examination of Water and Wastewatre,* 20th Edition, APHA-AWWA-WEF, Washington, DC.

CastilloG., Duarte R., Ruiz Z., Marucic M.T., Honorato R., Mercado R., Coloma V., Lorca V., Martins M.T., Dutka B.J. (1994). "Evaluation of disinfected and untreated drinking water supplies in Chile by the H_2S-Paper Strip Test." *Water Research* 28:1765-1770.

Crede, C.S.F. (1881). "Die Verhutung der Augenzundung der Neugeborene." *Arch. Gynako*. Volume 17, Issue 50.

Curiale, Mike (2003). MPN Calculator Developer. Personal communication. http://members.ync.net/mcruiale/mpn. Accessed 02-01-03.

Davis, Jennifer (2002). Class lecturer for class 11.479, "Water and Sanitation Planning in Developing Countries." MIT, Cambridge, Massachusetts, USA.

Dies, Rob (2003). MIT Masters of Engineering student. Personal communication.

Erikson, Sten (2001). Analysis of Ceramic Filter. Red Cross.

Franceys R., Pickford J., Reed R. (1992). *A Guide to the Development of Onsite Sanitation.* World Health Organization, Geneva, Switzerland. ISBN 92 4 154443 0.

Genthe B., Franck M. (1999). *A Tool for Assessing Microbial Quality in Small Community Water Supplies: An H_2S Strip Test.* WRC Report No. 961/1/99, 33 pages. To: Water Research Commission. By: Division of Water, Environment and Forestry Technology, CSIR, Stellenbosch, South Africa.

Gleick, Peter. (2000-2001). *The World's Water. The Biennial Report on Freshwater Resources.* Pacific Institute for Studies in Development, Environment, and Security Oakland, California, USA.

HACH (2002) . *Water Analysis Handbook.* 4th Edition. HACH, USA http://www.hach.com/wateranalysishandbook/index.htm Accessed 02-24-03.

HACH (1999). *HACH Method Specification Sheet For Hach Microbiological Methods – Total Coliforms and E-coli.* HACH, USA.

HACH (1999). *HACH Method Specification Sheet For Hach Microbiological Methods – mColiblue24®*. HACH, USA. http://ecommerce.hach.com/stores/hach/pdfs/literature/L8170.pdf. Accessed on 02-24-03.

HACH (2001). *Microbiology Environmental Laboratories – MEL Instrument and Procedures Manual for MEL P/A Safe Drinking Water Laboratory.* Online technical document.

HACH (2003). Equipment and laboratory supplies pricing. http://www.hach.com. Accessed 0-2-24-03

Heinig, Charles F. Jr (1993). "Research note. O_3 orO_2 and Ag. A new catalyst technology for aqueous phase sanitation." *Science and Engineering*. Volume 15, Issue 6.

Hiemenz P., Rajagopalan R. (1997). *Principles of Colloids and Surface Chemistry.* 3rd Edition, USA.

Howard, Guy (2002). *Water supply surveillance – a reference manual*. Loughborough University, UK.

Howard, Guy. (undated). *Water Safety Plans for Small Systems: a Model for Applying HACCP Concepts for Cost-effective Monitoring in Developing Countries.* Loughborough University, Leicestershire, UK.

Howard G., Bartram J. (2002). *Domestic Water Quantity, Service Level and Health.* Loughborough University, UK.

ICAITI (Central American Research Institute of Industrial Technology) (1984). *Identification and Evaluation of Design Alternatives for a LowCostDomestic Filter forDrinking Water*.

Kaspar P., Guillen I., Rivelli D., Valasquez G., De Kaspar H.M., Pozzoli L., Nunez C., Zoulek G. (1992). "Evaluation of a simple screening test for the quality of drinking water systems." *Tropical Medicine and Parasitolog*, 43(2):124-127.

Kromoredjo P., Fujioka R. (1991). "Evaluating Three Simple Methods to Assess the Microbial Quality of Drinking Water in Indonesia." *Environmental Technol ad Water Quality* 6:259-270.

Lantagne, Daniele (2001a). *Investigation of the Potters for Peace Colloidal Silver Impregnated Ceramic Filter*. Report 1: Intrinsic Effectiveness. Alethia Environmesntal

Lantagne, Daniele (2001a). *Investigation of the Potters for Peace Colloidal Silver Impregnated Ceramic Filter.* Report 2: Field Investigations. Alethia Environmental

Lantagne, Daniele (2001). *Trihalomethane Formation in Rural Household Water Filtration in Haiti*. Masters of Engineering Thesis. MIT, Cambridge.

Lin, Yu-Sen E., Vidic R., Stout J., McCartney C., Yu V. (1998). "Inactivation of Mycobacterium Avium by Copper and Silver Ions." *Water Resources*. Volume 32, Number 7.

Lira I., Matamoros A., Jacob F., Baltodano F., Harvey R. (undated). "Detection of H_2S-producing Bacteria to Measure Potable Water Quality; Comparison by Measuring Fecal

Coliform by using the Millipore Method in the field in Nicaragua." ENACAL/DAR, Matagalpa, Nicaragua.

Low, C.S. (2002). *Appropriate Microbial Indicator Tests for Drinking Water in Developing Countries and Assessment of Ceramic Water Filters.* Master's of Engineering Thesis, MIT.

Manja K.S., Maurya M.S., Rao K.M. (1982). "A simple field test for the detection of faecal pollution in drinking water." *Bulletin of the World Health Organization*. 60(5):797-801.

Martins M., Castillo G., Dukta B.J. (1997). "Evaluation of Drinking Water Treatment Plant Efficiency in Microorganism Removal by the Coliphage, Total Coliform and H_2S Paper Strip Tests." *Water Sci. Technol*. 35:403-407.

Millipore (1997). *Water Microbiology Laboratory and Field Procedures*. Bedford, USA.

Millipore (2003). Equipment and laboratory supplies pricing.

Nagaraju D., Sastri J.C.V. (1999). "Comfirmed Faecall Pollution to Bore Well Waters of Mysore City." *Environmental Geology*, 38 (4): 322-326.

(PAHO) Pan American Health Organization (2000). *Nicaragua*. http://www.paho.org/English/HVP/HVI/Profile_Nic_99-00.pdf Accessed 02-24-03

(PAHO) Pan American Health Organization (1999). *Nicaragua: Basic Country Health Profiles, Summaries 1999.* http://www.paho.org/English/SHA/prflnic.htm. Accessed 02-24-03

(PFP) Potters for Peace (2001). Home Page. http://www.potpaz.org/. Accessed 02-24-03.

Polz, Martin. (2002). Personal communication.

Ratto A., Dutka B.J, Vega C., Lopez C., El-Shaarawi A. (1989). "Potable Water Safety Assessed by Coliphage and Bacterial Tests." *Water Research* 23:253-255.

Reed R.A., (1995). *Sustainable Sewarage. Guidelines for Community Schemes.* Water, Engineering and Development Center, UK.

Rijal G.K., Fujioka R.S., Ziel C.A. (2000). "Evaluation of the Hydrogen Sulfide Bacteria Test: A Simple Test to Determine the Hygienic Quality of Drinking Water. Abstracts of the General Meeting of the American Society for Microbiology." Poster Presentation (unpublished). Abstract Q354, Page 622. *Amer. Soc. Microbiol*., Washington, DC.

Rivera, Ronald (10-2001). Personal communication.

Russell, A.D., Hugo W.B. (1994). "Antimicrobial Activity and Action of Silver." *Progress in Medicinal Chemistry*. Volume 31.

Sagara, Junko (2000). *Study of Filtration for Point-of-Use Drinking Water Treatment in Nepal*. Master's of Engineering Thesis. MIT.

Sánchez-Bain A., Dutka, B. (1998). *Module 7: Water Quality Control Techniques.* Fundación Tecnológica de Costa Rica. IRDC.

Stoller, Scout (2002). Unpublished manuscript.

Tillman T., Larsen T.A., Pahl-Wostl C., Gujer W. (2001). *Interaction Analysis of Stakeholders in Water Supply Systems.* Swiss Federal Institute for Environmental Science and Technology (EAWAG) and Swiss Federal Institute of Technology (ETH), CH-8600 Dubendorf, Switzerland.

Tsipouras N., Rix C.J., Brady P.H. (1997). "Passage of silver ions through membrane-mimetic materials, and its relevance to treatment of burn wounds with silver sulfadiazine cream." *Clinical Chemistry*. Volume 43, Issue 2.

(UN) United Nations Committee on Economic, Social and Cultural Rights (2002). http://www.worldwatercouncil.org/download/UN_water_public_good.pdf. Accessed 02-25-03.

(USAID) United States Aid for International Development (2001). *Hurricanes in Central America and the Carribean.*
http://hurricane.info.usaid.gov. Accessed 02-25-03

Van Zyl, Nadine.(2001). *Sodium Hypochlorite Generation for Household Water Disinfection in Haiti. Masters of Engineering Thesis*. MIT, Cambridge.

Varghese, Arun. (2002). *Point-of-Use Water Treatment Systems in Rural Haiti: Human Health and Water Quality Impact Assessment*. Masters of Engineering Thesis. MIT,

Venkobachar C., Kumar D., Talreja K., Kumar A. ,Iyengar I. (1994). "Assessment of Bacteriological Quality Using a Modified H_2S-Strip Test." *Aqua* (Oxford), 43(6):311-314.

(WHO) World Health Organization (1996). *Guidelines for drinking-water quality, 3rd Edition: Volume 3. Health criteria and other supporting information and Addendum to Volume 3.* Geneva

(WHO) World Health Organization (2002). *Evaluation of the H_2S Method for Detection of Fecal Contamination of Drinking Water.* Water, Sanitation and Health Department of Protection and the Human Environment, Geneva.

(WHO) World Health Organization (2003). *Guidelines, Standards and Health: Assessment of Risk and Risk Management for Water-Related Infectious Disease.* Center for Research into Environment and Health, Geneva, Switzerland.

APPENDIX A

Table A-1. Sample Demographics

#	Name of Person in Charge of Filter	Age y.old	Size Hhld	# Children	Age of Children y=years, m=months	Children under 5	Age of Filter months
1	Marina Conde	52	2	1	13 y	0	1
2	Eloísa Ovando/Rosa María González	58, 28	8	4	N/A	N/A	1
3	Esperanza González	30	3	1	4 m	1	>1
4	Juan Pablo Ovando Cano	73	2	0	N/A	N/A	1
5	Ramona Hernández	32	6	4	16 y,14 y,14 y, 4y	1	> 1
6	Danelia Salmerón-Rodríguez	?	6	N/A	N/A	N/A	> 1
7	Mariluz González	24	5	1	3 y	1	> 1
8	Narcisa Vásquez	22	4	2	4 y, 6 y	1	> 1
9	Juana Padilla	80	1	0	N/A	N/A	2
10	Susana López	38	7	4	2 y, 7y, 8y, 9y	1	>2
11	Maribel Salmerón	24	5	3	6 y,4y, 10m	1	> 1
12	Maryuri Padilla	14	8	6	14y,14y,11y,8y,5y,3y	1	> 1
13	Reynaldo Salmerón	78	3	0	N/A	N/A	> 1
14	María Inocente Hernández	74	2	0	N/A	N/A	2
15	Mónica de la Cruz Espinosa	61	9	1	2 y	1	> 1
16	Josefa Ordóñez	23	3	1	3 y	1	> 1
17	Lesbia Araya	35	4	2	5y, 15y	0	> 1
18	María Luz Castro Salina	36	7	3	2y, 1.5y, 3m	3	> 1
19	Carolina Antonia Ovando Torres	29	6	4	12y, 11y, 5y, 3y	1	> 1
20	Rebeca Ordóñez	22	7	3	11y,2y,7y	1	> 1
21	Eva Manzanares-Ordóñez	20	4	2	13y, 14m	1	2
22	Olga Monte	60	5	1	3y	1	1
23	Carla Salmerón	18	5	2	9y, 7m	1	1.5
24	Filomena Antonia Padilla Velásquez	60	4	2	14y, 13y	0	1
25	Romana Montez	38	6	4	14y,10y,9y,7y	0	2
26	Maryuri Padilla	17	3	1	6m	1	2
27	Audilia Hernandez	57	4	N/A	N/A	N/A	2
28	Carmina Padilla Rodrigez	24	6	2	5y, 4m	1	2
29	Hurania Padilla	42	8	2	6y, 8y		2
30	Esther Montes	23	4	2	4y, 2y	2	2
31	Ismelda Condez Rodrigez	28	5	3	9y, 8y, 2y	1	2
32	Leonor Padilla Salina	39	6	1	7y	0	2
33	Rosa Garcia Conde	38	5	3	11y, 15y, 7y	0	2
34	Damaris Padilla	16	3	1	6m	1	2
35	Rosa Padilla Castaño	21	3	1	2.5 y	1	2
36	Nely Padilla Castaño	19	3	1	4 y	1	2
37	Xiomara Padilla "P"	22	4	2	3y, 5y	1	2
38	Melba Padilla Montes	33	7	5	2y,8y, 9y,10y, 13y	1	2
39	Esmeralda chavez	24	3	1	4y	1	2
40	Esbelia Obando	52	6	2	8y, 12y	0	2

Table A-1. Sample Demographics (Continuation)

#	Name of Person in Charge of Filter	Age y.old	Size Hhld	# Children	Age of Children y=years, m=months	Children under 5	Age of Filter months
41	Adriana Salina Obando	20	4	2	5 y, 18m		2
42	Juana Conde Montes	41	9	5	3y, 7y, 9y, 12y, 13y	1	2
43	Ramona Padilla	55	4	-	N/A	N/A	2
44	Antonio Rojas Condez	59	2	-	N/A	N/A	2
45	Xiomara Rojas	20	3	1	9m	1	2
46	Inez Conde	56	4	1	6y	0	2
47	Elza Salmeron	70	6	2	4y, 7y	1	2
48	Vílma Zamora Reyes	45	7	2	13y, 15y	0	2
49	María Conde Salina	33	6	1	14 m	1	2
50	Leonsa Avendaño Ordoñez	59	7	2	4y, 5y	1	2½
51	Alejandra Escoto Avendaño	20	3	1	2y	1	2½
52	Jacudina Salina "A"	21	4	2	4y, 4m	2	2½
53	Socorro Padilla Aguilar	48	5	2	5y, 5y	0	2½
54	Rosa Alba Rojas Espinoza	26	8	6	2y, 3y, 6y, 7y, 8y, 10y	2	3
55	Jaquelin Picado Montes	18	3	1	4y	1	3
56	Eva Vasques Toruño	75	4	1	12y	0	2½
57	Guadalupe Padilla S	29	4	2	1y, 4y	2	3
58	Melania Montes Padilla	30	5	3	6y, 8y, 11y	0	2½
59	Ricardo Urroz B	30	5	3	3y, 8y, 13y	1	2
60	Angela Zambrana "A"	57	4	1	4y	1	3
61	Florencia Condez Godinez	60	6	1	2y	1	2
62	Albina Condez Vasque	36	5	3	1y, 7y, 11y	1	2
63	María Condez Perez	60	5	1	14m	1	2
64	Reina Salina Reyes	24	6	3	4y, 7y, 11y	1	2
65	Rosa Vasques Conde	40	8	1	6y	0	2
66	Telma Salina Barrera	54	3	1	3y	1	3
67	Elisabet Rojas Trejos	20	3	1	4y	1	3
68	Adela Reyes Salina	30	4	2	4y, 12y	1	3
69	Zorayda Reyes Salina	35	5	3	4y, 8y, 12y	1	3
70	María Obando Vasques	32	7	5	8y, 10y, 13y, 14y	0	3
71	María Ezpinosa Ramires	46	8	3	2y, 8y, 11y	1	3
72	Karla Mesa Ezpinosa	21	3	1	4m	1	3
73	Maria Mejia Zambrana	27	4	2	3y, 9m	2	3
74	Maria Reyes Rojas	57	6	1	8y	0	3
75	Simona Zamora "M"	69	3	N/A	N/A	N/A	3
76	Veronica Espinoza "S"	33	5	3	5y, 10y, 17m	0	3
77	María Reyes Murillo	55	7	5	5y, 8y, 9y, 11y, 13y	0	2½
78	Catalina Murillo Terminio	67	3	-	N/A	N/A	2½
79	Petrolina Urbina Urbiana	45	5	3	7y, 12y, 14y	N/A	2½
80	Enrriqueta Zotelo "M"	30	7	5	2y, 5y, 8y, 10y, 11y	1	2½

Table A-1. Sample Demographics (Continuation)

#	Name of Person in Charge of Filter	Age y.old	Size Hhld	# Children	Age of Children y=years, m=months	Children under 5	Age of Filter months
81	Aura Riveras Reyes	25	3	1	5y	0	2½
82	Marisela Reyes Benedith	29	4	1	1y	1	2½
83	Isabel Montes Pavón	23	6	3	6y, 11y, 12y	0	2½
84	Rosa Reyes Rojas	55	3	1	4y	1	2½
85	María Elena Alvarado	30	3	2	9y, 12y	0	2½
86	Juan Ramón Ramíres	72	1	N/A	N/A	N/A	2½
87	Socorro Moreno Blandon	40	8	4	3y, 5y, 13y, 15y	1	2½
88	Agustina Espínoza	70	1	N/A	N/A	N/A	2½
89	Lucia Mayorga Bobadillo	53	2	N/A	N/A	N/A	2½
90	Maria mesa Pavon	19	4	2	3y, 1m	2	2½
91	Llian Ramires Reyes	24	3	1	2y	1	2½
92	Amanda Urbina Espinoza	39	9	5	2y, 6y, 8y, 10y, 11y	1	2½
93	Agueda Cano Ramires	52	3	N/A	N/A	1	2½
94	Carla Arauz Reyes	28	5	3	4y, 6y, 10y	1	2½
95	Alba Luz Reyes Martinez	57	3	N/A	N/A	N/A	2½
96	Marta Rivera Espinoza	26	6	3	3y, 5y, 7y	1	2½
97	Juana Reyes Rojas	68	9	6	2y, 3y, 6y, 6y, 8y, 7m	2	2½
98	Telma Reyes Rojas	59	6	2	3y, 5y	1	2½
99	Mirna Briceño Terminio	42	1	N/A	N/A	N/A	2
100	Maura Obando	46	5	1	7y	0	2
AVERAGE		39.1	4.8	2.2		0.8	1.2

Table A-2. Results for Flow-rate measurements

#	Name	Community	Date	Starting Time	Ending Time	Volume Filtered	Use of Chlorine
1	Marina Condez	San Roque	7/10/2002	9:10 AM	10:15 AM	1,5	No
2	Eloisa Obando	San Roque	7/10/2002	9:15 AM	10:20 AM	1.8	Yes
3	Esperanza González	San Roque	7/10/2002	9:25 AM	10:30 AM	1.3	No
4	Juan Pablo Obando	San Roque	7/10/2002	9:28 AM	10:32 AM	1.5	Yes
5	Zorayda Leiva	SFL	9/3/2002	9:42 AM	10:45 AM	1.8	No
6	Danelia Salmerón	San Roque	7/10/2002	9:35 AM	10:40 AM	1.0	No
7	Mari Luz González	San Roque	7/10/2002	9:47 AM	10:49 AM	1.8	No
8	Narcisa Vasque	San Roque	7/10/2002	9:52 AM	10:53 AM	1.2	Yes
9	Juana Padilla	San Roque	7/10/2002	9:53 AM	10:58 AM	1.9	No
10	Adela Ordoñez	Pacora	9/3/2002	10:40 AM	11:05 AM	1.7	No
11	Maribel Salmerón	San Roque	7/11/2002	11:10 AM	12:10 PM	1.5	No
12	Flor Leiva D.	Laurel Galán	9/3/2002	9:55 A.M	11:00 AM	1.7	No
13	Reynaldo Salmerón	San Roque	7/11/2002	11:25 M	12:25 PM	2	No
14	María I. Hernandez	Pacora	7/11/2002	11:32 M	12:25 PM	1.6	No
15	Mónica Espinoza	Pacora	7/12/2002	10:30 AM	11:32 AM	1.2	No
16	Josefa Ordoñez	Pacora	7/12/2002	10:35 AM	11:37 AM	1.8	No
17	Lesbia Araya	Pacora	7/10/2002	10:05 A.M	11:10 AM	2.9	No
18	Mari Luz Castro S.	Pacora	7/12/2002	10:40 A.M	11:40 AM	1.5	No
19	Adela Manzanarez	Pacora	9/3/2002	10:45 A.M	11:46 M	2	No
20	Rebeca Ordoñez	Pacora	7/12/2002	10:47 AM	11:49 M	1.9	No
21	Eva Manzanarez C	Pacora	7/12/2002	10:55 AM	11:55 AM	1.6	No
22	Olga Montez H.	Pacora	7/12/2002	11:00 AM	12:02 PM	1.45	No
23	Karla Salmerón	Pacora	7/12/2002	11:07 AM	12:10 PM	1.75	No
24	Filomena Padilla	Pacora	7/12/2002	11:16 AM	12:18 PM	2.2	No
25	Ramona Montez	Pacora	7/12/2002	11:22 AM	12:24 PM	1.9	No
26	Teodora Rostrán	Laurel Galan	9/3/2002	9:05 AM	10:10 AM	1.8	No
27	Audelia Hernandez	Madroñito	7/12/2002	2:05 PM	3:08 PM	2	No
28	Carmina Padilla	Madroñito	7/12/2002	2:10 PM	3:12 PM	1.7	No
29	Urania Padilla	Madroñito	7/12/2002	2:16 PM	3:20 PM	1.85	No
30	Esther Montez	Madroñito	7/12/2002	2:20 PM	3:24 PM	1.25	No
31	Ismelda Condez	Madroñito	7/12/2002	2:28 PM	3:34 PM	1.35	No
32	Leonor Padilla	Madroñito	7/12/2002	2:35 PM	3:40 PM	1.8	No
33	Rosa Garcia	Madroñito	7/12/2002	2:38 PM	3:44 PM	1.75	No
34	Damaris Padilla	Madroñito	7/12/2002	2:50 PM	3:53 PM	1.95	No
35	Sonia Rojas	Laurel Galan	9/3/2002	9:11 A.M	10:15 A.M	1.6	No
36	Nely Padilla Castaño	Madroñito	7/15/2002	9:11 A:M	10:15 A.M	1.5	No
37	Xiomara Padilla Padi.	Madroñito	7/15/2002	9:16 A.M	10:19 AM	1.75	No
38	Melba Padilla Montes	Madroñito	7/15/2002	9:20 AM	10:23 AM	1.8	No
39	Esmeralda Chavez T.	Madroñito	7/15/2002	9:26 AM	10:29 AM	1.95	No
40	Esbelia Obando	Madroñito	7/15/2002	9:30 AM	10:34 AM	1.78	No
41	Adriana Salina	Madroñito	7/15/2002	9:35 A.M	10:40 AM	1.82	No
42	Juana Condez Montez	Madroñito	7/15/2002	10:04 AM	11:08 AM	1.9	No
43	Ramona Padilla	Madroñito	7/15/2002	10:06 AM	11:10 AM	1.47	No

Table A-2. Results for Flow-rate measurements (Continuation)

#	Name	Community	Date	Starting Time	Ending Time	Volume Filtered	Use of Chlorine
44	Antonio Rojas Condez	Madroñito	7/15/2002	10:10 AM	11:14 AM	1.85	No
45	Xiomara Rojas Vallejo	Madroñito	7/15/2002	10:15 AM	11.18 AM	1.95	No
46	Ines Condez	Madroñito	7/15/2002	10:20 AM	11:23 AM	1.78	No
47	Ma. Elsa Salmerón	San Roque	7/15/2002	10:25 AM	11:30 AM	2.1	Yes
48	Vilma Zamora Reyes	SFL	7/15/2002	2:18 PM	3:20 PM	2.0	No
49	Alejandra Sanch. Pad.	Pacora	N/A	N/A	N/A	N/A	N/A
50	Leonza Avendaño Ord.	Pacora		N/A	N/A	N/A	N/A
51	Alejandra Escoto A	Pacora	N/A	N/A	N/A	N/A	N/A
52	Jacundina Salina Ave.	Pacora	N/A	N/A	N/A	N/A	N/A
53	Socorro Padilla Aguil.	Pacora	N/A	N/A	N/A	N/A	N/A
54	Rosa Alba Rojas E	Pacora	N/A	N/A	N/A	N/A	N/A
55	Jaquelin Picado Mont.	Pacora	N/A	N/A	N/A	N/A	N/A
56	Eva Vasquez Toruño	San Roque	N/A	N/A	N/A	N/A	N/A
57	Guadalupe Padilla	San Roque	N/A	N/A	N/A	N/A	N/A
58	Melania Montez P.	Madroñito	N/A	N/A	N/A	N/A	N/A
59	Eva Leiva Avendaño	SFL	N/A	N/A	N/A	N/A	N/A
60	Alma Nidia Benedith	Laurel Galan	7/24/2002	9:35 AM	10:38 AM	1.8	No
61	Florencia Condez G.	San Roque	7/15/2002	10:32 AM	11:35 AM	1.8	No
62	Albina Condez Vasq.	San Roque	N/A	N/A	N/A	N/A	N/A
63	Maria Vasquez Perez	San Roque	7/15/2002	10:54 AM	12:00 PM	1.5	No
64	Reyna Salina Rojas	San Roque	N/A	N/A	N/A	N/A	N/A
65	Rosa Vasquez Cond.	San Roque	N/A	N/A	N/A	N/A	N/A
66	Telma Salina Barrera	San Roque	N/A	N/A	N/A	N/A	N/A
67	Elizabeth Rojas Trejos	San Roque	N/A	N/A	N/A	N/A	N/A
68	Adela Reyes Salina	San Roque	N/A	N/A	N/A	N/A	N/A
69	Zorayda Reyes Salina	San Roque	N/A	N/A	N/A	N/A	N/A
70	Maria Obando Vasque	San Roque	N/A	N/A	N/A	N/A	N/A
71	Maria Espinoza	Laurel Galan	7/18/2002	12:08 PM	1:10 PM	2.2	No
72	Karla Meza Espinoza	Laurel Galan	7/22/2002	11:11 AM	12:16 PM	1.2	No
73	Maria Mejia Zambrana	Laurel Galan	7/18/2002	12:00 PM	1:03 PM	1.5	No
74	Ma. Enriqueta Reyes	Laurel Galan	7/22/2002	10:25 AM	11:29 AM	2.8	No
75	Simona Zamara	Laurel Galan	7/18/2002	12:24 PM	1:26 PM	1.2	No
76	Veronica Espinoza	Laurel Galan	7/18/2002	12:35 PM	1:37 PM	1.8	No
77	Marina Reyes Murillo	Laurel Galan	7/18/2002	12:20 PM	1:22 PM	1.3	No
78	Ma. Ilaria Reyes Muri.	Laurel Galan	N/A	N/A	N/A	N/A	N/A
79	Catalina Murillo T.	Laurel Galan	7/18/2002	2:35 PM	3:35 PM	1	No
80	Petronila Urbina	Laurel Galan	7/23/2002	10:00 AM	11.04 AM	1.9	Yes
81	Enriqueta Sotelo M.	Laurel Galan	7/24/2002	10:10	11:13 AM	1.8	No
82	Petronila Mayorga	Laurel Galan	N/A	N/A	N/A	N/A	N/A
83	Marisela Reyes B.	Laurel Galan	7/23/2002	9:52 AM	10:56 AM	1.6	Yes
84	Ma. Estela Treminio	Laurel Galan	N/A	N/A	N/A	N/A	N/A

Table A-2. Results for Flow-rate measurements (Continuation)

#	Name	Community	Date	Starting Time	Ending Time	Volume Filtered [L]	Use of Chlorine
85	Rosa Reyes Rojas	Laurel Galan	7/23/2002	9:30 AM	10:32 AM	2	No
86	Ma. Elena Alvarado	Laurel Galan	7/24/2002	9:42 AM	10:47 AM	1.9	No
87	Juan Ramón Ramirez	Laurel Galan	7/24/2002	9:50 AM	10:56 AM	1.7	No
88	Sara Moreno Blandon	Laurel Galan	7/23/2002	9:46 AM	10:50 AM	1.3	Yes
89	Agustina Espinoza	Laurel Galan	7/23/2002	9:36 AM	10:40 AM	1.9	No
90	Lucia Mayorga B.	Laurel Galan	7/23/2002	9:40 AM	10:44 AM	1.5	No
91	Ma. Isabel Meza Pav.	Laurel Galan	7/23/2002	10:08 AM	11:12 AM	1.9	No
92	Lilian Ramirez	Laurel Galan	7/22/2002	10:37 AM	11:40 AM	1.1	No
93	Amanda Urbina	Laurel Galan	7/18/2002	2:23 PM	3:25 PM	1.8	No
94	Agueda Cano Ramirez	Laurel Galan	7/22/2002	10:43 AM	11:46 PM	1.2	No
95	Carla Arauz	Laurel Galan	7/22/2002	10:52 AM	11:56 PM	1.8	Yes
96	Alba Luz Reyes	Laurel Galan	7/22/2002	11:08 AM	12:11 PM	1.8	Yes
97	Martha Rivera E.	Laurel Galan	7/23/2002	10:15 AM	11:18 AM	2	No
98	Aracely urbina	Laurel Galan	N/A	N/A	N/A	N/A	N/A
99	Telma Espinoza T.	Laurel Galan	7/22/2002	10:59 AM	12:02 PM	1.35	No
100	Rosario Hernandez	San Roque	N/A	N/A	N/A	N/A	N/A

AVERAGE: 1.71 L

APPENDIX B

Results for Monitoring Program by using H_2S Paper Strip Testing

- "A" represents each vial where H_2S production was absent
- "P" represents each vial where H_2S production was present
- "A*" represents each vial where 1/3 of the vial was black
- "*P" represents each vial where 2/3 of the vial was black

Table B-1. Results for July [1]

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
58	Melania Montes Padilla			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
59	Eva Leiva			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAA+A+	AAAAA
60	Alma Nidia Benedith			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAP+P+P+	AAAAA	AAAAA
	Day 3	AP+P+P+P+	AAAAA	AAAAA
61	Florencia Condez Godinez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
62	Albina Condez Vasque			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
63	María Condez Perez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
64	Reina Salina Reyes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A

[1] In July, only 24 families were surveyed. The complete list of 100 households was completed in August

Table B-1. Results for July (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
68	Adela Reyes Salina			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
69	Zorayda Reyes Salina			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
70	María Obando Vásquez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
71	María Espinoza Ramírez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
72	Carla Mesa Espinoza			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
73	Maria Mejia Zambrana			
	Day 1	N/A	PPPPP+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
74	Maria Enriqueta Reyes Rojas			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAAA	AAAAA
75	Simona Zamora "M"			
	Day 1	AAAP+P+	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
76	Veronica Espinoza Saldaña			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
77	Marina Reyes Murillo			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-1. Results for July (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
78	María Ilaria Reyes Murillo			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
79	Catalina Murillo Terminio			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
79	Petrolina Urbina Urbiana			
	Day 1	N/A	PPPPP	PPPPP+
	Day 2	N/A	PPPPP	PPPPP
	Day 3	N/A	PPPPP	PPPPP
81	Enrriqueta Zotelo "M"			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
82	Petronila Mayorga Bobadillo			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
83	Marisela Reyes Benedith			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
84	María Estela Treminio			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
85	Rosa Reyes Rojas			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAAA	AAAAA
86	María Elena Alvarado			
	Day 1	N/A	PPPPP	AAA+P+P+
	Day 2	N/A	PPPPP	AAA+A+A+
	Day 3	N/A	PPPPP	AAA+A+A+
87	Juan Ramón Ramíres			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A

Table B-1. Results for July (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
88	Socorro Moreno Blandon			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
89	Agustina Espínoza			
	Day 1	N/A	AAAPP+	AAAAA
	Day 2	N/A	AAAPP+	AAAAA
	Day 3	N/A	AAAPP	AAAAA
90	Lucia Mayorga Bobadillo			
	Day 1	N/A	PPPPP+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
91	Maria mesa Pavon			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
92	Llian Ramirez Reyes			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAAAA	AAAAA	AAAAA
	Day 3	AAAAA	AAAAA	AAAAA
93	Amanda Urbina Espinoza			
	Day 1	N/A	APPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
94	Agueda Cano Ramírez			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAAA	AAAAA
95	Carla Arauz Reyes			
	Day 1	N/A	AAPPP+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
96	Alba Luz Reyes Martinez			
	Day 1	AAPPP+	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
97	Marta Rivera Espinoza			
	Day 1	N/A	AAP*P*P*	AAAAA
	Day 2	N/A	PPPPP*	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-1. Results for July (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
98	Araceli Urbina Saldaña			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
99	Telma Espinoza			
	Day 1	PPPPP+	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAP+P+
100	Rosario Hernández			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
101	School			
	Day 1	AAAAA	N/A	N/A
	Day 2	P*AAAA	N/A	N/A
	Day 3	PPPPP	N/A	N/A

Table B-2. Results for August

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
1	Marina Conde			
	Day 1	AAAPP+	PPPPP	AAAP+P+
	Day 2	PPPP+P+	PPPPP	AAPPP+
	Day 3	PPPPP	PPPPP	AAPPP
2	Eloísa Ovando/Rosa María González			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAP+
3	Esperanza González			
	Day 1	N/A	AP+P+P+P+	AAAAA
	Day 2	N/A	PPPPP	AAAP+P+
	Day 3	N/A	PPPPP	AAAPP
4	Juan Pablo Ovando Cano			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	PPP+P+P+	AAAP+P+
	Day 3	N/A	PPPPP	AAAPP
5	Zoraida Leiva			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAP+P+
6	Danelia Salmerón-Rodríguez			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
7	Mariluz González			
	Day 1	AAAAP	PPPAA	AAAAA
	Day 2	PPPPP	PPPAA	PAAAA
	Day 3	PPPPP	PPPPA	PPAAA
8	Narcisa Vásquez			
	Day 1	N/A	AAPP+P+	PAAAA
	Day 2	N/A	PPPPP	AAAAP
	Day 3	N/A	PPPPP	AAAPP+
9	Juana Padilla			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
10	Adela Ordóñez			
	Day 1	PPPPP	PPPPP	PPPPP
	Day 2	PPPPP	PPPPP	PPPPP
	Day 3	PPPPP	PPPPP	PPPPP

Table B-2. Results for August (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
11	Maribel Salmerón			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
12	Leiva Delgadillo			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAAA	AAAAA
13	Reynaldo Salmerón			
	Day 1	AAAAP+	AAAAA+	AAAAA
	Day 2	A+A+PPP+	APPP+P+	AAP+P+P+
	Day 3	PPPPP	APPPP	AAPPP
14	María Inocente Hernández			
	Day 1	PPPPP	PPPPP+	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
15	Mónica de la Cruz Espinosa			
	Day 1	N/A	AAAAA	AAAA+A+
	Day 2	N/A	AAAAP+	AAAP+P+
	Day 3	N/A	AAAPP	AAAPP
16	Josefa Ordóñez Castro Salina			
	Day 1	N/A	PPPPP	AAAAP+
	Day 2	N/A	PPPPP	AAAAP
	Day 3	N/A	PPPPP	AAPPP
17	Lesbia Araya			
	Day 1	PPPPP	PPPPP	PPPPP
	Day 2	PPPPP	PPPPP	PPPPP
	Day 3	PPPPP	PPPPP	PPPPP
18	María Luz Castro Salina			
	Day 1	N/A	PPPPP	PPPP+P+
	Day 2	N/A	PPPPP	PPPPP
	Day 3	N/A	PPPPP	PPPPP
19	Adela Manzanárez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
20	Rebeca Ordóñez			
	Day 1	PPPPP	PPPP+P+	AP+P+P+P+
	Day 2	PPPPP	PPPP+P+	PPPPP+
	Day 3	PPPPP	PPPPP	PPPPP

Table B-2. Results for August (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
21	Elia Manzanares-Ordóñez			
	Day 1	PPPPP	PPPPA	AAAA+P+
	Day 2	PPPPP	PPPPP+	A+A+P+P+P+
	Day 3	PPPPP	PPPPP	PPPPP
22	Olga Montes			
	Day 1	PPPPP	PPAAA	AAAAA
	Day 2	PPPPP	PPPAA	AAAAP+
	Day 3	PPPPP	PPPAA	AAAP+P+
23	Carla Salmerón			
	Day 1	PPPPP+	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAP
24	Filomena Antonia Padilla Velásquez			
	Day 1	PPPPP	PPPPP+	AAP+P+P+
	Day 2	PPPPP	PPPPP	AAPP+P+
	Day 3	PPPPP	PPPPP	AAPPP
25	Romana Montez			
	Day 1	PPPP+P+	APPP+P	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
26	Teodora Rostrán			
	Day 1	N/A	PPPPP+	AAAAP
	Day 2	N/A	PPPPP	AAAPP+
	Day 3	N/A	PPPPP	AAAPP
27	Audilia Hernandez			
	Day 1	PPPPP	PPPPP	PPPPP
	Day 2	PPPPP	PPPPP	PPPPP
	Day 3	PPPPP	PPPPP	PPPPP
28	Carmina Padilla Rodrigez			
	Day 1	APAPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAPAA
	Day 3	PPPPP	PPPPP	AAAAA
29	Hurania Padilla			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	PPPPP
	Day 3	N/A	PPPPP	AAAAP+
30	Esther Montes			
	Day 1	N/A	AP+AAA	AAAAA
	Day 2	N/A	PAPAA	AAAAP
	Day 3	N/A	PPPAA	AAAPP+

Table B-2. Results for August (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
31	Ismelda Condez Rodrigez			
	Day 1	N/A	PPPPP	PPPPP
	Day 2	N/A	PPPPP	PPPPP
	Day 3	N/A	PPPPP	PPPPP
32	Leonor Padilla Salina			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA+	AAAAA+
	Day 3	N/A	P+AAAA	AAAAA
33	Rosa Garcia Conde			
	Day 1	N/A	AP+AP+A	AAAAA
	Day 2	N/A	PPPPP	AAAAP+
	Day 3	N/A	PPPPP	AAAAP+
34	Damaris Padilla			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
35	Sonia Rojas			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
36	Nely Padilla Castaño			
	Day 1	N/A	PPPPP	AAAAP+
	Day 2	N/A	PPPPP	AAAAP+
	Day 3	N/A	PPPPP	AAAAP+
37	Xiomara Padilla "P"			
	Day 1	N/A	APPPP+	PPPPP
	Day 2	N/A	PPPPP	PPPPP
	Day 3	N/A	PPPPP	PPPPP
38	Melba Padilla Montes			
	Day 1	N/A	PPPPP	AAAAP+
	Day 2	N/A	PPPPP	AAAAP+
	Day 3	N/A	PPPPP	AAAAP+
39	Esmeralda chavez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
40	Esbulia Obando			
	Day 1	N/A	AAP+P+P+	PPPPP
	Day 2	N/A	AAPPP+	PPPPP
	Day 3	N/A	PPPPP	PPPPP

Table B-2. Results for August (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
41	Adriana Salinas Obando			
	Day 1	N/A	PPPPP+	APP+P+P+
	Day 2	N/A	PPPPP	PPPPP
	Day 3	N/A	PPPPP	PPPPP
42	Juana Conde Montes			
	Day 1	AAAP+P+	PPPPP	PPPPP+
	Day 2	PPP+P+P+	PP+P+P+P+	PPPP+P+
	Day 3	PPPPP	PPPPP	PPPPP
43	Ramona Padilla			
	Day 1	N/A	PPPPP	PPPPP
	Day 2	N/A	PPPPP	PPP+P+P+
	Day 3	N/A	PPPPP	PPPPP
44	Antonio Rojas Condez			
	Day 1	N/A	PPP+P+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA+
	Day 3	N/A	PPPPP	AAAAP
45	Xiomara Rojas			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPP+P+P+	APP+P+P+
	Day 3	N/A	PPPPP	APPPP
46	Inez Condez			
	Day 1	N/A	AAAPP+	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
47	María Elza Salmeron			
	Day 1	N/A	PPPPP+	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
48	Vílma Zamora Reyes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
49	Adelaida Sánchez Padilla			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAP+P+P+	AAAAA
	Day 3	N/A	PPPPP+	AAAAA
50	Leonsa Avendaño Ordoñez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-2. Results for August (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
51	Alejandra Escoto Avendaño			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAAP+P+	AAAAA
52	Jacudina Salina "A"			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
53	Socorro Padilla Aguilar			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	P+P+PPP	P+P+P+AA	AAAAA
	Day 3	PPPPP	PPPP+P+	AAAAA
54	Rosa Alba Rojas Espinoza			
	Day 1	N/A	P+PP+P+A	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
55	Jaquelin Picado Montes			
	Day 1	N/A	PPPPP	AAAPP
	Day 2	N/A	PPPPP	AAAPP
	Day 3	N/A	PPPPP	AAAPP
56	Eva Vasques Toruño			
	Day 1	N/A	AAAAP	AAAPP
	Day 2	N/A	PPPP+P+	AAAPP
	Day 3	N/A	PPPPP	AAAPP
57	Guadalupe Padilla S			
	Day 1	AAAAP	AAAPP	AAAAA
	Day 2	APPPP+	APPPP	AAAAA
	Day 3	APPPP	APPPP	AAAAA
58	Melania Montes Padilla			
	Day 1	AAAPP	PPPPP	PPPPP
	Day 2	AA+PPP+	PPPPP	PPPPP
	Day 3	PPPPP	PPPPP	PPPPP
59	Eva Leiva			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
60	Alma Nidia Benedith			
	Day 1	AAAAA	PPPPP+	AAAAA
	Day 2	AAAP+P+	PPPPP	AAAAA
	Day 3	AAAP+P+	PPPPP	AAAAA

Table B-2. Results for August (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
61	Florencia Condes Godinez			
	Day 1	AAAAA	PPPPP+	AAAAA
	Day 2	AAAP+P+	PPPPP	AAAAA
	Day 3	AAAP+P+	PPPPP	AAAAA
62	Albina Condez Vasquez			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	AAAAP+	AAAAA
	Day 3	N/A	AAAAP+	AAAAA
63	María Condez Perez			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
64	Reina Salina Reyes			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAAA	AAAAA
65	Rosa Vasquez Conde			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
66	Telma Salina Barrera			
	Day 1	PPPP+P+	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
67	Elisabet Rojas Trejos			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
68	Adela Reyes Salina			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA+
	Day 3	N/A	PPPPP	AAAAA+
69	Zorayda Reyes Salina			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA+
	Day 3	N/A	PPPPP	AAAAA+
70	María Obando Vasquez			
	Day 1	N/A	AAAAA	AAAAA+
	Day 2	N/A	APPPP+	AAAP+P+
	Day 3	N/A	PPPPP+	AAPPP

Table B-2. Results for August (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
71	María Espinoza Ramírez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
72	Carla Mesa Espinoza			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
73	Maria Mejia Zambrana			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
74	Maria Reyes Rojas			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
75	Simona Zamora "M"			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
76	Veronica Espinoza "S"			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
77	María Reyes Murillo			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
78	María Ilaria Reyes Murillo			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
79	Catalina Murillo Terminio			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
80	Petrolina Urbina Urbiana			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A

Table B-2. Results for August (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
81	Enrriqueta Zotelo "M"			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
82	Petronila Mayorga Bobadillo			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
83	Marisela Reyes Benedith			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
84	María Estela Treminio			
	Day 1	AAAAA	AAPPP	AAAAA
	Day 2	AAAAP	AAPPP	AAAAA
	Day 3	AAAAP	AAPPP	AAAAA
85	Rosa Reyes Rojas			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
86	María Elena Alvarado			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
87	Juan Ramón Ramírez			
	Day 1	N/A	AAAAA	PPPPP
	Day 2	N/A	AAAAA	PPPPP
	Day 3	N/A	AAAAA	PPPPP
88	Sara Socorro Moreno Blandon			
	Day 1	N/A	PPPPP	AAAP+P+
	Day 2	N/A	PPPPP	AAAPP
	Day 3	N/A	PPPPP	AAAPP
89	Agustina Espínoza			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
90	Lucia Mayorga Bobadillo			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A

Table B-2. Results for August (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
91	María Isabel Mesa Pavón			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	AAAAA	PPPPP	AAAPP
	Day 3	AAAAA	PPPPP	AAAPP
92	Llian Ramirez Reyes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
93	Amanda Urbina Espinoza			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
94	Agueda Cano Ramires			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
95	Carla Arauz Reyes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
96	Alba Luz Reyes Martinez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
97	Marta Rivera Espinoza			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
98	Araceli Urbina Saldaña			
	Day 1	N/A	AAAA+A+	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAAP+P+	AAAAA
99	Telma Espinoza			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
100	Rosario Hernández			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAP+P+

Table B-3. August Survey Results

Sample #	How many members drink from the filter?	How long does it take to fetch water? [minutes]	In what type of container do you fetch the water?	In what type of container do you store the water?
1	entire family	3	plastic bucket	plastic bucket/filter
2	entire family	3	plastic bucket	plastic bucket/filter
3	entire family	3	plastic bucket	plastic bucket/filter
4	entire family	4	plastic bucket	bucket
5	entire family	5	plastic bucket	plastic bucket
6	entire family	5	plastic bucket	plastic bucket
7	entire family	3	plastic bucket	plastic bucket/filter
8	entire family	5	plastic bucket	plastic bucket
9	entire family	7	plastic bucket	plastic bucket/ceramic pot
10	5 members	7	plastic bucket	plastic bucket/ceramic pot
11	entire family	5	plastic bucket	plastic bucket
12	entire family	5	plastic bucket	plastic bucket/filter
13	entire family	10	plastic bucket	ceramic pot/ plastic can
14	entire family	10	plastic bucket	
15	entire family	7	plastic bucket	plastic bucket -with lid
16	entire family	5	plastic bucket	plastic bucket
17	entire family	10	plastic bucket	plastic bucket -with lid
18	entire family	8	plastic bucket	plastic bucket/ceramic pot
19	entire family	5	plastic bucket	plastic bucket/ceramic pot
20	entire family	3	plastic bucket	plastic bucket/ceramic pot
21	entire family	3	plastic bucket	plastic bucket/ceramic pot
22	entire family	4	plastic bucket	plastic bucket/ceramic pot
23	entire family	5	plastic bucket	plastic bucket
24	entire family	3	plastic bucket	filter
25	entire family	5	plastic bucket	plastic bucket/filter
26	entire family	5	plastic bucket	plastic bucket/filter
27	entire family	3	plastic bucket	filter
28	entire family	8	plastic bucket	
29	entire family	6	plastic bucket	plastic bucket/filter
30	entire family	4	plastic bucket	plastic bucket/filter
31	entire family	7	plastic bucket	ceramic pot/ filter
32	entire family	6	plastic bucket	plastic bucket/filter
33	entire family	4	plastic bucket	plastic bucket
34	entire family	7	plastic bucket	plastic bucket
35	4 members	6	plastic bucket	plastic bucket/filter
36	entire family	6	plastic bucket	plastic bucket
37	3 members	10	plastic bucket	plastic bucket
38	entire family	8	plastic bucket	ceramic pot/filter
39	entire family	6	plastic bucket	plastic bucket/filter
40	entire family	5	plastic bucket	filter
41	entire family	5	plastic bucket	ceramic filter/plastic bucket
42	entire family	6	plastic bucket	filter

Table B-3. August Survey Results (continuation)

Sample #	How many members drink from the filter?	How long does it take to fetch water? [minutes]	In what type of container do you fetch the water?	In what type of container do you store the water?
41	entire family	5	plastic bucket	ceramic filter/plastic bucket
42	entire family	6	plastic bucket	filter
43	entire family	3	plastic bucket	filter
44	entire family	5	plastic bucket	plastic bucket/filter
45	entire family	5	plastic bucket	plastic bucket/filter
46	entire family	6	plastic bucket	filter
47	entire family	5	plastic bucket	plastic bucket/ceramic pot
48	entire family	15	plastic bucket	25 gal can with faucet
49	entire family	15	plastic bucket	plastic bucket/filter
50	entire family	15	plastic bucket	25 gal can with faucet
51	entire family	4	plastic bucket	plastic bucket
52	entire family	10	plastic bucket	plastic bucket/filter
53	entire family	10	plastic bucket	plastic bucket
54	entire family	5	plastic bucket - no lid	plastic bucket/ceramic pot
55	entire family	2	plastic bucket	filter
56	entire family	3	plastic bucket	filter
57	entire family	5	plastic bucket - no lid	ceramic pot
58	entire family	8	plastic bucket	plastic bucket. ceramic pot
59	entire family	8	plastic bucket	plastic bucket. ceramic pot
60	entire family	10	plastic bucket	plastic bucket. ceramic pot
61	entire family	15	plastic bucket	plastic bucket. ceramic pot
62	entire family	10	plastic bucket	plastic bucket. ceramic pot
63	entire family	7	plastic bucket	plastic bucket. ceramic pot
64	entire family	7	plastic bucket	plastic bucket. ceramic pot
65	entire family	8	plastic bucket	plastic bucket. ceramic pot
66	entire family	9	plastic bucket	plastic bucket. ceramic pot
67	entire family	6	plastic bucket - no lid	plastic bucket/filter
68	children	5	plastic bucket- with lid	bucket/can
69	entire family	5	ceramic pot with lid	can - with lid
70	children	6	bucket -with lid	bucket and can
71	entire family	15	bucket -no lid	ceramic pot
72	entire family	5	bucket -with lid	ceramic pot
73	entire family	5	bucket -no lid	ceramic pot
74	entire family	3	bucket -with lid	bucket -with lid
75	entire family	5	plastic bucket	plastic bucket
76	entire family	5	bucket -with lid	bucket and can
77	entire family	10	bucket -no lid	vase/ceramic pot
78	entire family	10	plastic bucket	plastic bucket/ceramic pot
79	entire family	7	plastic bucket	
80	entire family	10	plastic bucket	ceramic pot

Table B-3. August Survey Results (continuation)

Sample #	How many members drink from the filter?	How long does it take to fetch water? [minutes]	In what type of container do you fetch the water?	in what type of container do you store the water?
81	entire family	8	plastic bucket	plastic bucket/ceramic pot
82	entire family	15	ceramic pot -with lid	ceramic pot
83	entire family	4	plastic bucket - no lid	filter
84	entire family	5	plastic bucket	ceramic pot/plastic bucket
85	entire family	10	plastic bucket and pot	ceramic pot/plastic bucket
86	entire family	5	plastic bucket	ceramic pot
87	children	8	bucket - with lid	bucket -with lid
88	entire family	9	plastic bucket	plastic bucket
89	entire family	5	bucket - no lid	ceramic pot
90	entire family	3	bucket - no lid	ceramic pot
91	entire family	3	bucket - no lid	ceramic pot
92	entire family	3	bucket - no lid	ceramic pot
93	entire family	5	bucket - no lid	bucket/ceramic pot
94	entire family	7	plastic bucket	plastic bucket
95	entire family	5	bucket - no lid	bucket -with lid
96	entire family	5	plastic bucket	plastic bucket/ceramic pot
97	entire family	5	plastic bucket	plastic bucket/ceramic pot
98	entire family	5	plastic bucket	plastic bucket/ceramic pot
99	entire family	5	plastic bucket	plastic bucket/ceramic pot
100	entire family	5	plastic bucket	plastic bucket/ceramic pot
	AVERAGE	6.42		

Table B-4. Results for September

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
1	Marina Conde			
	Day 1	AAAAP+	AAAP+P+	AAAAA
	Day 2	APP+P+P+	PPPP+P+	AAAAA
	Day 3	PPPPP	PPPAP	AAAAA
2	Eloísa Ovando/Rosa María González			
	Day 1	AAAP+P+	P+P+PPP	AAAAA
	Day 2	AAPPP+	PPPPP	AAAAA
	Day 3	APPPP+	PPPPP	AAAAA
3	Esperanza González			
	Day 1	N/A	P+P+P+AP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
4	Juan Pablo Ovando Cano			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
5	Zoraida Leiva			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAAAA	AAAAA	AAAAA
	Day 3	AAAAA	AAAAA	AAAAA
6	Danelia Salmerón-Rodríguez			
	Day 1	AAAP+P+	AAPPP+	AAAAA
	Day 2	AP+P+P+P+	AP+PPP	AAAAA
	Day 3	PPPP+P+	PPPPP	AAAAA
7	Mariluz González			
	Day 1	PPPP+P+	AAP+PP	AAAAA
	Day 2	PPPPP+	PPPAA	AAAAA
	Day 3	PPPPP	PPPPA	AAAAA
8	Narcisa Vásquez			
	Day 1	N/A	PP+P+AA	AAAAA
	Day 2	N/A	PPPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
9	Juana Padilla			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
10	Adela Ordóñez			
	Day 1	N/A	AAAAP	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-4. Results for September (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
11	Maribel Salmerón			
	Day 1	N/A	PPPAP+	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	AAAAA	AAAAA
12	Flow Leiva Delgadillo			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAAAA	AAAAA	AAAAA
	Day 3	AAAAA	AAAAA	AAAAA
13	Reynaldo Salmerón			
	Day 1	AAAA+P+	AAAA+A+	AAAAA
	Day 2	APPP+P+	PPAP+P+	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
14	María Inocente Hernández			
	Day 1	PPPP+P+	APPPP+	AAAAA
	Day 2	PPPPP	PPPPP+	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
15	Mónica de la Cruz Espinosa			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAAPP	AAAAA
16	Josefa Ordóñez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
17	Lesbia Araya			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
18	María Luz Castro Salina			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
19	Adela Manzanárez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
20	Rebeca Ordóñez			
	Day 1	AAPP+P+	P+P+P+PP	AAAAA
	Day 2	PPPP+P+	P+PPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA

Table B-4. Results for September (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
21	Eva Manzanares-Ordóñez			
	Day 1	PPP+P+P+	PPPPA	AAAAA
	Day 2	PPPPP+	PPPPP+	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
22	Olga Monte			
	Day 1	PPP+P+P+	AAP+P+P+	AAAAA
	Day 2	PPPPP	AAPPP	AAAA+P+
	Day 3	PPPPP	PPPPP	AAAPP+
23	Carla Salmerón			
	Day 1	PPPP+P+	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	A+A+A+AA
	Day 3	PPPPP	PPPPP	AAPP+P+
24	Filomena Antonia Padilla Velásquez			
	Day 1	PPPPP+	PPPP+P+	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
25	Ramona Montez			
	Day 1	AAAP+P+	APPP+P+	AAAAA
	Day 2	AAPPP+	PPAP+P	AAAAA
	Day 3	APPPP+	PPPPP	AAAAA
26	Teodora Rostrán			
	Day 1	N/A	APPPP+	AAAAA
	Day 2	N/A	PPPPP	AAAPP+
	Day 3	N/A	APPPP	AAPPP
27	Audilia Hernandez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
28	Carmina Padilla Rodrigez			
	Day 1	AAAAP+	PPPP+P+	AAAAA
	Day 2	AAAPP	PPPPP	AAAAA
	Day 3	AAP+PP	PPPPP	AAAAA
29	Hurania Padilla			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
30	Esther Montes			
	Day 1	N/A	APAAA+	AAAAA
	Day 2	N/A	APPAA	AAAAA
	Day 3	N/A	AAPPP	AAAAA

Table B-4. Results for September (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
31	Ismelda Condez Rodrigez			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
32	Leonor Padilla Salina			
	Day 1	N/A	AAAPP+	AAAAA
	Day 2	N/A	AAAP+P	AAAAA
	Day 3	N/A	AAAP+P	AAAAA
33	Rosa Garcia Conde			
	Day 1	N/A	AAAP+P	AAAAA
	Day 2	N/A	APPP+P+	AAAAP+
	Day 3	N/A	PPPPP+	AAAAP
34	Damaris Padilla			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	APPPP	AAAAA
	Day 3	N/A	APPPP	AAAAA
35	Sonia Rojas			
	Day 1	N/A	PPP+P+P+	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
36	Nely Padilla Castaño			
	Day 1	N/A	PPPPP	AAAAP+
	Day 2	N/A	PPPPP	AAAAP
	Day 3	N/A	PPPPP	AAAP+P
37	Xiomara Padilla "P"			
	Day 1	N/A	PPPAA	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
38	Melba Padilla Montes			
	Day 1	N/A	PPPPP	AAAP+P+
	Day 2	N/A	PPPPP	AAAPP
	Day 3	N/A	PPPPP	AAA+PP
39	Esmeralda chavez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
40	Esbelia Obando			
	Day 1	N/A	AAP+P+P+	AAAAA
	Day 2	N/A	PPP+AA	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-4. Results for September (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
41	Adriana Salina Obando			
	Day 1	N/A	PPPPP+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
42	Juana Conde Montes			
	Day 1	AAAP+P+	PPPPP	AAAAA
	Day 2	PPPPP+	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
43	Ramona Padilla			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
44	Antonio Rojas Condez			
	Day 1	N/A	PPP+P+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
45	Xiomara Rojas			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
46	Inés Conde			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AA+P+PP	AAAAA
	Day 3	N/A	APPPP	AAAAA
47	Elza Salmeron			
	Day 1	AAAPP	PPPAP	AAAAA
	Day 2	P+P+PPP	PPPPP	AAAAA
	Day 3	PPPPP	AAAAA	AAAAA
48	Vílma Zamora Reyes			
	Day 1	AAAAA	PPP+P+P+	AAAAA
	Day 2	AAAAA	PPPPP+	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
49	Adelaida Sánchez Padilla			
	Day 1	N/A	AAAA+A+	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	PPPP+P+	AAAAA
50	Leonsa Avendaño Ordoñez			
	Day 1	N/A	PP+PP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-4. Results for September (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
51	Alejandra Escoto Avendaño			
	Day 1	N/A	P+P+AAA	AAAAA
	Day 2	N/A	PPP+AP+	AAAAA
	Day 3	N/A	PPP+P+A	AAAAA
52	Jacudina Salina "A"			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
53	Socorro Padilla Aguilar			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	P+P+PPP	AAP+P+P+	AAAAA
	Day 3	PPPPP	PPPP+P+	AAAAA
54	Rosa Alba Rojas Espinoza			
	Day 1	N/A	P+P+P+PA	AAAAA
	Day 2	N/A	P+PPPA	AAAAA
	Day 3	N/A	PPPPP	AAAAA
55	Jaquelin Picado Montes			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
56	Eva Vasques Toruño			
	Day 1	N/A	AAAAP	AAAAA
	Day 2	N/A	P+P+PPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
57	Guadalupe Padilla S			
	Day 1	AAAPA	AAAPP	AAAAA
	Day 2	PPPAP+	PPPPA	AAAAA
	Day 3	PPPAP	PPPPA	AAAAA
58	Melania Montes Padilla			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
59	Eva Leiva			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAA+A+A+	AAAAA
60	Alma Nidia Benedith			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAAA	AAAAA

Table B-4. Results for September (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
61	Florencia Condez Godinez			
	Day 1	AAAAA	PPP+P+P+	AAAAA
	Day 2	AAA+P+P+	PPPPP	AAAAA
	Day 3	AAA+P+P+	PPPPP	AAAAA
62	Albina Condez Vásquez			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	AAAPP	AAAAA
	Day 3	N/A	AAAPP	AAAAA
63	María Vásquez Perez			
	Day 1	N/A	AAAA+A+	AAAAA
	Day 2	N/A	AA+PP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
64	Reina Salina Reyes			
	Day 1	N/A	AA+A+A+A+	AAAAA
	Day 2	N/A	AAA+A+P+	AAAAA
	Day 3	N/A	AAA+P+P+	AAAAA
65	Rosa Vásquez Conde			
	Day 1	N/A	P+P+PP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
66	Telma Salina Barrera			
	Day 1	PP+P+P+P+	P+P+PPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
67	Elisabet Rojas Trejos			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
68	Adela Reyes Salina			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
69	Zorayda Reyes Salina			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
70	María Obando Vásquez			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	APPPP	AAAAA

Table B-4. Results for September (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
71	María Espinoza Ramírez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
72	Carla Mesa Espinoza			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
73	Maria Mejia Zambrana			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
74	Maria Enriqueta Reyes Rojas			
	Day 1	N/A	AAAA+A+	AAAAA
	Day 2	N/A	AAAA+A+	AAAAA
	Day 3	N/A	AAAA+A+	AAAAA
75	Simona Zamora "M"			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
76	Veronica Espinoza "S"			
	Day 1	AAAAA	AAAPP	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
77	Marina Reyes Murillo			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
78	María Ilaria Reyes Murillo			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
79	Catalina Murillo Terminio			
	Day 1	N/A	P+P+PPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
80	Petrolina Urbina Urbiana			
	Day 1	N/A	P+P+PP+P+	AAAAA
	Day 2	N/A	P+P+PP+P+	AAAAA
	Day 3	N/A	P+P+PP+P+	AAAAA

Table B-4. Results for September (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
81	Enrriqueta Zotelo "M"			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	P+P+AAP+	PPPPP	AAAAA
	Day 3	PPPP+P+	PPPPP	AAAAA
82	Petronila Mayorga Bobadillo			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
83	Marisela Reyes Benedith			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
84	María Estela Treminio			
	Day 1	AAAAA	AAAPP	AAAAA
	Day 2	AAAP+P+	A+A+PPP	AAAAA
	Day 3	AAAPP	A+A+PPP	AAAAA
85	Rosa Reyes Rojas			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAAAA	AAAA+A+	AAAAA
	Day 3	AAAAA	AAA+A+A+	AAAAA
86	María Elena Alvarado			
	Day 1	N/A	AA+P+P+P	AAAAA
	Day 2	N/A	A+P+PPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
87	Juan Ramón Ramíres			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAA+A+	AAAAA
	Day 3	N/A	AAAA+A+	AAAAA
88	Sara Socorro Moreno Blandon			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
89	Agustina Espínoza			
	Day 1	AAAAA	P+PPPP+	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
90	Lucia Mayorga Bobadillo			
	Day 1	N/A	PPP+P+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-4. Results for September (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
91	María Isabel Pavón			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
92	Llian Ramirez Reyes			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAAAA	AAAAA	AAAAA
	Day 3	AAAAA	AAAAA	AAAAA
93	Amanda Urbina Espinoza			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
94	Agueda Cano Ramires			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAAA	AAAAA
95	Carla Arauz Reyes			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
96	Alba Luz Reyes Martinez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
97	Marta Rivera Espinoza			
	Day 1	N/A	AAP+P+P	AAAAA
	Day 2	N/A	PPP+P+P	AAAAA
	Day 3	N/A	PPPPP	AAAAA
98	Araceli Urbina Saldaña			
	Day 1	N/A	AAAA+A+	AAAAA
	Day 2	N/A	AAP+P+P+	AAAAA
	Day 3	N/A	AAAAA	AAAAA
99	Telma Espinoza			
	Day 1	AAAAA	AAPP+P+	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
100	Rosario Hernández			
	Day 1	PPPP+P+	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA

Table B-5. September Survey Results

Sample #	How frequently do you clean the filter?	Do you know how to read?	Are the instructions on the back of the filter clear?	When you clean the filter. which water do you use?
1	every 2 days	yes	instructions are clear	well water without chlorine
2	every 48 hours	yes	instructions are clear	well water without chlorine
3	every 2 days	yes	instructions are clear	filtered water
4	every 4 days	yes	instructions are clear	well water without chlorine
5	every 2 days	yes	instructions are clear	filtered water
6	every 2 days	no	daughter reads intructions	well water without chlorine
7	every 2 days	yes	instructions are clear	filtered water
8	every 3 days	yes	everything is clear	well water without chlorine
9	every 2 days	no	grandchild explains instructions	well water without chlorine
10	every 48 hours	yes	everything is clear	well water with chlorine
11	every 3 days	yes	everything is clear	well water with chlorine
12	every 4 days	no	brother explains instructions	well water without chlorine
13	every 2 dias	no	grandchild explains instructions	well water without chlorine
14	every 3 days	yes	instructions are clear	well water without chlorine
15	every 2 days	no	daughter reads intructions	well water without chlorine
16	every 2 days	yes	everything is clear	filtered water
17	every 2 days	yes	everything is clear	filtered water
18	every 2 days	yes	everything is clear	filtered water
19	every 2 days	yes	everything is clear	filtered water
20	every 2 days	yes	everything is clear	filtered water
21	every 2 days	yes	everything is clear	filtered water
22	every 2 days	yes	everything is clear	filtered water
23	every 2 days	yes	everything is clear	filtered water
24	every 2 days	yes	everything is clear	filtered water
25	every 2 days	yes	instructions are clear	filtered water
26	every 2 days	yes	instructions are clear	filtered water
27	every 2 days	yes	instructions are clear	filtered water
28	every 8 days	yes	instructions are clear	well water with chlorine
29	every 3 days	yes	instructions are clear	well water with chlorine
30	every 2 days	yes	instructions are clear	well water without chlorine
31	every 2 days	yes	instructions are clear	well water with chlorine
32	every 8 days	no	daughter reads intructions	well water with chlorine
33	daily	no	daughter cleans filter	filtered water
34	daily	yes	instructions are clear	filtered water
35	every 3 days	yes	instructions are clear	well water with chlorine
36	every 3 days	yes	instructions are clear	well water with chlorine
37	every 3 days	yes	instructions are clear	well water with chlorine
38	every 3 days	yes	instructions are clear	well water with chlorine
39	every 3 days	yes	instructions are clear	well water with chlorine
40	daily	no	daughter explains instructions	filtered water

Table B-5. September Survey Results (continuation)

Sample #	How frequently do you clean the filter?	Do you know how to read?	Are the instructions on the back of the filter clear?	When you clean the filter. which water do you use?
40	daily	no	daughter explains instructions	filtered water
41	daily	yes	instructions are clear	filtered water
42	every 2 days	yes	instructions are clear	filtered water
43	every 2 days	yes	instructions are clear	filtered water
44	every 2 days	yes	instructions are clear	filtered water
45	every 2 days	yes	instructions are clear	filtered water
46	every 2 days	yes	instructions are clear	filtered water
47	every 2 days	yes	instructions are clear	filtered water
48	every 2 days	yes	instructions are clear	filtered water
49	every 2 days	yes	instructions are clear	filtered water
50	every 2 days	yes	instructions are clear	filtered water
51	every 2 days	yes	instructions are clear	filtered water
52	every 2 days	yes	instructions are clear	filtered water
53	every 2 days	yes	instructions are clear	filtered water
54	every 2 days	yes	instructions are clear	filtered water
55	every 2 days	yes	instructions are clear	filtered water
56	every 2 days	yes	instructions are clear	filtered water
57	every 2 days	yes	instructions are clear	filtered water
58	every 2 days	yes	instructions are clear	filtered water
59	every 2 days	yes	instructions are clear	filtered water
60	every 48 hours	yes	instructions are clear	well water without chlorine
61	every 48 hours	yes	instructions are clear	well water without chlorine
62	every 48 hours	yes	instructions are clear	well water without chlorine
63	every 48 hours	yes	instructions are clear	well water without chlorine
64	every 48 hours	yes	instructions are clear	well water without chlorine
65	every 48 hours	yes	instructions are clear	well water without chlorine
66	every 48 hours	yes	instructions are clear	well water without chlorine
67	every 48 hours	yes	instructions are clear	well water without chlorine
68	every 48 hours	yes	instructions are clear	well water without chlorine
69	every 48 hours	yes	instructions are clear	well water without chlorine
70	every 48 hours	yes	instructions are clear	well water without chlorine
71	every 3 days	yes	instructions are clear	well water with chlorine
72	every 3 days	yes	instructions are clear	well water with chlorine
73	every 2 days	yes	instructions are clear	well water with chlorine
74	every 2 days	yes	instructions are clear	well water with chlorine
75	every 3 days	yes	instructions are clear	well water without chlorine
76	every 3 days	yes	instructions are clear	filtered water
77	every 5 days	yes	instructions are clear	well water with chlorine
78	every 2 days	yes	instructions are clear	stored water without chlorine
79	every 3 days	no	son explains instructions	well water with chlorine
80	every 3 days	no	son explains instructions	well water with chlorine

Table B-5. September Survey Results (continuation)

Sample #	How frequently do you clean the filter?	Do you know how to read?	Are the instructions on the back of the filter clear?	When you clean the filter. which water do you use?
81	every 48 hours	yes	instructions are clear	filtered water
82	daily	yes	instructions are clear	well water with chlorine
83	every 3 days	yes	instructions are clear	filtered water
84	every 3 days	yes	instructions are clear	filtered water
85	every 3 days	yes	instructions are clear	filtered water
86	every 3 days	yes	instructions are clear	filtered water
87	every 3 days	yes	instructions are clear	filtered water
88	every 2 days	yes	instructions are clear	filtered water
89	every 2 days	no	instructions are clear	filtered water
90	every 3 days	no	grandchild explains instructions	well water without chlorine
91	every 2 days	yes	everything is clear	well water with chlorine
92	every 3 days	yes	everything is clear	filtered water and well water without chlorine
93	every 2 days	yes	instructions are clear	"clean" water without chlorine
94	every 2 days	yes	instructions are clear	well water without chlorine
95	every 48 hours	yes	instructions are clear but does not follow them thoroughly	filtered water
96	every 2 days	yes	instructions are clear	well water without chlorine
97	every 48 hours	yes	instructions are clear	filtered water
98	every 2 days	yes	instructions are clear	well water without chlorine
99	every 2 days	yes	instructions are clear	filtered water
100	every 3 days	yes	daugther reads instructions	well water without chlorine

Table B-6. Results for October

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
1	Marina Conde			
	Day 1	AAAAA	AAAPP+	AAAAA
	Day 2	AAAPP	AAPPP+	AAAAA
	Day 3	AAPPP	APPPP	AAAAA
2	Eloísa Ovando/Rosa María González			
	Day 1	AAAAP+	AAPPP	AAAAA
	Day 2	AAAPP	PPPP+P+	AAAAA
	Day 3	AAPPP	PPPPP	AAAAA
3	Esperanza González			
	Day 1	N/A	APPPP+	AAAAA
	Day 2	N/A	PPPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
4	Juan Pablo Ovando Cano			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	APPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
5	Zoraida Leiva			
	Day 1	AAAAA	PPPP+P+	AAAAA
	Day 2	AAAAA	PPPPP	AAAA+A+
	Day 3	AAAAA	PPPPP	AAAP+P+
6	Danelia Salmerón-Rodríguez			
	Day 1	AAA+PP	AAPPP	AAAAA
	Day 2	AAPPP+	APPPP	AAAAA
	Day 3	APPPP	PPPPP	AAAAA
7	Mariluz González			
	Day 1	AAPPP+	AAPPP+	AAAAA
	Day 2	APPPP	AAPPP	AAAAA
	Day 3	PPPPP+	APPPP	AAAAA
8	Narcisa Vásquez			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
9	Juana Padilla			
	Day 1	N/A	PPP+P+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
10	Adela Ordóñez			
	Day 1	N/A	AAAAP	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	APPPP+	AAAAA

Table B-6. Results for October (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
11	Maribel Salmerón			
	Day 1	N/A	APPPP+	AAAAA
	Day 2	N/A	PPPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
12	Flor Leiva Delgadillo			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAAAA	AAAAA+	AAAAA
	Day 3	AAAP+P+	AAAAP	AAAAA
13	Reynaldo Salmerón			
	Day 1	AAAP+P+	AAAPP+	AAAAA
	Day 2	APPP+P+	APPPP+	AAAAA
	Day 3	PPPPP+	PPPPP	AAAAA
14	María Inocenta Hernández			
	Day 1	AAPPP	APPPP	AAAAA
	Day 2	APPPP	A+PPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
15	Mónica de la Cruz Espinosa			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	APPPP	AAAAA
16	Josefa Ordóñez			
	Day 1	N/A	AAPPP+	AAAAA
	Day 2	N/A	APPPP+	AAAAA
	Day 3	N/A	PPPPP+	AAAAA
17	Lesbia Araya			
	Day 1	N/A	PPPAA	AAAAA
	Day 2	N/A	PPPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
18	María Luz Castro Salina			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
19	Adela Manzanárez			
	Day 1	N/A	PPP+P+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
20	Rebeca Ordóñez			
	Day 1	AAPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA

Table B-6. Results for October (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
21	Eva Manzanares-Ordóñez			
	Day 1	PPPP+P+	PPPAA	AAAAA
	Day 2	PPPPP	PPPPP+	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
22	Olga Monte			
	Day 1	PPP+P+P+	AA+P+P+P+	AAAAA
	Day 2	PPPPP	APPPP+	AAAPP+
	Day 3	PPPPP	PPPPP	PPAAA
23	Carla Salmerón			
	Day 1	PPPPA	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAA+P+P+
	Day 3	PPPPP	PPPPP	PPPP+A
24	Filomena Antonia Padilla Velásquez			
	Day 1	PPP+P+P+	PPP+P+P+	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
25	Ramona Montez			
	Day 1	AAAPP	APPP+P+	AAAAA
	Day 2	APPP+P+	APPPP	AAAAA
	Day 3	APPPP	PPPPP	AAAAA
26	Teodora Rostrán			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAP+P+
27	Audilia Hernandez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
28	Carmina Padilla Rodrigez			
	Day 1	AAPP+P+	PPPP+P+	AAAAA
	Day 2	AAPPP	PPPPP	AAAAA
	Day 3	APPPP	PPPPP	AAAAA
29	Hurania Padilla			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
30	Esther Montes			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	PPPAA	AAAAA
	Day 3	N/A	PPPPA	AAAAA

Table B-6. Results for October (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
31	Ismelda Cóndez Rodríguez			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
32	Leonor Padilla Salina			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAAPP	AAAAA
33	Rosa Garcia Conde			
	Day 1	N/A	AAPPP+	AAAAA
	Day 2	N/A	APPPP+	AAAP+P+
	Day 3	N/A	PPPPP	AAAPP
34	Damaris Padilla			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	APPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
35	Sonia Rojas			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	PPPP+P+	AAAP+P+
	Day 3	N/A	PPPPP	AAAPP
36	Nely Padilla Castaño			
	Day 1	N/A	PPPPP	AAAAP+
	Day 2	N/A	PPPPP	AAAA+P+
	Day 3	N/A	PPPPP	AAAPP
37	Xiomara Padilla "P"			
	Day 1	N/A	AAPPP+	AAAAA
	Day 2	N/A	PPP+P+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
38	Melba Padilla Montes			
	Day 1	N/A	PPPPP	AAAP+P+
	Day 2	N/A	PPPPP	AAPPP+
	Day 3	N/A	PPPPP	AAPPP+
39	Esmeralda chavez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
40	Esbelia Obando			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	APPPP	AAAAA

Table B-6. Results for October (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
41	Adriana Salina Obando			
	Day 1	N/A	PPPP+A	AAAAA
	Day 2	N/A	PPPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
42	Juana Conde Montes			
	Day 1	AAPPP+	PPPAA	AAAAA
	Day 2	PPP+P+P+	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
43	Ramona Padilla			
	Day 1	N/A	PPPPP+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
44	Antonio Rojas Condez			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
45	Xiomara Rojas			
	Day 1	N/A	PPP+P+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
46	Inez Conde			
	Day 1	N/A	AAAAP	AAAAA
	Day 2	N/A	AAPP+P+	AAAAA
	Day 3	N/A	APPPP	AAAAA
47	Elza Salmeron			
	Day 1	AAAAP	PPPPA	AAAAA
	Day 2	PPPP+P+	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
48	Vílma Zamora Reyes			
	Day 1	N/A	PPPAA	AAAAA
	Day 2	N/A	PPPPP	AAAP+P+
	Day 3	N/A	PPPPP	AAAPP
49	Adelaida Sánchez Padilla			
	Day 1	N/A	AAA+A+A+	AAAAA
	Day 2	N/A	AAAPP	AAAAA
	Day 3	N/A	PPP+P+	AAAAA
50	Leonsa Avendaño Ordoñez			
	Day 1	N/A	PPP+P+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA+
	Day 3	N/A	PPPPP	AAAA+P+

Table B-6. Results for October (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
51	Alejandra Escoto Avendaño			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	APPPP	PPPPA
52	Jacudina Salina "A"			
	Day 1	N/A	PPPP+A	AAAAA
	Day 2	N/A	PPPPP+	AAAA+A+
	Day 3	N/A	PPPPP	AAAP+P+
53	Socorro Padilla Aguilar			
	Day 1	AAAA+A+	AAAPP+	AAAAA
	Day 2	AAAPP+	AAPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
54	Rosa Alba Rojas Espinoza			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
55	Jaquelin Picado Montes			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
56	Eva Vasques Toruño			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	AAAPP	AAAAA
	Day 3	N/A	PPP+P+A	AAAAA
57	Guadalupe Padilla S			
	Day 1	AAAA+P	AAAP+P+	AAAAA
	Day 2	APPPP+	AAPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
58	Melania Montes Padilla			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAP+
	Day 3	N/A	PPPPP	AAAPP+
59	Eva Leiva			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAAPP	AAAAA
60	Alma Nidia Benedith			
	Day 1	N/A	AAAAP	AAAAA
	Day 2	N/A	AAAPP+	AAAAA
	Day 3	N/A	AAPPP+	AAAAA

Table B-6. Results for October (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
61	Florencia Condez Godinez			
	Day 1	AAAAA	PPP+P+P+	AAAAA
	Day 2	AAAPP	PPPP+P+	AAAAA
	Day 3	AAPPP	PPPPP	AAAAA
62	Albina Condez Vasque			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	AAPPP	AAAAA
63	María Condez Perez			
	Day 1	N/A	AAAAP	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
64	Reina Salina Reyes			
	Day 1	N/A	AAAA+A+	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAAPP	AAAAA
65	Rosa Vasques Conde			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
66	Telma Salina Barrera			
	Day 1	PPPPA	PPPP+P+	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
67	Elisabet Rojas Trejos			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
68	Adela Reyes Salina			
	Day 1	N/A	PPPAA	AAAAA
	Day 2	N/A	PPPPA	AAAAA
	Day 3	N/A	PPPPP	AAAAA
69	Zorayda Reyes Salina			
	Day 1	N/A	PPPP+A	AAAAA
	Day 2	N/A	PPPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
70	María Obando Vásquez			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAPP+	AAAAA
	Day 3	N/A	AAPPP	AAAAA

Table B-6. Results for October (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
71	María Espinoza Ramírez			
	Day 1	N/A	PPPPP+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
72	Carla Mesa Espinoza			
	Day 1	N/A	PPPPP	PPPPP
	Day 2	N/A	PPPPP	PPPPP
	Day 3	N/A	PPPPP	PPPPP
73	María Mejia Zambrana			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAAAA	AAAAA	AAAAA
	Day 3	AAAAA	AAAAA	AAAAA
74	Maria Reyes Rojas			
	Day 1	N/A	AAAAP	AAAAA
	Day 2	N/A	AAPP+P+	AAAAA
	Day 3	N/A	AAPPP	AAAAA
75	Simona Zamora "M"			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
76	Veronica Espinoza "S"			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
77	María Reyes Murillo			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
78	María Ilaria Reyes			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	APPPP	AAAAA
79	Catalina Murillo Terminio			
	Day 1	N/A	PP+P+P+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
80	Petrolina Urbina Urbiana			
	Day 1	N/A	AAPP+P+	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	AAPPP	AAAAA

Table B-6. Results for October (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
81	Enrriqueta Zotelo "M"			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
82	Petronila Mayorga Bobadillo			
	Day 1	N/A	PPP+P+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
83	Marisela Reyes Benedith			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAA+A+P	AAAAA
	Day 3	N/A	AAPP+P+	AAAAA
84	María Estela Treminio			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	APPPP+	AAAAA
	Day 3	N/A	APPPP	AAAAA
85	Rosa Reyes Rojas			
	Day 1	N/A	AAPPP	AAAPP
	Day 2	N/A	APPPP+	AAPPP+
	Day 3	N/A	APPPP	AAPPP
86	María Elena Alvarado			
	Day 1	N/A	PPPPA	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
87	Juan Ramón Ramíres			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	AAAPP+	AAAAA
	Day 3	N/A	AAAPP	AAAAA
88	Socorro Moreno Blandon			
	Day 1	N/A	PPPAA	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
89	Agustina Espínoza			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
90	Lucia Mayorga Bobadillo			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAA+PP	AAAAA

Table B-6. Results for October (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
91	Maria mesa Pavon			
	Day 1	AAAAA	PPP+P+P+	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAAA	PPPPP	AAAAA
92	Llian Ramirez Reyes			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAAAA	AAAAA	AAAAA
	Day 3	AAAAA	AAAAA	AAAAA
93	Amanda Urbina Espinoza			
	Day 1	AAAAA	AAA+PP	AAAAA
	Day 2	AAAAA	AAPPP	AAAAA
	Day 3	AAAAA	AAPPP	AAAAA
94	Agueda Cano Ramires			
	Day 1	N/A	PPPPP+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
95	Carla Arauz Reyes			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
96	Alba Luz Reyes Martinez			
	Day 1	PPPPP	AAAAA	AAAAA
	Day 2	PPPPP	AAAP+P+	AAAAA
	Day 3	PPPPP	AAPPP+	AAAAA
97	Marta Rivera Espinoza			
	Day 1	PPPPP	PPPPP	PPPPP
	Day 2	PPPPP	PPPPP	PPPPP
	Day 3	PPPPP	PPPPP	PPPPP
98	Araceli Urbina Saldaña			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAPPP+	AAAAA
99	Telma Espinoza			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
100	Rosario Hernández			
	Day 1	AAPPP	PPPP+P+	AAAAA
	Day 2	PPPP+P+	PPPPP	AAAA+A+
	Day 3	PPPPP	PPPPP	AAAP+P+

Table B-7. October Survey Results

Sample #	Do you ever buy bottled water?	Does anybody in your house take filtered water to work?	Where is your latrine? Is it near your house? Near your well?
1	no	yes. husband to the farm	at 13 m from the house
2	when I travel to Managua	yes. child takes water to school	at 17 m from the house
3	sometimes for my child	no	at 23 m from the house
4	no	yes. husband to the farm	at 29 m from the house and 33 m from the well
5	when I travel to Managua	no	at 17 m from the house
6	no	yes. only to school	at 25 m from the house
7	yes. for the younger children	no	at 25 m from the house
8	no	no	at 29 m from the house
9	no	yes. children take water to school	at 17 m from the house
10	no	yes. children take water to school	at 17 m from the house
11	sometimes	yes. to the health center	at 21 m from the house and 65 m from the well
12	no	yes. to the farm	at 25 m from the house
13	no	yes. hustanb to the farm	at 13 m from the house
14	no	yes. husband to farm and children to school	at 17 m from the house
15	no	yes. husband to the farm	at 21 m from the house and 65 m from the well
16	when I travel to Managua	yes. husband to farm and children to school	at 23 m from the house
17	no	yes. husband to the farm	at 25 m from the house
18	no	yes. husband to the farm	at 13 m from the house
19	when I travel to Managua	yes. father to farm. brother to school	at 29 m from the house
20	no	yes. husband to the farm	at 21 m from the house and 65 m from the well
21	no	yes. husband to the farm	at 17 m from the house
22	when I travel to Managua	yes. brother to the farm	at 25 m from the house
23	no	no	at 21 m from the house
24	when I travel to Managua	yes. children to farm	at 17 m from the house
25	no	yes. husband to the farm	at 21 m from the house
26	N/A	N/A	N/A
27	no	yes. husband to the farm	at 25 m from the house
28	no	yes. husband to the farm	at 13 m from the house
29	no	yes. husband to the farm	at 29 m from the house
30	no	yes. husband to fetch fire-wood	at 33 m from the house
31	no	yes. children to school	at 13 m from the house
32	no	yes. child to school	at 17 m from the house
33	no	yes. husband to the farm	at 25 m from the house
34	no	no	does not have letrine
35	no	yes. husband to the farm	near to the house

Table B-7. October Survey Results (continuation)

Sample #	Do you ever buy bottled water?	Does anybody in your house take filtered water to work?	Where is your latrine? Is it near your house? Near your well?
36	no	yes. husband to fetch fire-wood	near to the house
37	no	yes. children to school	near to the house
38	no	yes. husband to the farm	near to the house
39	no	yes. child to school	near to the house
40	no	yes. husband to fetch fire-wood	at 21 m from the house
41	no	yes. husband to fetch fire-wood	at 25 m from the house
42	no	no	at 13 m from the house
43	no	yes. husband to the farm	at 25 m from the house
44	no	yes. husband to the farm	does not have letrine
45	no	yes. child to school	near to the house
46	no	yes. child to school	at 21 m from the house
47	when I travel to Managua	yes. husband to the farm	at 21 m from the house
48	no	no	at 17 m from the house
49	no	no	near to the house
50	no	no	near to the house
51	when I travel to Managua	yes. hustand to the farm	near to the house
52	when I travel to Managua	yes. son to school	near to the house
53	no	yes. children to school	near to the house
54	no	yes. husband to farm	near to the house
55	when I travel to Managua	yes. grandchild to school	near to the house
56	sometimes	yes. husband to farm	near to the house
57	no	yes. husband to farm	near to the house
58	no	no	near to the house
59	no	no	at 21 m from the house
60	no	only the children drink from filter	at 8 m from the house and 30 m from the well
61	when I travel to Managua	yes. husband and son to the farm	at 21 m from the house
62	when I travel to Managua	yes. children to school	at 17 from the house
63	no	yes. grandchildren to school	at 29 m from the house
64	no	yes. husband to the farm	at 21 m from the house
65	no	yes. to school (teacher)	at 38 m from the house
66	when I travel to Managua	yes. husband to the farm	at 42 m from the house
67	when I travel to Managua	no	at 42 m from the house
68	no	no	at 25 m from the house and 50 m from the well
69	when I travel to Managua	no	at 21 m from the house
70	when I travel to Managua	yes. children to school	at 21 m from the house

Table B-7. October Survey Results (continuation)

Sample #	Do you ever buy bottled water?	Does anybody in your house take filtered water to work?	Where is your latrine? Is it near your house? Near your well?
71	no	no	does not have letrine
72	yes. a month ago	no	at 8 m from the house
73	no	yes. children to school	at 8 m from the house and 30 m from the well
74	no	no	at 17 m from the house and 39 m from the well
75	no	yes. children to school	at 13 m from the house and 31 m from the well
76	no	yes. son to the farm and to church	at 17 m from the house and 80 m from the well
77	no	yes. husband to the farm	at 17 m from the house and 35 m from the well
78	no	yes. son takes water	at 13 m from the house and 33 m from the well
79	no	yes. husband to the farm	at 17 m from the house and 29 m from the well
80	no	yes. children and husband to the farm	at 13 m from the house and 33 m from the well
81	no	yes. husband to the farm	at 17 m from the house and 60 m from the well
82	no	yes. husband to the farm	at 8 m from the house and 40 m from the well
83	no	yes. son to the farm	at 8 m from the house and 25 m from the well
84	when I travel to Managua	yes. husband to the farm	at 4 m from the house and 50 m from the well
85	yes. US$ 0.07 per 5 gal	yes. daughter to school	at 8 m from the house and at 25 m from the well
86	no	yes. children to school	at 35 m from the well
87	no	no	at 8 m from the house
88	no	no	at 8 m from the house and 29 from the well
89	no	no	at 4 m from the house and 25 m from the well
90	no	yes. husband to the farm	does not have letrine
91	no	yes. husband to the farm	at 8 m from the house
92	when I travel to Managua	yes. husband to the farm	at 13 m from the house and 60 m from the well
93	no	yes. husband to the farm	at 8 m from the house and 40 m from the well

Table B-7. October Survey Results (continuation)

Sample #	Do you ever buy bottled water?	Does anybody in your house take filtered water to work?	Where is your latrine? Is it near your house? Near your well?
94	no	yes. husband to the farm	does not have letrine
95	no	yes. husband and children to farm	at 17 m from the house and 13 m from the well
96	no	yes. daughters to school	at 10 m from the house and 40 m from the well
97	no	yes. brothers to the farm	at 17 m from the house and at 60 m from the well
98	when I travel to Managua	no	at 8 m from the house and 17 m from the well
99	no	yes. children to school	at 25 m from the house and 33 m from the well
100	no	yes. children to school	at 25 m from the house and 33 m from the well

Table B-8. Results for November

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
1	Marina Conde			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
2	Eloísa Ovando/Rosa María González			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
3	Esperanza González			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
4	Juan Pablo Ovando Cano			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
5	Zoraida Leiva			
	Day 1	APPPP	PPPPP	AAAAA
	Day 2	PPPPP+	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
6	Danelia Salmerón-Rodríguez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
7	Mariluz González			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
8	Narcisa Vásquez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
9	Juana Padilla			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
10	Ade;a Ordóñez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A

Table B-8. Results for November (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
11	Maribel Salmerón			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
12	Flor Leiva Delgadillo			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
13	Reynaldo Salmerón			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
14	María Inocenta Hernández			
	Day 1	N/A	AAAA+A+	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	AAPPP	AAAAA
15	Mónica de la Cruz Espinosa			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
16	Josefa Ordóñez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
17	Lesbia Araya			
	Day 1	N/A	PPPPP	AAPPP+
	Day 2	N/A	PPPPP	AAPPP
	Day 3	N/A	PPPPP	AAPPP
18	María Luz Castro Salina			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
19	Adela Manzanárez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
20	Rebeca Ordóñez			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA

Table B-8. Results for November (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
21	Eva Manzanares-Ordóñez			
	Day 1	N/A	PPPPP	PPPPP
	Day 2	N/A	PPPPP	PPPPP
	Day 3	N/A	PPPPP	PPPPP
22	Olga Monte			
	Day 1	N/A	PPPPP	PPPPP
	Day 2	N/A	PPPPP	PPPPP
	Day 3	N/A	PPPPP	PPPPP
23	Carla Salmerón			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
24	Filomena Antonia Padilla Velásquez			
	Day 1	N/A	AAPPP+	AAAAA
	Day 2	N/A	APPPP+	AAAAA
	Day 3	N/A	APPPP+	AAAAA
25	Romana Montez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
26	Teodora Rostrán			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
27	Audilia Hernandez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
28	Carmina Padilla Rodrigez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
29	Hurania Padilla			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
30	Esther Montes			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-8. Results for November (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
31	Ismelda Condez Rodrigez			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
32	Leonor Padilla Salina			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
33	Rosa Garcia Conde			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
34	Damaris Padilla			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
35	Sonia Rojas			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAPP
36	Nely Padilla Castaño			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
37	Xiomara Padilla "P"			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
38	Melba Padilla Montes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
39	Esmeralda chavez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
40	Esbelia Obando			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-8. Results for November (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
41	Adriana Salina Obando			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
42	Juana Conde Montes			
	Day 1	N/A	PPPP+P+	AAAAA+
	Day 2	N/A	PPPPP	AAAAP+
	Day 3	N/A	PPPPP	AAAPP+
43	Ramona Padilla			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAP+P+
	Day 3	N/A	PPPPP	AAAPP
44	Antonio Rojas Condez			
	Day 1	N/A	P+P+P+P+P+	AAAAA
	Day 2	N/A	PPP+P+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
45	Xiomara Rojas			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAA+P+P+	AAAAA
	Day 3	N/A	APPPP	AAAAA
46	Inez Conde			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAAPP	AAAAA
47	Elza Salmeron			
	Day 1	AAPP+P+	PPPPP	AAAAA
	Day 2	AAPPP	PPPPP	AAAAA
	Day 3	AAPPP	PPPPP	AAAAA
48	Vílma Zamora Reyes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
49	Adelaida Sánchez Padilla			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
50	Leonsa Avendaño Ordoñez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-8. Results for November (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
51	Alejandra Escoto Avendaño			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
52	Jacudina Salina "A"			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
53	Socorro Padilla Aguilar			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
54	Rosa Alba Rojas Espinoza			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
55	Jaquelin Picado Montes			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
56	Eva Vásquez Toruño			
	Day 1	N/A	APPPP	AAAAA
	Day 2	N/A	APPPP	AAAAA
	Day 3	N/A	APPPP	AAAAA
57	Guadalupe Padilla S			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
58	Melania Montes Padilla			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AP+P+P+P+	AAAAA
	Day 3	N/A	PPPPP+	AAAAA
59	Eva Leiva			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAP+	AAAAA
	Day 3	N/A	AAAAP	AAAAA
60	Alma Nidia Benedith			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	AAAAP+	PPPPP	AAAAA
	Day 3	AAAAP	PPPPP	AAAAA

Table B-8. Results for November (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
61	Florencia Condez Godinez			
	Day 1	AAAAA	AAPPP	AAAAA
	Day 2	AAAAP	APPPP	AAAAA
	Day 3	AAPP+P+	PPPPP	AAAAA
62	Albina Condez Vasque			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	APPPPP+	AAAAA
	Day 3	N/A	APPPP	AAAAA
63	María Condez Perez			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	APP+P+P+	AAAAA
	Day 3	N/A	PPPPP+	AAAAA
64	Reina Salina Reyes			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	AAPP+P+	AAAAA
	Day 3	N/A	AAPPP+	AAAAA
65	Rosa Vasques Conde			
	Day 1	N/A	PPPPP	AAAPP
	Day 2	N/A	PPPPP	AAPPP
	Day 3	N/A	PPPPP	APPPP
66	Telma Salina Barrera			
	Day 1	AAAAA	AAAA+P	AAAAA
	Day 2	AAAAA	AAAA+P	AAAAA
	Day 3	AAAAP+	AAAPP+	AAAAA
67	Elisabet Rojas Trejos			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AAAPP	AAAAA
	Day 3	N/A	AAAPP	AAAAA
68	Adela Reyes Salina			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	AAAPP+	AAAAA
	Day 3	N/A	AAAPP	AAAAA
69	Zoraida Reyes Salina			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	AAAAP	AAAAA
	Day 3	N/A	AAAPP+	AAAAA
70	María Obando Vásquez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-8. Results for November (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
71	María Espinoza Ramírez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
72	Carla Mesa Ezpinosa			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
73	Maria Mejia Zambrana			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAAA	AAAAA
74	Maria Reyes Rojas			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
75	Simona Zamora "M"			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
76	Veronica Espinoza "S"			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	AAAAA	PPPPP	AAAAA
	Day 3	AAAA+A+	PPPPP	AAAAA
77	María Reyes Murillo			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
78	María Ilaria Reyes			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
79	Catalina Murillo Terminio			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
80	Petrolina Urbina Urbiana			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-8. Results for November (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
81	Enrriqueta Zotelo "M"			
	Day 1	AAAAA	PPPPP	AAAAA
	Day 2	AAAAP+	PPPPP	AAAAA
	Day 3	AAAAP	PPPPP	AAAAA
82	Petronila Mayorga Bobadillo			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
83	Marisela Reyes Benedith			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
84	María Estela Treminio			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
85	Rosa Reyes Rojas			
	Day 1	AAAAA	PPPPP	AAAPP
	Day 2	AAAAP+	PPPPP	APPP+P+
	Day 3	AAAP+P+	PPPPP	APPPP
86	María Elena Alvarado			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
87	Juan Ramón Ramíres			
	Day 1	N/A	AAAPP+	AAAAA
	Day 2	N/A	AAAPP	AAAAA
	Day 3	N/A	AAAPP	AAAAA
88	Socorro Moreno Blandon			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
89	Agustina Espínoza			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
90	Lucia Mayorga Bobadillo			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAAAA	AAAP+P+	AAAAA
	Day 3	AAAAA	AAPPP	AAAAA

Table B-8. Results for November (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
91	Maria mesa Pavon			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	APPPP	AAAAA
92	Llian Ramirez Reyes			
	Day 1	AAAAA	AAAAA	AAAAA
	Day 2	AAAAA	AAAAA	AAAAA
	Day 3	AAAAA	AAAAA	AAAAA
93	Amanda Urbina Espinoza			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
94	Agueda Cano Ramires			
	Day 1	N/A	APPP+P+	AAAAA
	Day 2	N/A	APPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
95	Carla Arauz Reyes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
96	Alba Luz Reyes Martinez			
	Day 1	PPPP+P+	PPPP+P+	AAAAA
	Day 2	PPPPP	PPPPP	AAAAP+
	Day 3	PPPP	PPPPP	AAAAP+
97	Marta Rivera Espinoza			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAPP	AAAAA
98	Araceli Urbina Saldaña			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAA+PP	AAAAA
99	Telma Espinoza			
	Day 1	N/A	AAPP+P+	APPPP+
	Day 2	N/A	PPPPP	PPPPP
	Day 3	N/A	PPPPP	PPPPP
100	Rosario Hernández			
	Day 1	APPPP	PPPPP	AAAAA
	Day 2	PPPPP+	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA

Table B-9. November Survey Results

Sample #	When did you clean your filter for the last time?	Did you notice any difference in the water's taste or in the filtration rate?	Do you wash your hands before handling the filter?
1	20 days ago	No changes	Yes. with well water and soap
2	15 days ago	No changes	Yes. with well water and soap
3	3 days ago	No changes	Yes. with well water and soap
4	2 days ago	No changes	Yes. with well water and soap
5	filter broke	filter broke	filter broke
6	3 days ago	No. filtered water is light	Yes. with well water and soap
7	11/15/2002	No changes	Yes. with well water and soap
8	11/13/2002	No changes	Yes. with well water and soap
9	filter broke	filter broke	filter broke
10	filter broke	filter broke	filter broke
11	11/10/2002	No changes	Yes. with well water and soap
12	11/8/2002	No changes	Yes. with well water and soap
13	11/11/2002	No changes	Yes. with well water and soap
14	every day	No changes	Yes. with well water and soap
15	filter broke	filter broke	filter broke
16	11/4/2002	No changes	Yes. with well water and soap
17	every day	No changes	Yes. with well water and soap
18	filter broke	filter broke	filter broke
19	every day	No changes	Yes. with well water and soap
20	11/2/2002	No changes	Yes. with well water and soap
21	11/10/2002	No changes	Yes. with well water and soap
22	10/28/2002	No changes	Yes. with well water and soap
23	11/16/2002	No changes	Yes. with well water and soap
24	10/29/2002	No changes	Yes. with well water and soap
25	11/17/2002	No changes	Yes. with well water and soap
26	11/17/2002	No changes	Yes. with well water and soap
27	filter broke	filter broke	filter broke
28	11/5/2002	No changes	Yes. with well water and soap
29	11/16/2002	No changes	Yes. with well water and soap
30	11/17/2002	No changes	Yes. with well water and soap
31	11/10/2002	No changes	Yes. with well water and soap
32	11/25/2002	No changes	Yes. with well water and soap
33	11/17/2002	No changes	filter broke
34	11/17/2002	No changes	Yes. with well water and soap
35	11/7/2002	No changes	Yes. with well water and soap
36	11/17/2002	No changes	Yes. with well water and soap
37	11/24/2002	No changes	Yes. with well water and soap
38	filter broke	filter broke	filter broke
39	every day	No changes	Yes. with well water and soap
40	11/19/2002	No changes	Yes. with well water and soap
41	filter broke	filter broke	filter broke
42	11/15/2002	No changes	Yes. with well water and soap

Table B-9. November Survey Results (continuation)

Sample #	When did you clean your filter for the last time?	Did you notice any difference in the water's taste or in the filtration rate?	Do you wash your hands before handling the filter?
44	11/15/2002	No changes	Yes. with well water and soap
45	11/15/2002	No changes	Yes. with well water and soap
46	11/17/2002	No changes	Yes. with well water and soap
47	11/16/2002	No changes	Yes. with well water and soap
48	filter broke	filter broke	filter broke
49	11/25/2002	No changes	Yes. with well water and soap
50	11/24/2002	No changes	Yes. with well water and soap
51	11/25/2002	No changes	Yes. with well water and soap
52	11/24/2002	No changes	Yes. with well water and soap
53	11/25/2002	No changes	Yes. with well water and soap
54	11/8/2002	No changes	Yes. with well water and soap
55	11/20/2002	No changes	Yes. with well water and soap
56	11/20/2002	No changes	Yes. with well water and soap
57	6 days ago	No changes	Yes. with well water and soap
58	11/17/2002	No changes	Yes. with well water and soap
59	11/17/2002	No changes	Yes. with well water and soap
60	11/7/2002	No changes	Yes. with well water and soap
61	11/3/2002	No changes	Yes. with well water and soap
62	11/2/2002	No changes	Yes. with well water and soap
63	11/4/2002	No changes	Yes. with well water and soap
64	11/5/2002	No changes	Yes. with well water and soap
65	11/11/2002	No changes	Yes. with well water and soap
66	11/9/2002	No changes	Yes. with well water and soap
67	11/7/2002	No changes	Yes. with well water and soap
68	11/6/2002	No changes	Yes. with well water and soap
69	10/28/2002	No changes	Yes. with well water and soap
70	11/5/2002	No changes	Yes. with well water and soap
71	11/5/2002	No changes	Yes. with well water and soap
72	11/5/2002	No changes	Yes. with well water and soap
73	11/25/2002	No changes	Yes. with well water and soap
74	10/30/2002	No changes	Yes. with well water and soap
75	11/19/2002	No changes	Yes. with well water and soap
76	11/18/2002	No changes	Yes. with well water and soap
77	11/5/2002	No changes	Yes. with well water and soap
78	11/7/2002	No changes	Yes. with well water and soap
79	11/6/2002	No changes	Yes. with well water and soap
80	11/2/2002	No changes	Yes. with well water and soap
81	11/5/2002	No changes	Yes. with well water and soap
82	11/7/2002	No changes	Yes. with well water and soap
83	11/1/2002	No changes	Yes. with well water and soap
84	filter broke	filter broke	filter broke
85	11/25/2002	No changes	Yes. with well water and soap

Table B-9. November Survey Results (continuation)

Sample #	When did you clean your filter for the last time?	Did you notice any difference in the water's taste or in the filtration rate?	Do you wash your hands before handling the filter?
86	11/20/2002	No changes	Yes. with well water and soap
87	10/28/2002	No changes	Yes. with well water and soap
88	11/21/2002	No changes	Yes. with well water and soap
89	11/7/2002	No changes	Yes. with well water and soap
90	11/7/2002	No changes	Yes. with well water and soap
91	11/8/2002	No changes	Yes. with well water and soap
92	11/12/2002	No changes	Yes. with well water and soap
93	11/4/2002	No changes	Yes. with well water and soap
94	11/3/2002	No changes	Yes. with well water and soap
95	filter broke	filter broke	filter broke
96	11/25/2002	No changes	Yes. with well water and soap
97	11/20/2002	No changes	Yes. with well water and soap
98	11/5/2002	No changes	Yes. with well water and soap
99	11/5/2002	No changes	Yes. with well water and soap
100	11/5/2002	No changes	Yes. with well water and soap

Table B-10. Results for December

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
1	Marina Conde			
	Day 1	AAPPP+	PPPPP	AAAAA
	Day 2	APPPP+	PPPPP	AAAAA
	Day 3	APPPP	PPPPP	AAAAA
2	Eloísa Ovando/Rosa María González			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
3	Esperanza González			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
4	Juan Pablo Ovando Cano			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
5	Zoraida Leiva			
	Day 1	AAPPP	AAPPP	AAAAA
	Day 2	PPPPP	PPPP+P+	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
6	Danelia Salmerón-Rodríguez			
	Day 1	PPPPP	PPPPP	AAPPP
	Day 2	PPPPP	PPPPP	AAPPP
	Day 3	PPPPP	PPPPP	AAPPP
7	Mariluz González			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
8	Narcisa Vásquez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
9	Juana Padilla			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
10	Adela Ordóñez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A

Table B-10. Results for December (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
11	Maribel Salmerón			
	Day 1	AAAPP	AAPPP	AAAAA
	Day 2	APPPP+	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
12	Flor Leiva Delgadillo			
	Day 1	N/A	APPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
13	Reynaldo Salmerón			
	Day 1	AAPP+P+	AAPPP	AAAAA
	Day 2	APPPP+	PPPPP	AAAAA
	Day 3	PPPPP	APPPP	AAAAA
14	María Inocente Hernández			
	Day 1	AAAPP	AAPPP	AAAAA
	Day 2	AA+A+PP	APPPP+	AAAAA
	Day 3	APPPP	PPPPP	AAAAA
15	Mónica de la Cruz Espinosa			
	Day 1	AAAAA	AAAPP	AAAAA
	Day 2	AAAAA	APPPP+	AAAAA
	Day 3	AAAAA	PPPPP+	AAAAA
16	Josefa Ordóñez			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	APPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
17	Lesbia Araya			
	Day 1	N/A	PPPPP	AAAPP
	Day 2	N/A	PPPPP	AA+PPP
	Day 3	N/A	PPPPP	APPPP
18	María Luz Castro Salina			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
19	Carolina Antonia Ovando Torres			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
20	Rebeca Ordóñez			
	Day 1	AAA+PP	AAPPP	AAPP+P+
	Day 2	AAPPP	PPPPP	PPPPP
	Day 3	APPPP+	PPPPP	PPPPP

Table B-10. Results for December (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
21	Eva Manzanares-Ordóñez			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
22	Olga Monte			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAPPP
	Day 3	PPPPP	PPPPP	APPPP
23	Carla Salmerón			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	APPPP+	AAAAA
	Day 3	N/A	APPPP	AAAAA
24	Filomena Antonia Padilla Velásquez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
25	RAmona Montez			
	Day 1	N/A	PPPPP	AAAPP
	Day 2	N/A	PPPPP	AAAPP
	Day 3	N/A	PPPPP	AAAPP
26	Teodora Rostrán			
	Day 1	AAAAP+	AAPPP	AAAAA
	Day 2	AAAAP	APPPP+	AAAAA
	Day 3	AAAAP	APPPP	AAAAA
27	Audilia Hernandez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
28	Carmina Padilla Rodrigez			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
29	Hurania Padilla			
	Day 1	PPPPP	PPPPP	AAAAA
	Day 2	PPPPP	PPPPP	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA
30	Esther Montes			
	Day 1	PPPPP	PPPPP	PPPPP
	Day 2	PPPPP	PPPPP	PPPPP
	Day 3	PPPPP	PPPPP	PPPPP

Table B-10. Results for December (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
31	Ismelda Condez Rodríguez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
32	Leonor Padilla Salina			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
33	Rosa Garcia Conde			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
34	Damaris Padilla			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	AA+PPP	AAAAA
	Day 3	N/A	APPPP	AAAAA
35	Sonia Rojas			
	Day 1	N/A	APPPP	AAAAA
	Day 2	N/A	PPPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
36	Nely Padilla Castaño			
	Day 1	PPPPP	PPPPP	PPPPP
	Day 2	PPPPP	PPPPP	PPPPP
	Day 3	PPPPP	PPPPP	PPPPP
37	Xiomara Padilla "P"			
	Day 1	N/A	A+PPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
38	Melba Padilla Montes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
39	Esmeralda Chávez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
40	Esbelia Obando			
	Day 1	APPPP+	AAPPP	AAAAA
	Day 2	APPPP	APPPP+	AAAAA
	Day 3	PPPPP+	APPPP	AAAAA

Table B-10. Results for December (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
41	Adriana Salina Obando			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
42	Juana Conde Montes			
	Day 1	AAPPP	APPPP	AAAAA+
	Day 2	APPPP+	PPPPP	AAAPP
	Day 3	APPPP	PPPPP	AAPPP
43	Ramona Padilla			
	Day 1	PPPPP+	APPPP	AAAPP+
	Day 2	PPPPP	PPPPP+	AAPPP+
	Day 3	PPPPP	PPPPP	AAPPP
44	Antonio Rojas Condez			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
45	Xiomara Rojas			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
46	Inez Conde			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	AAAPP	AAAAA
	Day 3	N/A	AAPPP	AAAAA
47	Elza Salmerón			
	Day 1	AAAPP	PPPPP+	AAAAA
	Day 2	AAPPP+	PPPPP	AAAAA
	Day 3	APPPP+	PPPPP	AAAAA
48	Vílma Zamora Reyes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
49	Adelaida Sánchez Padilla			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
50	Leonsa Avendaño Ordoñez			
	Day 1	N/A	PPAAA	AAAAA
	Day 2	N/A	PPPA+A+	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-10. Results for December (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
51	Alejandra Escoto Avendaño			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	A+A+PPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
52	Jacudina Salina "A"			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
53	Socorro Padilla Aguilar			
	Day 1	AAA+PP	AAPPP	AAAAA
	Day 2	AAPPP	APPPP+	AAAAA
	Day 3	APPPP+	PPPPP	AAAAA
54	Rosa Alba Rojas Espinoza			
	Day 1	N/A	APPPP+	AAAAA
	Day 2	N/A	A+PPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
55	Jaquelin Picado Montes			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	PPPPA	AAAAA
	Day 3	N/A	PPPPA	AAAAA
56	Eva Vásquez Toruño			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	AAPPP	AAAAA
57	Guadalupe Padilla S			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
58	Melania Montes Padilla			
	Day 1	N/A	PPPPP+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
59	Eva Leiva			
	Day 1	N/A	PPPPP+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
60	Alma Nidia Benedith			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	AAPPP	AAAAA

Table B-10. Results for December (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
61	Florencia Cóndez Godínez			
	Day 1	AAAAP	PPP+P+P+	AAAAA
	Day 2	AAAPP+	PPPPP	AAAAA
	Day 3	AAAPP+	PPPPP	AAAAA
62	Albina Cóndez Vásquez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
63	María I. Rojas			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	AAPPP	AAAAA
64	Reina Salina Reyes			
	Day 1	N/A	AAPP+P+	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	AA+PPP	AAAAA
65	Rosa Vásquez Cóndez			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	AAAPP	AAAAA
	Day 3	N/A	AAPPP	AAAAA
66	Telma Salina Barrera			
	Day 1	AAAAA	AAAPP	AAAAA
	Day 2	AAAAA+	AAA+PP	AAAAA
	Day 3	AAAAP	AAPPP+	AAAAA
67	Elisabet Rojas Trejos			
	Day 1	N/A	AAPP+P+	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	AAPPP	AAAAA
68	Adela Reyes Salina			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AAA+PP	AAAAA
	Day 3	N/A	AAPPP	AAAAA
69	Zorayda Reyes Salina			
	Day 1	N/A	AAA+PP	AAAAA
	Day 2	N/A	AAA+PP	AAAAA
	Day 3	N/A	AAPPP+	AAAAA
70	María Obando Vásquez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-10. Results for December (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
71	María Espinoza Ramírez			
	Day 1	AAAAA	AAAPP	AAAAA
	Day 2	AAAAA	APPPP+	AAAAA
	Day 3	AAAAA	PPPPP+	AAAAA
72	Carla Mesa Espinoza			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	APPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
73	Maria Mejia Zambrana			
	Day 1	N/A	PPP+P+P+	AAAAA
	Day 2	N/A	PPPP+P+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
74	María Reyes Rojas			
	Day 1	N/A	APPPP+	PPPPP
	Day 2	N/A	PPPP+P+	PPPPP
	Day 3	N/A	PPPPP	PPPPP
75	Simona Zamora "M"			
	Day 1	N/A	APPPP+	AAAP+P+
	Day 2	N/A	PPPPP	AAAP+P+
	Day 3	N/A	PPPPP	AAA+PP
76	Verónica Espinoza "S"			
	Day 1	N/A	PPPPP	AAAP+P+
	Day 2	N/A	PPPPP	AAAP+P+
	Day 3	N/A	PPPPP	AAPPP+
77	María Reyes Murillo			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
78	Maria Ilaria Reyes Murillo			
	Day 1	AAAAA	APPPP	AAAAA
	Day 2	AAAAP+	PPPPP+	AAAAA
	Day 3	AAAAP	PPPPP	AAAAA
79	Catalina Murillo Terminio			
	Day 1	N/A	APPPP	AAAAA
	Day 2	N/A	PPPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
80	Petrolina Urbina Urbiana			
	Day 1	N/A	AAAPPP	AAAAA
	Day 2	N/A	APPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA

Table B-10. Results for December (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
81	Enrriqueta Zotelo "M"			
	Day 1	AAAAA	AAAPP	AAAAA
	Day 2	AAAAP	AAPPP	AAAAA
	Day 3	AAAA+P	PPPP+P+	AAAAA
82	Petronila Mayorga Bobadillo			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	APP+P+P+	AAAAA
	Day 3	N/A	APPP+P+	AAAAA
83	Marisela Reyes Benedith			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAA	AAAAA
	Day 3	N/A	AAAAA	AAAAA
84	María Estela Treminio			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
85	Rosa Reyes Rojas			
	Day 1	N/A	AAAPP	AAAAA
	Day 2	N/A	AAPPP	AAAAA
	Day 3	N/A	APPPP+	AAAAA
86	María Elena Alvarado			
	Day 1	N/A	AAPPP	AAAAA
	Day 2	N/A	PPPPP+	AAAAA
	Day 3	N/A	PPPPP	AAAAA
87	Juan Ramón Ramírez			
	Day 1	N/A	AAAAA	AAAAA
	Day 2	N/A	AAAAP+	AAAAA
	Day 3	N/A	AAAPP	AAAAA
88	Socorro Moreno Blandon			
	Day 1	N/A	AAPPP+	AAAAA
	Day 2	N/A	APPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
89	Agustina Espínoza			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
90	Lucia Mayorga Bobadillo			
	Day 1	N/A	AAAAP+	AAAAA
	Day 2	N/A	AAAP+P+	AAAAA
	Day 3	N/A	AAP+P+P+	AAAAA

Table B-10. Results for December (continuation)

#	Name of Person in Charge of Filter	Results Source	Results Before Filtration	Results After Filtration
91	María Mesa Pavón			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
92	Llian Ramirez Reyes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
93	Amanda Urbina Espinoza			
	Day 1	N/A	PPPP+P+	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
94	Agueda Cano Ramírez			
	Day 1	N/A	PPPPP	AAAAA
	Day 2	N/A	PPPPP	AAAAA
	Day 3	N/A	PPPPP	AAAAA
95	Carla Aráuz Reyes			
	Day 1	N/A	N/A	N/A
	Day 2	N/A	N/A	N/A
	Day 3	N/A	N/A	N/A
96	Alba Luz Reyes Martínez			
	Day 1	APPPP	PPPPP+	AAAAA
	Day 2	PPPPP	PPPPP	AAAPP+
	Day 3	PPPPP	PPPPP	AAAPP
97	Marta Rivera Espinoza			
	Day 1	N/A	AAAP+P+	AAAAA
	Day 2	N/A	AAAPP	AAAAA
	Day 3	N/A	AAPPP	AAAAA
98	Araceli Urbina Saldaña			
	Day 1	N/A	AAA+PP	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	AAPPP	AAAAA
99	Telma Espinoza			
	Day 1	N/A	AAA+PP	AAAAA
	Day 2	N/A	AAPPP+	AAAAA
	Day 3	N/A	AAPPP	AAAAA
100	Rosario Hernández			
	Day 1	AAPPP	AAPPP	AAAAA
	Day 2	PPPPP	PPPP+P+	AAAAA
	Day 3	PPPPP	PPPPP	AAAAA

Table B-11. December Survey Results

Sample #	What do you like the best about the filter?	What would you like to see changed on the filter?	If a neighbor offered you you money to buy your filter. how much would you charge?	Is the amount of filtered water enough for the family?
1	Water comes out without contamination	nothing	I would not sell it	I feel it constantly as it starts emptying
2	Water comes out clean	That the recipient vessel were ceramic	I would not sell it because it woud be a mistake	Yes. it is enough for the whole family
3	Water is safer	That the recipient vessel were ceramic	I would not sell it	Yes. enough for everybody
4	Water comes out cleaner	nothing	I would not sell it for any price	Yes. it is enough for everybody
5	filter broke	filter broke	filter broke	filter broke
6	Water is safer	That filter were larger	I would not sell it	Yes. enough for everybody
7	Water is safer	That filter were larger	I would not sell it	Yes. enough for everybody
8	Water is safer	That filter were larger	I would not sell it because I would be left without it	No. but I fill it constantly
9	filter broke	filter broke	filter broke	filter broke
10	filter broke	filter broke	filter broke	filter broke
11	filter broke	filter broke	filter broke	filter broke
12	Water is safer	Free replacements every 6 months	I would not sell it	Yes. if I fill it twice a day
13	Water comes out distilled	That filter were larger	I would not sell it	Yes
14	Water comes out without contamination	That filter were larger	I would not sell it	Yes. if I fill it twice a day
15	filter broke	filter broke	filter broke	filter broke
16	Water comes out cleaner	That filter were larger	I would not sell it	Yes. if I fill it twice a day
17	Water is maintained clean	That filter were larger	I would not sell it for any price	Yes. if I fill it twice a day
18	filter broke	filter broke	filter broke	filter broke
19	Water comes out clean	That filter were larger	I would not sell it for anything	Yes. if I fill it three times a day
20	Water comes out cleaner	That water came out cooler	I would not sell it	Yes. if I fill it twice a day
21	Water comes out healthier	nothing	I would not sell it for any price	Yes. enough for the whole family
22	Water comes out distilled	That filter were larger	I would not sell it for any price	Yes. but I have to fill it constantly
23	Water is cooler	That the recipient vessel were ceramic	I would not sell it for any price	Yes. but I have to fill it constantly
24	Water is healthier	That filter were larger	I would not sell it for any price	Yes. but I have to fill it constantly

Table B-11. <u>December Survey Results (continuation)</u>

Sample #	What do you like the Best about the filter?	What would you like to see changed on the filter?	If a neighbor offered you you money to buy your filter. how much would you charge?	Is the amount of filtered water enough for the family?
25	Water is healther	That filter were larger	I would not sell it for any price	Yes. if I fill it three times a day
26	Water is safer	That the recipient vessel were not plastic	I would not sell it	Yes. if I fill it twice a day
27	filter broke	filter broke	filter broke	filter broke
28	Water comes out clean	That filter were larger	I would not sell it	Yes. by filling it several times
29	Water comes out distilled	That filter were larger	I would not sell it	Yes. by filling it several times
30	Water comes out filtered	That filter were larger	I would not sell it	Yes. by filling it often
31	Water is safe	That filter were larger	I would not sell it	Yes. if I fill it twice a day
32	Water is filtered	That filter were larger	I would not sell it	Yes. if I fill it three times a day
33	filter broke	filter broke	filter broke	filter broke
34	Water comes out clean	That filter were larger	I would not sell it	Yes. by filling it several times
35	Water is safer	That filter were larger	I would not sell it	Yes. if I fill it twice a day
36	Filtered water is safer	That filter were larger	I would not sell it	Yes. if I fill it twice a day
37	Water is cleaner	That filter were larger	I would not sell it	Yes. by filling it several times
38	filter broke	filter broke	filter broke	filter broke
39	Water is cleaner	That filter were larger	I would not sell it	Yes. if I fill it twice a day
40	Water is cleaner	nothing	I would not sell it for any price	Yes. if I fill it twice a day
41	filter broke	filter broke	filter broke	filter broke
42	Water comes out without contamination	That recipient vessel were not plastic	I would not sell it	Yes. if I fill it twice a day
43	Water comes out cleaner	That recipient vessel were not plastic	I would not sell it	Yes. if I fill it three times a day
44	Not using filter	Not using filter	Not using filter	Not using filter
45	filter broke	filter broke	filter broke	filter broke
46	Water is safer	nothing	I would not sell it	Yes
47	Water is cooler	That filter were larger	I would not sell it	Yes. if I fill it constantly
48	filter broke	filter broke	filter broke	filter broke
49	Water is cleaner	That filter were larger	I would not sell it	Yes. by filling it several times
50	Water is cleaner	That filter were larger	I would not sell it	Yes. by filling it several times
51	Water is cleaner and safer	That filter were larger	I would not sell it	Yes. if I fill it three times a day
52	Water is cleaner and safer	That filter were larger	I would not sell it	Yes. by filling it 5 times a day
53	Water is cleaner and safer	That filter were larger	I woud not sell it	Yes. by filling it 5 times a day

Table B-11. December Survey Results (continuation)

Sample #	What do you like the best about the filter?	What would you like to see changed on the filter?	If a neighbor offered you you money to buy your filter. how much would you charge?	Is the amount of filtered water enough for the family?
54	Water is cooler and cleaner	That filter were larger	I would not sell it	Yes. if I fill it three times a day
55	Not at home	Not at home	Not at home	Not at home
56	Water comes out cooler	That filter were larger	I would not sell it for any price	Yes. by filling it several times a day
57	Water is well protected	That filter were larger	I would not sell it for any price because I would be left with nothing	Yes. enough for the whole family
58	Water is protected and clean	That filter were larger	I would not sell it because I don't want to be left with nothing	Yes
59	Water is protected and clean	That filter were larger	I would not sell it because I don't want to be left with nothing	Yes
60	Water comes out cleaner	That filter were larger	I would not sell it for any price	Yes. by filling it several times a day
61	Water is safer	That filter were larger	I would not sell it	Yes
62	Water comes out without contamination	That filter were larger	I would not sell it	Yes
63	Water comes out without contamination	That filter were larger	I would not sell it	Yes
64	Water is distilled	That filter were larger	I would not sell it	Yes
65	Water is distilled	That filter were larger	I would not sell it	Yes
66	Water is well protected	That recipient vessel were not plastic	I would not sell it	Yes
67	Water is well protected	That recipient vessel is not plastic	I would not sell it	Yes
68	Water is cleaner	That filter were larger	I would not sell it	Yes. by filling it several times
69	Water comes out without contamination	That recipient vessel were ceramic	I would not sell it for any price	Yes. by filling it twice a day
70	Water comes out purified	That they replace my filter when it stops working	I would not sell it for any price	N/A
71	Water comes out cleaner	That recipient vessel were not plastic	I would not sell it	Yes. by filling it several times
72	Water comes out cleaner	That recipient vessel were not plastic	I would not sell it	Yes. by filling it several times
73	Water comes out cleaner	That recipient vessel were not plastic	I would not sell it	Yes. by filling it several times

Table B-11. December Survey Results (continuation)

Sample #	What do you like the best about the filter?	What would you like to see changed on the filter?	If a neighbor offered you you money to buy your filter. how much would you charge?	Is the amount of filtered water enough for the family?
74	Water comes out distilled	That filter were larger	I would not sell it	Yes. by filling it several times
75	Water is lighter	That filter were larger	I would not sell it	Yes. by filling it three times a day
76	Water comes out without contamination	That filter were larger (ceramic component)	I would not sell it	Yes. by filling it three times a day
77	Water is more hygienic	That filter were larger	I would not sell it	Yes. by filling it three times a day
78	Water is more hygienic	That filter were larger	I would not sell it	Yes. by filling it three times a day
79	Water is healthier	That filter were larger	I would not sell it	Yes. by filling it twice a day
80	Water is safe	That filter were not plastic	I would not sell it	Yes. by filling it twice a day
81	Water is cool	That filter were larger	I would not sell it	Yes. by filling it three times a day
82	Water is safe	That filter were larger	I would not sell it	Yes. by filling it twice a day
83	Water is more hygienic	That water would not come out warm	I would not sell it for any price	Yes. by filling it twice a day
84	filter broke	filter broke	filter broke	filter broke
85	Water is cleaner	That filter were not plastic	I would not sell it	Yes. by filling it several times
86	Water comes out cleaner	That filter were larger	I would not sell it	Yes. by filling it twice a day
87	Water comes out healthier	That filter were larger	I would not sell it	Yes. by filling it three times a day
88	Water comes out distilled	That filter were larger	I would not sell it	Yes. by filling it twice a day
89	Water comes out safer	That filter were larger	I would not sell it	Yes. by filling it twice a day
90	Water comes out cleaner	That filter were larger	I would not sell it	Yes. by filling it several times
91	Water comes out healthier	That filter were larger	I would not sell it	Yes. by filling it twice a day
92	filter broke	filter broke	filter broke	filter broke
93	Water is safer	That recipient vessel were not plastic	I would not sel lit for any price	Yes. by filling it several times
94	Water comes out distilled	nothing	I would not sell it	Yes. by filling it several times
95	filter broke	filter broke	filter broke	filter broke
96	Water is healthier	That faucet had a lid	I would not sell it for for any price	Yes. by filling it several times
97	Water is healthier	That faucet had a lid	I would not sell it for for any price	Yes. by filling it several times
98	Water is safer	That filter were larger	I would not sell it	Yes. by filling it twice a day
99	Water is cleaner	That filter were larger	I would not sell it for for any price	Yes. by filling it several times
100	Water is cleaner	That filter were larger	I would not sell it for for any price	Yes. by filling it several times

APPENDIX C

Table C-1. Results for Membrane Filtration Tests Performed in January 2003

#	Name of Person in Charge of Filter	Results Before Filtration	Results After Filtration	Percent Removal	Observations
1	**Marina Conde**	**1/21/2003**	**1/21/2003**		
	Red Colonies	TNTC	TNTC	N/A	
	Blue Colonies	18	2	88.9	
	Volume of Sample Tested (mL)	10, 50	100		
2	**Eloísa Ovando/Rosa María González**	**1/22/2003**	**1/22/2003**		
	Red Colonies	4334	1	100.0	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1, 10	100		
3	**Esperanza González**	**1/22/2003**	**1/22/2003**		
	Red Colonies	TNTC	13	N/A	
	Blue Colonies	67.0	2	97.0	
	Volume of Sample Tested (mL)	1, 10	100		
5	**Zoraida Leiva**	**1/22/2003**	**1/22/2003**		
	Red Colonies	TNTC	20	N/A	
	Blue Colonies	TNTC	4	N/A	
	Volume of Sample Tested (mL)	1, 10	100		
7	**Mariluz González**	**1/22/2003**	**1/22/2003**		
	Red Colonies	TNTC	TNTC	N/A	
	Blue Colonies	23.0	0	100.0	
	Volume of Sample Tested (mL)	1, 10	100		
8	**Narcisa Vásquez**	**1/22/2003**	**1/22/2003**		
	Red Colonies	TNTC	22	N/A	
	Blue Colonies	45.0	0	100.0	
	Volume of Sample Tested (mL)	1, 10	100		
14	**María Inocenta Hernández**	**1/22/2003**	**1/22/2003**		
	Red Colonies	0	0	N/A	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1, 10	100		
16	**Josefa Ordóñez**	**1/26/2003**	**1/26/2003**		
	Red Colonies	560	0	100.0	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1	100		
17	**Lesbia Araya**	**1/22/2003**	**1/22/2003**		
	Red Colonies	2900	4	99.9	
	Blue Colonies	300	0	100.0	
	Volume of Sample Tested (mL)	1, 10	100		
20	**Rebeca Ordóñez**	**1/21/2003**	**1/21/2003**		
	Red Colonies	620	10	98.4	
	Blue Colonies	3	0	100.0	
	Volume of Sample Tested (mL)	10, 50	100		

Table C-1. Results for Membrane Filtration Tests Performed in January 2003 (continuation)

#	Name of Person in Charge of Filter	Results Before Filtration	Results After Filtration	Percent Removal	Observations
22	**Olga Monte**	**1/21/2003**	**1/21/2003**		
	Red Colonies	TNTC	TNTC	N/A	
	Blue Colonies	TNTC	136	N/A	
	Volume of Sample Tested (mL)	10, 50	100		
24	**Filomena Antonia Padilla Velásquez**	**1/21/2003**	**1/21/2003**		
	Red Colonies	TNTC	0	100.0	20 red in border -
	Blue Colonies	52.5	0	100.0	Bad sealing
	Volume of Sample Tested (mL)	10, 50	100		
25	**Ramona Montez**	**1/22/2003**	**1/22/2003**		
	Red Colonies	535	0	100.0	
	Blue Colonies	12	0	100.0	
	Volume of Sample Tested (mL)	1, 10	100		
29	**Hurania Padilla**	**1/21/2003**	**1/21/2003**		
	Red Colonies	TNTC	6	N/A	
	Blue Colonies	50	0	100.0	
	Volume of Sample Tested (mL)	10, 50	100		
30	**Esther Montes**	**1/21/2003**	**1/21/2003**		
	Red Colonies	650	27	N/A	
	Blue Colonies	18	0	100.0	
	Volume of Sample Tested (mL)	10, 50	100		
31	**Ismelda Condez Rodríguez**	**1/21/2003**	**1/21/2003**		
	Red Colonies	TNTC	19	N/A	
	Blue Colonies	95	0	100.0	
	Volume of Sample Tested (mL)	10, 50	100		
32	**Leonor Padilla Salina**	**1/21/2003**	**1/21/2003**		
	Red Colonies	TNTC	TNTC	N/A	
	Blue Colonies	15	0	100.0	
	Volume of Sample Tested (mL)	10, 50	100		
34	**Damaris Padilla**	**1/21/2003**	**1/21/2003**		
	Red Colonies	TNTC	39	N/A	
	Blue Colonies	122.5	0	100.0	
	Volume of Sample Tested (mL)	10, 50	100		
37	**Xiomara Padilla "P"**	**1/21/2003**	**1/21/2003**		
	Red Colonies	55	10	81.8	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	10, 50	100		
39	**Esmeralda Chávez**	**1/22/2003**	**1/22/2003**		
	Red Colonies	TNTC	1	N/A	
	Blue Colonies	123	0	100.0	
	Volume of Sample Tested (mL)	1, 10	100		

Table C-1. Results for Membrane Filtration Tests Performed in January 2003 (continuation)

#	Name of Person in Charge of Filter	Results Before Filtration	Results After Filtration	Percent Removal	Observations
40	**Esbelia Obando**	**1/21/2003**	**1/21/2003**		
	Red Colonies	TNTC	5	N/A	
	Blue Colonies	138	0	100.0	
	Volume of Sample Tested (mL)	10, 50	100		
42	**Juana Condes Montes**	**1/21/2003**	**1/21/2003**		
	Red Colonies	TNTC	TNTC	N/A	
	Blue Colonies	TNTC	TNTC	N/A	
	Volume of Sample Tested (mL)	10, 50	100		
47	**Elsa Salmerón**	**1/22/2003**	**1/22/2003**		
	Red Colonies	2945	4	99.9	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1, 10	100		
49	**Adelaida Sánchez Padilla**	**1/26/2003**	**1/26/2003**		
	Red Colonies	0	0	N/A	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1	100		
51	**Alejandra Escoto Avendaño**	**1/26/2003**	**1/26/2003**		
	Red Colonies	210	48	77.1	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1	100		
52	**Jacundina Salina "A"**	**1/26/2003**	**1/26/2003**		
	Red Colonies	190	11	94.2	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1	100		
53	**Sara Socorro Padilla Aguilar**	**1/26/2003**	**1/26/2003**		
	Red Colonies	670	12	98.2	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1	100		
56	**Eva Vásquez Toruño**	**1/22/2003**	**1/22/2003**		
	Red Colonies	3845	0	100.0	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1, 10	100		
71	**María Espinoza Ramírez**	**1/26/2003**	**1/26/2003**		
	Red Colonies	200	TNTC	N/A	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1	100		
72	**Carla Mesa Espinoza**	**1/26/2003**	**1/26/2003**		
	Red Colonies	200	8	96.0	
	Blue Colonies	0	1	N/A	
	Volume of Sample Tested (mL)	1	100		

Table C-1. Results for Membrane Filtration Tests Performed in January 2003 (continuation)

#	Name of Person in Charge of Filter	Results Before Filtration	Results After Filtration	Percent Removal	Observations
73	**Maria Mejia Zambrana**	**1/20/2003**	**1/20/2003**		
	Red Colonies	45	0	100.0	
	Blue Colonies	3	0	100.0	
	Volume of Sample Tested (mL)	100	100		
74	**María Reyes Rojas**	**1/24/2003**	**1/24/2003**		
	Red Colonies	100	34	66.0	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1	100		
75	**Simona Zamora "M"**	**1/20/2003**	**1/20/2003**		
	Red Colonies	22	0	100.0	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	100	100		
76	**Verónica Espinoza "S"**	**1/20/2003**	**1/20/2003**		
	Red Colonies	TNTC	4	N/A	Before filtration: ring
	Blue Colonies	0	1	N/A	Bad sealing
	Volume of Sample Tested (mL)	100	100		
77	**María Reyes Murillo**	**1/20/2003**	**1/20/2003**		
	Red Colonies	432	85	80.3	
	Blue Colonies	8	3	62.5	
	Volume of Sample Tested (mL)	100	100		
78	**Maria Ilaria Reyes Murillo**	**1/20/2003**	**1/20/2003**		
	Red Colonies	105	56	46.7	
	Blue Colonies	0	0	0.0	
	Volume of Sample Tested (mL)	100	100		
79	**Catalina Murillo Terminio**	**1/24/2003**	**1/24/2003**		
	Red Colonies	100	1	99.0	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1, 5	100		
80	**Petrolina Urbina Urbiana**	**1/24/2003**	**1/24/2003**		
	Red Colonies	4200	TNTC	N/A	
	Blue Colonies	75	4	94.7	
	Volume of Sample Tested (mL)	1, 5	100		
81	**Enrriqueta Zotelo "M"**	**1/24/2003**	**1/24/2003**		
	Red Colonies	1675	TNTC	N/A	
	Blue Colonies	1125	3	99.7	
	Volume of Sample Tested (mL)	1, 5	100		
82	**Petronila Mayorga Bobadillo**	**1/20/2003**	**1/20/2003**		
	Red Colonies	32	24	25.0	
	Blue Colonies	0	1	N/A	
	Volume of Sample Tested (mL)	100	100		

Table C-1. Results for Membrane Filtration Tests Performed in January 2003 (continuation)

#	Name of Person in Charge of Filter	Results Before Filtration	Results After Filtration	Percent Removal	Observations
85	**Rosa Reyes Rojas**	**1/24/2003**	**1/24/2003**		
	Red Colonies	1725	1	99.9	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1, 5	100		
88	**Socorro Moreno Blandon**	**1/26/2003**	**1/26/2003**		
	Red Colonies	230	81	64.8	
	Blue Colonies	0	2	N/A	
	Volume of Sample Tested (mL)	1	100		
89	**Agustina Espinoza**	**1/26/2003**	**1/26/2003**		
	Red Colonies	0	0	N/A	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1	100		
90	**Lucia Mayorga Bobadillo**	**1/20/2003**	**1/20/2003**		
	Red Colonies	TNTC	0	100.0	
	Blue Colonies	0	0	0.0	
	Volume of Sample Tested (mL)	100	100		
94	**Agueda Cano Ramírez**	**1/20/2003**	**1/20/2003**		
	Red Colonies	372	36	90.3	very small 36 red
	Blue Colonies	3	0	100.0	
	Volume of Sample Tested (mL)	100	100		
96	**Alba Luz Reyes Martínez**	**1/24/2003**	**1/24/2003**		
	Red Colonies	4125	1	100.0	
	Blue Colonies	0	0	N/A	
	Volume of Sample Tested (mL)	1, 5	100		
97	**Marta Rivera Espinoza**	**1/20/2003**	**1/20/2003**		
	Red Colonies	298	3	99.0	very small 3 red
	Blue Colonies	9	0	100.0	
	Volume of Sample Tested (mL)	100	100		
98	**Araceli Urbina Saldaña**	**1/26/2003**	**1/26/2003**		
	Red Colonies	460	TNTC	N/A	very small TNTC
	Blue Colonies	0	32	N/A	
	Volume of Sample Tested (mL)	1	100		
99	**Telma Espinoza**	**1/20/2003**	**1/20/2003**		
	Red Colonies	TNTC	23	N/A	
	Blue Colonies	0	1	N/A	
	Volume of Sample Tested (mL)	100	100		

APPENDIX D

Table D-1. Cost breakdown for MF (Total Coliform and E-coli) method

Description	Manufacturer	Catalogue #	Cost [US$]
MF Kit	Millipore	XX6300120	$ 1,200.00
47 mm filters (1000 pk)	Millipore	HAWG047S1	$ 300.00
petri dishes with pads (500/pk) x2	Millipore	PD10047S5	$ 256.00
Single Chamber Incubator (2nd hand)	Millipore	XX631K230	$ 750.00
4 oz plastic bottles	VWR-S	SC16129-028	$ 6.64
Automatic pipette, autoclavable 1-5 ml	Oxford	53502-440	$ 153.83
Whirlpack bags - 100 ml - 100/pk x10	VWR	11216-780	$ 139.40
1/34 Dual Magnifier, 3x, 10x	VWR	36934-117	$ 13.50
Alcohol burners, Boekel (B234)	VWR	17822-605	$ 15.71
Nalgene Hand pump (P1287)	VWR	6131-0020	$ 67.54
graduated cylinder, polyp-100 ml	VWR	24776-086	$ 8.65
Latex gloves 100/pk x10	VWR	32916-536	$ 86.30
Methanol			$ 21.00
mColiBlue media (50/pk) x 20	HACH	M00PMCB24	$ 1,700.00
Capital Investment			$ 2,209.23
Total Cost for 1000 tests			$ 4,718.57
Cost per test			$ 4.72
Cost per test (without including capital investment)			$ 2.50

Table D-2. Cost breakdown for H_2S-MPN method[12]

Description	Manufacturer	Catalogue #	Cost [US$]
Potassium Phosphate Dibasic - 500g	J.T. Baker	JT4012-1	$65.68
Sodium Thiosulfate - 500 g	Mallinckrodt	MK809612	$9.76
Ferric Amonium citrate - 500 g	J.T. Baker	JT1977-1	$45.43
Sodium Dodecyl sulfate - 100 g	ICN	IC811034	$20.40
Bacteriological Peptone - 250 g x 3	BD/Difco	DF0118-17	$132.96
weighing paper	VWR-S	12578-165	$3.67
graduated cylinder, polyp-100 ml	VWR	24776-086	$ 8.65
Latex gloves 100/pk x10	VWR	32916-536	$ 86.30
Whirlpack bags - 100 ml - 100/pk x10	VWR	11216-780	$ 139.40
4 oz plastic bottles	VWR-S	SC16129-028	$ 6.64
12 ml borosilicate glass vials (144/pk) x2	Wheaton	66011-314	$101.18
15-25 Teflon caps (200/pk) x2	Wheaton	66012-372	$175.72
0.1 g Compact Balance 200 g capacity***	Ohaus	65500-204	$79.80
Economy Oven 120 V ***	VWR	52200-534	$440.00
Capital Investment			$ 811.99
Total Cost for 2000 tests			$ 1,315.59
Cost per test			$ 0.66
Cost per test (without including capital investment)			$ 0.25

[12] number of tests for the amount of chemicals is approximate and each test includes five 10 mL vials

Table D-3. Cost breakdown for H_2S-P/A method[13]

Description	Manufacturer	Catalogue #	Cost [US$]
H2S Pathoscreen 20 ml vol, 50/pk x20	HACH	26107-96	$419.80
Latex gloves 100/pk x10	VWR	32916-536	$ 86.30
Whirlpack bags - 100 ml - 100/pk x10	VWR	11216-780	$ 139.40
4 oz plastic bottles	VWR-S	SC16129-028	$ 6.64
12 ml borosilicate glass vials (144/pk)	Wheaton	66011-314	$ 50.59
15-25 Teflon caps (200/pk)	Wheaton	66012-372	$ 87.86
Economy Oven 120 V ***	VWR	52200-534	$ 440.00
Capital Investment			$ 585.09
Total Cost for 1000 tests			$ 1,230.59
Cost per test			$ 1.23
Cost per test (without including capital investment)			$ 0.65

Table D-4. Cost breakdown for Coliplate method

Description	Manufacturer	Catalogue #	Cost [US$]
Coliplates (100 plates/pk) x 10	EPBI	5062	$ 3,800.00
Latex gloves 100/pk x10	VWR	32916-536	$ 86.30
Single Chamber Incubator (2nd hand)	Millipore	XX631K230	$ 750.00
Whirlpack bags - 100 ml - 100/pk x10	VWR	11216-780	$ 139.40
Capital Investment			$ 750.00
Total Cost for 1000 tests			$ 4,775.70
Cost per test			$ 4.78
Cost per test (without including capital investment)			$ 4.03

[13] for 1 P/A test by using pre-made HACH Pathoscreen culture media.