Water Quality Initiatives

Sustainable Educational Programs and Research Documentation for the Community of Rancho al Medio, Dominican Republic

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PLUG HIA

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Abstract

Since the first visit in 2005, engineers working with BLUELab and Health In Action have installed several dual-bucket filters and Biosand filters in the rural community of Rancho al Medio, Dominican Republic. This past February, the HIA engineering team conducted water quality tests on filters being used in the community to access the efficiency and sustainability of the filters. Community surveys were performed to determine the use of the filters and alternative water purification techniques. A community meeting was held to determine the need for future water purification projects in the community. In this report, the results of the testing and surveys will be presented, along with recommendations regarding new filters, pumps, and future trips to Rancho al Medio.

Project Background

Currently, 1 billion people lack access to safe drinking water supply and 2.6 billion lack water sanitation services.[1] Rancho al Medio, an impoverished rural community in the Dominican Republic, has been the focus of HIA's water purification projects over the past few years. Medical students with HIA first visited the community of Rancho al Medio in 2002. They have operated a medical clinic every year since 2002. In 2004, BLUELab collaborated with the newly formed undergraduate chapter of HIA and students in Engineering 490 to conduct a quality assessment of water sources in the community. The team found high levels of contamination in the river and they returned in 2005 to install dual-bucket filters. Five dual-bucket filters were installed in 2005. In 2006, the team returned and installed a pilot Biosand filter in Mercedes' house (a predominant woman in the community). In 2007, the team found that the Biosand filter was working well and installed four more Biosand filters.

The dual-bucket system is a two bucket system that uses granular activated carbon to treat the water. Typically dual-bucket systems have a design life of one to two years. A picture of the dual-bucket system is included in Figure 1.

Figure 1: Dual Bucket Filter

The Biosand filters combine both biological and mechanical removal mechanisms. A description and a picture of the Biosand filter are included in Figures 2 and 3, respectively.[2] The Biosand filter was invented by Dr. David

Manz, a civil engineer from Alberta, Canada. Laboratory testing has obtained removal efficiencies of 97%-99.7%.[2] The design life for the Biosand filter is 50 years.

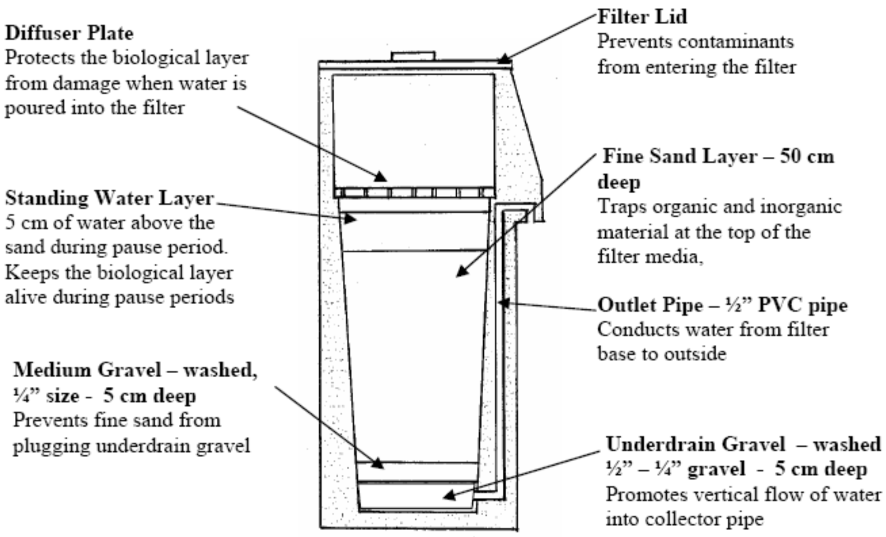

Figure 2: Biosand Filter Description

Figure 3: Picture of Biosand Filter in Rancho Al Medio

Problem Identification

Previous BLUELab teams traveled to the community and implemented two type of point-of-use systems: Biosand filters and dual-bucket systems. Due to infrequent communication with Rancho al Medio community members and Manos Tiempo (partnering NGO), HIA receives little feedback regarding the continued use and effectiveness of the filters, the community's satisfaction with the filters, and the community's demand for new filters or other water treatment techniques. Before pursuing future water projects, the engineering team needed to perform a follow-up study on previous projects and installations. The engineering team's 2008 project goals were to assess the sustainability of the previously installed filters and the need for future projects related to water quality.

Methods

A quantitative analysis of the effectiveness and popularity of the filters was determined to be essential to HIA's primary goal of developing useful, sustainable solutions to the community's problems.   A diagram of how we planned to determine the sustainability of the point-of-use treatment systems is shown in Figure 4.

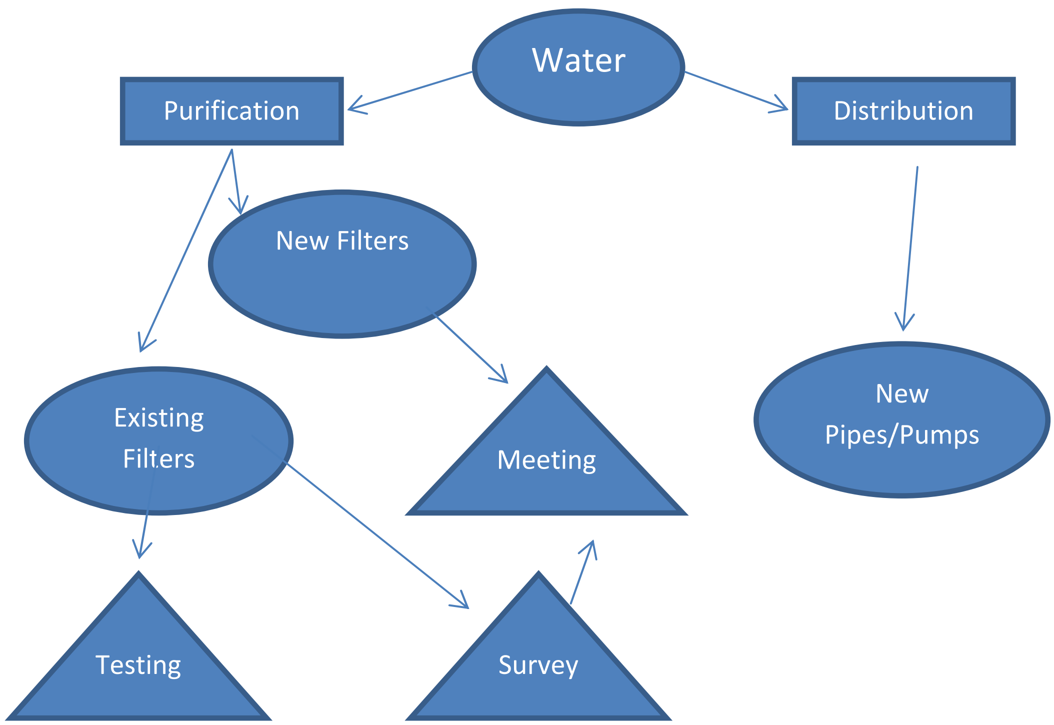

Figure 4: Structure for Obtaining Objectives of Water Quality Assessment

Water Quality Testing

We rated the effectiveness of the filters based on their impact on human health. We used microbial contamination as an indicator of poor water quality. Disease causing microorganisms or pathogens can have negative health effects such as diarrhea, craps, and nausea. Pathogens pose a significant health risk to infants, young children, the elderly, and people with comprised immune systems. We tested microbial contamination through the measurement of total coliforms and *E. coli* using Coliscan Easygel test kits purchased from Micrology Laboratories. Included in Appendix D is a description of how the Coliscan Easygel test kits work and the procedure followed by the engineering team.

Coliforms are not a health threat in themselves, but they are used by the Environmental Protection Agency (EPA) and drinking water treatment operators in the United States to indicate whether potentially harmful bacteria may be present. Coliforms are naturally present in the environment. However, *E. coli* is only present through contamination of water from human and animal fecal waste. The EPA sets the Maximum Contaminant Level Goal for total coliforms including *E. coli* and fecal matter at zero.[3] The Maximum Contaminant Level (MCL) is set at 5%, which means that no more than 5% of the samples taken each month can be positive for total coliforms.[3] For water systems that collect fewer than 40 samples per month, no more than one sample can be positive for total coliforms. Once a system tests positive for total coliforms, the water system must than test for *E. coli* and fecal coliforms. If one sample tests positive for E. coli or fecal coliforms, it is in violation of the MCL.

Community Assessment

In order to get feedback from the community on their level of satisfaction with the filters and their demand for new projects, a survey and a community dialogue was also considered an important facet of this year's project. Since the filters were placed in individual households, two different surveys were developed to diagnose the use of the filters in the community. Appendix E is an example of the survey used for households with a filter. The survey that was employed in households without a filter is included in Appendix F. Both of these surveys were modeled from previous engineering teams to maintain consistency and to be able to quantify whether the implementation of the Biosand filters improved the view of water quality and sanitation practices throughout Rancho Al Medio. The team designed the community surveys in order to determine the community's satisfaction with the quality, distance, and accessibility of each filter. The surveys included questions about health, methods of gathering water, methods of treating water, and frequency of filter use.

We also prepared for two community meetings focused on water quality. The first was a presentation for children about good sanitation and water practices, such as washing one's hands after using the restroom. The second was a meeting intended to engage adult community members in a discussion about water quality and encourage them to identify problems and seek out solutions.

Results

Water Treatment

We tested the water quality of five Biosand filters, one dual-bucket system, and well water near the school using the Coliscan Easygel test kits. We also tested bottled water as a negative control to ensure that the test kits were working correctly. The results of the Coliscan Easygel testing are provided in Table 1. For the testing of the filters, we took a water quality test sample before and after the filter. Most community members obtained their source water from a combination of rainwater and well water. Pictures of the test results and households are included in Appendix B. The test results are based on coliform forming units (CFUs) per 100 mL which is the total number of cell colonies on the Petri dish.

Table 1: Water Quality Testing Results

Filter Type	Filter Location	Water Source	CFUs/100 ml Total Coliform	CFUs/100 ml E. coli	Recommendation
		Bottled Water	0	0	NA
		Unfiltered Well Water	160	0	Stop Use
Biosand	Candita	Before Filter	59000	450	Continue Use
		After Filter	0	0	
Biosand	Merecedes	Before Filter	10550	0	Continue Use
		After Filter	0	0	
Biosand	Sophia	Before Filter	650	0	Continue Use
		After Filter	40	0	
		Ceramic Container	1390	0	
Biosand	Lilia	Before Filter	59500	275	Stop Use
		After Filter	1640	20	
Biosand	Israel	Before Filter	100	0	-
		After Filter	40	0	
Dual Bucket	Josefina	Before Filter	1500	200	Stop Use
		After Filter	450	105	

All of the Biosand filters reduced the number of total coliforms present in the source water. However, not all of the Biosand filters functioned within U.S. drinking water standards. We recommended the homeowner and neighbors stop the use of the Biosand filter in Lilia's home. Even though the Biosand filter is reducing the number of total coliforms and E. coli, the filter is still not operating within U.S. drinking water standards.

We did not make a recommendation for the Biosand filter at Israel's home because the team was told by one of Israel's children that the source water entering the filter was bottled water. Israel was never available when the team stopped by to test the filter. We were told by neighbors that the Biosand filter at Israel's home was not operating properly.

In the prior reports from BLUELab, there were five dual-bucket filters listed to be present in the community. While we were in Rancho Al Medio, they discovered three dual-bucket filters with an expiration date of September 2007. We tested the water quality of one dual-bucket system in the home of Josefina. The dual-bucket filter located in Josefina's home was not functioning properly. There was still a large amount of *E. coli* present after the filter. We recommended that Josefina immediately discontinue use.

Through the testing and demonstrations, we learned that filter maintenance is very important to the removal efficiency of the filter. Lilia performed the least maintenance based on our survey and the Biosand filter in her home had the lowest quality water. Mercedes performed the most maintenance and her water was of very high quality after the filter. Therefore, we reminded the homeowners of the proper filter maintenance procedure (see Appendix C) and taped the procedure on the filters as a reminder.

In addition to maintenance, the correct procedure for use of the filter is necessary. Using the same container after and before the filter will cause contamination of the filter water despite the Biosand filter's removal of microbial contaminants. The storage container of the filter water is also very important. At Sophia's home, the water from directly after the Biosand filter and a ceramic container was tested. The ceramic container greatly reduced the quality of the water. The ceramic container was uncovered and not washed regularly. We recommended that the homeowners use covered plastic containers that are bleached or cleaned regularly.

Community Assessment

In implementing the surveys, the team was not strict about filling out the forms. We obtained a large enough sample size to get a good idea of how many people treat their water. For the rest of the responses, we present our results based on general observations.

From our sample group of eighteen community members, 89% claimed to treat their water on a regular basis. Most of the survey targets were aware of treatment methods such as boiling and chlorination, and many of them knew the location of the nearest Biosand filter. A large portion of the people surveyed complained about various pains and illnesses, but this may have been influenced by the presence of the medical clinic. Almost everyone was aware that untreated water is unhealthy. The most common complaint was about distance from the home to the nearest pump. In the process of surveying, we found one large family that was interested in cooperating to buy a Biosand filter.

The survey of Biosand filter owners yielded a variety of results. Mercedes and Sofia genuinely appreciate the filter, share it with community members, and demonstrate a desire to maintain and use it properly. Sofia, however, was ignorant of some of the necessary maintenance techniques. The filter in Israel's home appears neglected. Lilia appreciates the filter but does not maintain it properly. Candita is using the filter and appreciates it but is not sharing it with the community.

The children's presentation was successful. One student was very attentive and seemed to know a lot about sanitation. Most of the children seemed to have been educated on proper water use, sanitary practices, and water purification methods.

The adult meeting was held in the schoolhouse and advertised throughout the week to be held at noon on Thursday. Despite the fact that many community members said they would come, there was no turnout for this meeting. The team spent the next few hours recruiting heavily, and at five o'clock sent out groups to gather up everybody in the immediate area. At 5:15 about forty people were in the schoolhouse. The team presented the results of the testing, described dual-bucket and Biosand filters, recommended that the community stop using the filter in Sofia's house, and presented a cost analysis comparing the price of a Biosand filter to daily bottled water purchases over the life of a filter. One gentleman in particular, who was from a neighboring community, was very engaged, asked intelligent questions, and at the end of the meeting indicated that he would like to collaborate with his family members to buy a filter.

We also spoke with community leaders about water distribution systems. The community is in the process of installing running water throughout the community. The pump that delivers water to the school, which has been broken since HIA at the University of Miami spoke with Manos a Tiempo earlier this year, is being replaced. Although the we were presented with a receipt with two different pump price quotes, we spoke with Chicho from Manos a Tiempo and Bartolo, the president of the neighborhood association, and after some encouragement they decided to get the community together to buy the pump themselves. Many people indicated that water distribution is a significant problem, but since the community seems to be making steps toward solving these problems themselves, we do not recommend any water distribution projects at this time.

Future Plans

HIA does not travel frequently enough to the community to give people short-term water treatment methods. The community will not have sophisticated testing methods and they may not see the connection between getting sick and the filter they are using to treat their water. If more point-of-use treatment systems are to be implemented in the future, the team recommends long-term, sustainable systems such as the Biosand filters, since the families rely so heavily on what we provide.

Future teams should regularly evaluate the community's usage of the Biosand filters in order to ensure that they are being used and maintained properly and that the filters are still working. If the filter users have been frequently ill, the water appears turbid, or testing shows unhealthy levels of contamination, we recommend treating the filter with bleach. For information on trouble shooting different problems associated with the Biosand filter, see Appendix G.

Based on the survey, 89% of the community drinks bottled water or treats their water in some way (filtration, chlorination, or boiling). We feel that the knowledge of proper water treatment and sanitation has increased in the community throughout the years of HIA visiting the community. However, the survey results may be biased by language barriers and/or community members trying to tell us what we want to hear. We recommend future trips involve home-stays or high exposure to the day-to-day life of community members. This would be a valuable opportunity to observe the water treatment habits with less potential bias.

We saw the community demonstrate a high degree of self-motivation to purchase and install their own technologies. Because of this, we recommend that future groups do not give anything to the community. A more sustainable approach would be to work with the community to develop a purchasing plan and provide technical expertise where needed. The community has an electrical network, TVs in many homes, and many motorcycles. If they collaborate, the community has the financial resources to make water quality a priority.

Because of the self-motivation and financial capacity that we observed, we recommend that HIA consider projects in other, less fortunate communities in future years. The lessons we have learned in Rancho al Medio should be greatly useful for endeavors in other communities. One of the major difficulties that we encountered this year was a lack of communication and active participation on the part of our host non-profit, Manos a Tiempo. Choosing a strong, active, cooperative non-profit will be essential to the success of future trips.

Conclusions

Three Biosand filters are working optimally and meeting U.S. drinking water quality standards. One Biosand filter is working below optimum level. The fifth Biosand filter was tested, but the results were inconclusive. The dual-bucket filter is no longer functioning. We recommended that all dual-bucket filters be dismantled and replaced by some other more sustainable purification method.

The filter maintenance and the use of proper containers are vital to good water quality. If the filter is not maintained properly, the removal efficiency and the life-time of the filter will be greatly reduced. Separate containers should be used for the water placed into the Biosand filter and the water after the filter. The choice of storage container is critical and the team recommends a covered plastic container. Despite the Biosand filter's treatment abilities, if the same container or a contaminated container is used, pathogens will exist in the water no matter how effective the Biosand filter is at treating the water.

Of the community members surveyed, 89% used a water purification method to treat their drinking water. Based on the survey, the location of the filters was not well known and underutilized. Water quality is also not the highest priority among community members. Even though we told many community members about our meetings, only a small percentage were represented at them. At the meeting, there was interest by a few community members in pooling financial resources together to purchase water purification systems. However, we found that the community was more interested in water distribution than water purification.

We recommend that future project teams provide expertise/education and do not give material things to the community. The community has the financial resources to make water purification a priority. Giving things to the community creates an unsustainable situation where negative connotations can easily foster. We recommend that HIA consider projects in other less fortunate communities in future years, because of the self-motivation and financial capacity that we observed.

References

[1] World Health Organization/UNICEF. 2004. Meeting the MDG drinking water and sanitation target: A mid-term assessment of progress. http://wssinfo.org/pdf/JMP_04_tables.pdf.

[2] Rod & Ingrid McCarroll. Friends Who Care Charities, Ltd. January 2008. http://www.friendswhocare.ca/index.htm

[3] U.S. Drinking Water Standards. Environmental Protection Agency. 2008. www.epa.gov/drinkingwater

Appendix A: Survey Results

Using the survey for community members who do not own Biosand filters (Appendix F), the team interviewed several people in the community to determine the quality of their water and what purification techniques they use. In order to briefly summarize the interviews, the team developed a rating system to indicate high, medium, and low water quality. “High” indicates that the interviewee had not noticed anything negative about the taste or smell of the water and believed that the water was clean. If the interviewee complained about any aspect of the water quality, a rating of “Low” was given.General impressions from the survey include that most people use bleach to treat their water and that different community members have a wide range of satisfaction with their drinking water quality.

Last Name	First Name	Treatment method	Quality	Distance to water (km)	Container
Franco de Lopez	Nuñia	Bleach	High	1	Plastic
Vallera	Rafael	None (bottled)	High	0.5	Plastic
Perdomo Vallera	Angelina	Boil (5 min)	Med	3	Plastic
Lopez Martez	Josefina	Bleach	Low	1	Plastic
Valera Valdez	Josefina	Dual-Bucket	Low	2	Plastic
Serra	**Rosalia**	**None**	**Low**	**2**	**Plastic**
Avelino	Yaniris	Bleach	Low	1	Plastic
Lopez Valdera	Clara	Bleach	High	1	Plastic, Metal
de los Angeles Valdez	Maria	Bleach	Low	1	Plastic
	Mariana	None (bottled)	n/a	1	Plastic
	Biljirio	Bleach	n/a	1	
	Diana	Bleach	n/a	1	
	Antonia	Bleach	n/a		Plastic
	Jose Juana	Bleach	n/a	1	Plastic
	Rauline	None	High	1	Plastic
	Dinora	Bleach	n/a		
	Mariyendo	Bleach	n/a		
	Leon	None (bottled)	n/a		

Appendix B: Coliscan Easygel Testing Results

The HIA engineering team performed water quality testing on the five Biosand filters and the one dual-bucket system using the Coliscan Easygel test kits (see Appendix D for details regarding the Coliscan Easygel test kits).

When visiting the filters in community homes, the team asked the homeowners to demonstrate how they used the filter. The team took water quality samples of the source water before entering the filter and after the filter using 15 mL sterile test tubes. After the samples were taken, the samples were inserted into the Coliscan Easygel kit within an hour as per the instructions of the manufacturer. Then the samples were plated within 15 minutes. The cells grew for 2 days and then cell colonies were counted.

<u>Biosand Filters</u>

<u>Lilia's House</u>

The first Biosand filter test took place at Lilia Preide's house. A picture of where Lilia obtained her source water for the Biosand filter and the filter itself are shown in Figure 1. The source water was in an open steel container lined with concrete that looked to be of poor water quality. Many flies swarmed around the Biosand filter from left over fruit scraps, thus creating a poor sanitation condition.

Figure 1: (left) Source water for Lilia's Biosand filter, (middle) Lilia's Biosand filter, (right) Inside Biosand filter`

When performing cell counts, the optimal number of cell colonies is 30 to 300. In order to determine the appropriate dilutions for the week of testing, the team took four separate volumes for the source water at Lillia's house (2,000 ul, 200 ul, 20 ul, and 2 ul samples).   Based on the testing results, the team chose to use 1,000 ul and 200 ul samples for the source water. The Coliscan testing kits specified that the volume of 5.0 ml is necessary for water used for drinking. The results of the Coliscan Easygel test on Lilia's Biosand filter is shown in Figure 2. Each red dot on the Petri dish represents a cell colony of total coliform.   The team concluded that the Lilia's Biosand filter is not operating correctly because of the large amount of total coliforms present in the water after the filter.

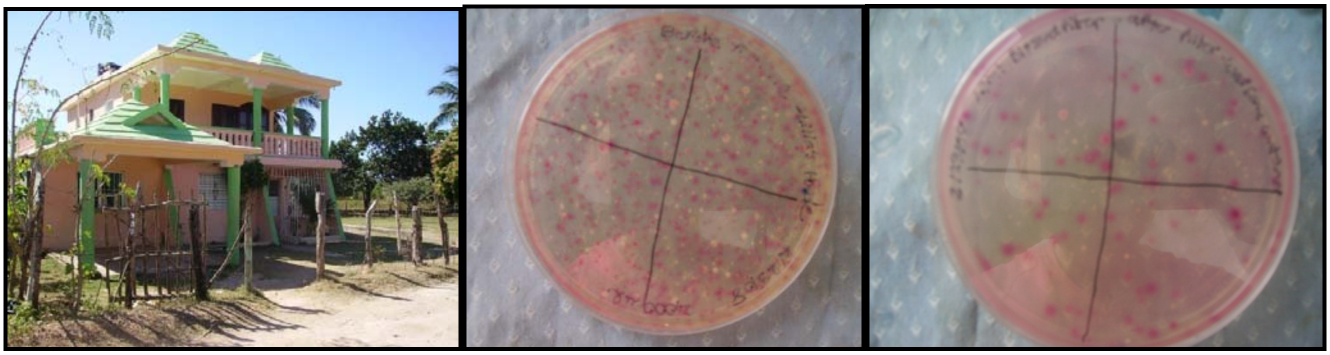

Figure 2: (left) Lilia's house where Biosand filter is located, (middle) Coliscan testing results before Biosand filter for 2.0 mL sample, (right) Coliscan testing results after Biosand filter for 5.0 mL sample

<u>Candita's House</u>

The water quality tested before the Biosand filter came from the top of the Biosand filter. While obtaining the sample, the team noticed a tadpole swimming in the top of the filter. Despite the seemly poor water quality, the Biosand filter effectively treated the water to U.S. drinking water standards, see Figure 3. From discussions with Candita, the team felt that she did not allow other members of the community to access the filter.

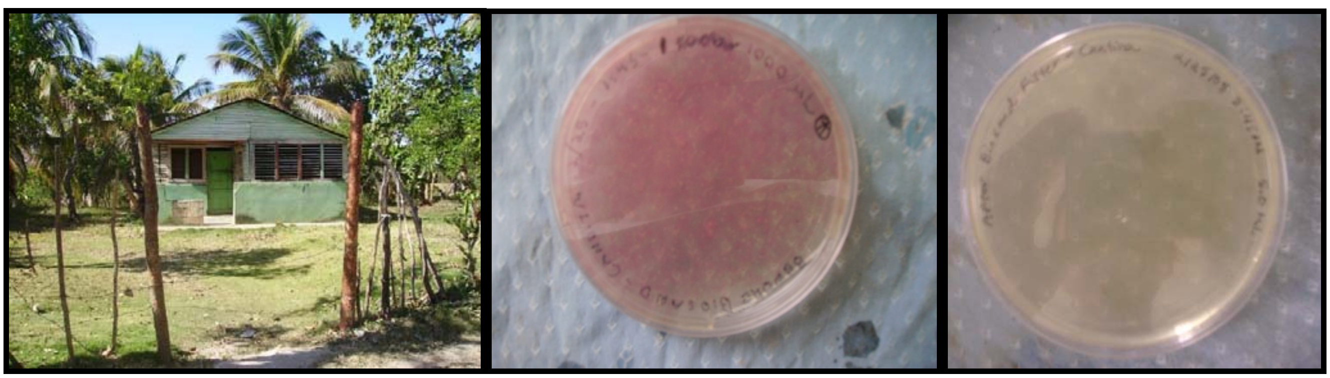

Figure 3: (left) House of Candita's son where Biosand filter is located, (middle) Coliscan testing results before Biosand filter for 1.0 mL sample, (right) Coliscan testing results after Biosand filter for 5.0 mL sample

<u>Merecedes' House</u>

Merecedes acquires her source water from a combination of rainwater collection and well water. She follows the correct maintenance steps to keep the Biosand filter operating correctly. The results of the Biosand filter testing show that the filter is efficiently removing the total coliforms to U.S. drinking water standards, see Figure 4. Merecedes uses a separate container for the source water and the post Biosand filter water. She regularly rinses the white lid at the top of the filter. Every six months, she scoops the top layer of water at the top of the filter and replaces it with new source water. Merecedes also said that she lets approximately 15 other people use the filter. She was very satisfied with the cleanliness and taste of the water after the filter. She also said that she has not had an upset stomach or diarrhea since the use of the filter in her home. However, when drinking water outside of her home, she says she will get sick if it is not purified water.

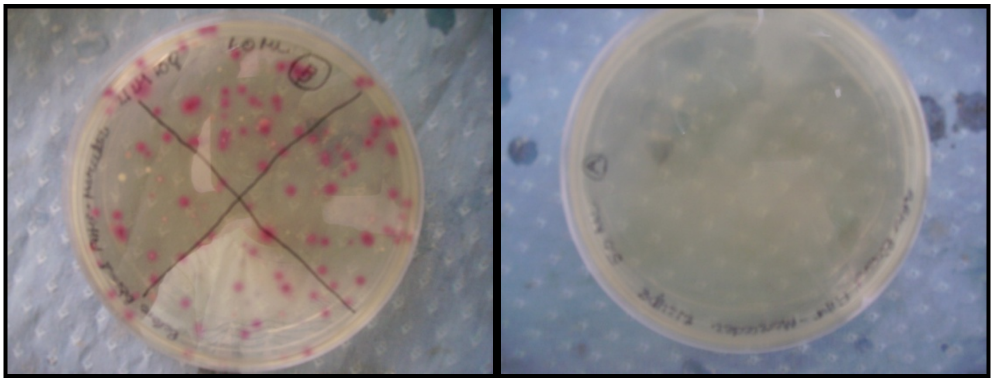

Figure 4: (left) Coliscan testing results before Biosand filter for 1.0 mL sample, (right) Coliscan testing results after Biosand filter for 5.0 mL sample

Sophia's House

The Biosand filter at Sophia's house was moved from its prior location at Domingo's house. Domingo moved away from the community and sold his home. Sophia obtains her source water from a metal container similar to Lilia's except for the fact that Sophia's container has a lid and a cloth to prevent contamination. In spite of moving the Biosand filter, which is not recommended by the manufacturer, the filter still functions properly, see Figure 5. Sophia used the same container to get the source water as after the filter.

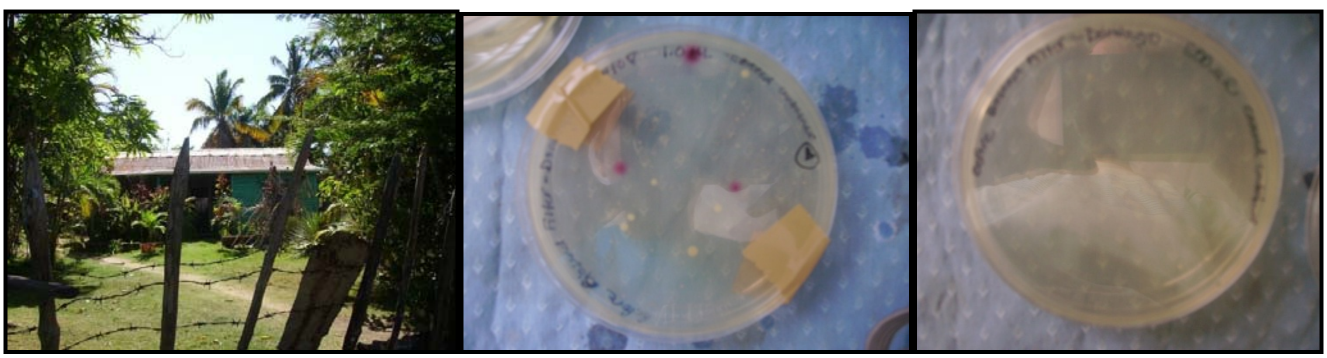

Figure 5: (left) Sophia' house where Biosand filter is located, (middle) Coliscan testing results before Biosand filter for 1.0 mL sample, (right) Coliscan testing results after Biosand filter for 5.0 mL sample

When the team visited Sophia's home again, they realized that she stored her water after the filter in a ceramic container. The team tested the water quality again of the water after the Biosand filter and the water in the ceramic container, see Figure 6. The ceramic container was open to the air and caused the water to be of poor water quality. Furthermore, research has shown that ceramic containers can leach lead into the drinking water held in the container.   The team then spoke with Sophia and educated her in proper container use. This is an important point. **Despite the Biosand's treatment abilities, if the same container or a contaminated container is used, pathogens will exist in the water no matter how effective the Biosand filter is at treating the water.**

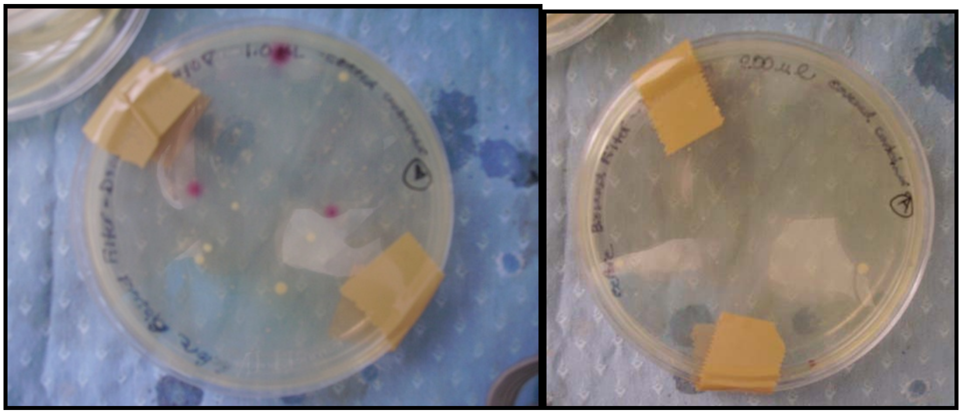

Figure 6: (left) Coliscan testing results from ceramic container for 5.0 mL sample, (right) Coliscan testing results after Biosand filter for 5.0 mL sample

Israel

Israel was never at his home when the team tried to visit several times. Based from discussions with surrounding homes, the overall consensus was that the filter was not working.   Israel's children demonstrated using the filter. When the team asked the children where the source water was from that was placed in the filter, the children said that it was from bottled water. The Coliscan Easygel testing results are shown in Figure 7. The team did not feel confident determining a recommendation for this filter's use.

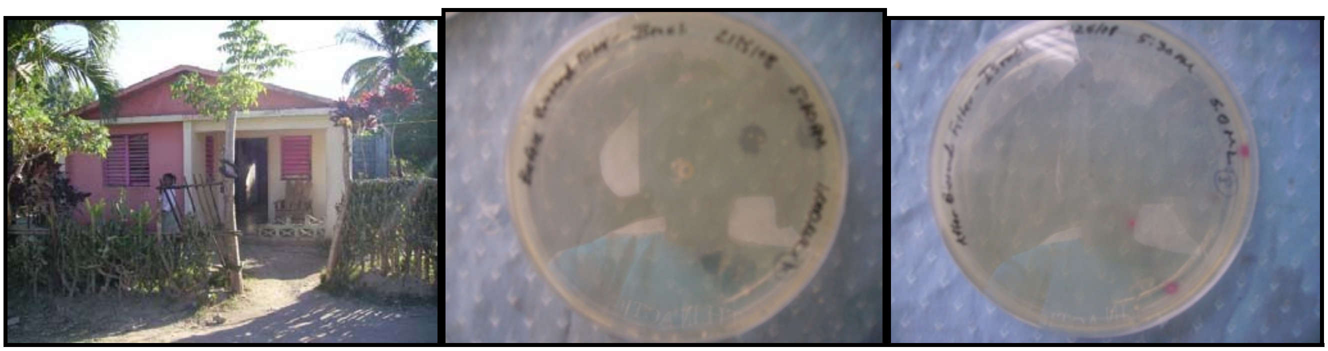

Figure 7: (left) Israel's house where Biosand filter is located, (middle) Coliscan testing results before Biosand filter for 1.0 mL sample, (right) Coliscan testing results after Biosand filter for 5.0 mL sample

Dual-bucket Filter

Josefina's House

In the prior reports from BLUELab, there were five dual-bucket filters listed to be present in the community. While the HIA team was in Rancho Al Medio, they discovered three dual-bucket filters with an expiration date of September 2007. The team tested the water quality of one dual-bucket system in the home of Josefina. Her source water was from a well near her home. Josefina solely relied on the dual-bucket system to provide her seven children with clean water. The testing results are included in Figure 8. The team recommended that Josefina immediately discontinue use. **If more point-of-use treatment systems are to be implemented in the future, the team recommends more sustainable alternatives, such as the Biosand filters, since the families rely so heavily on what we provide.**

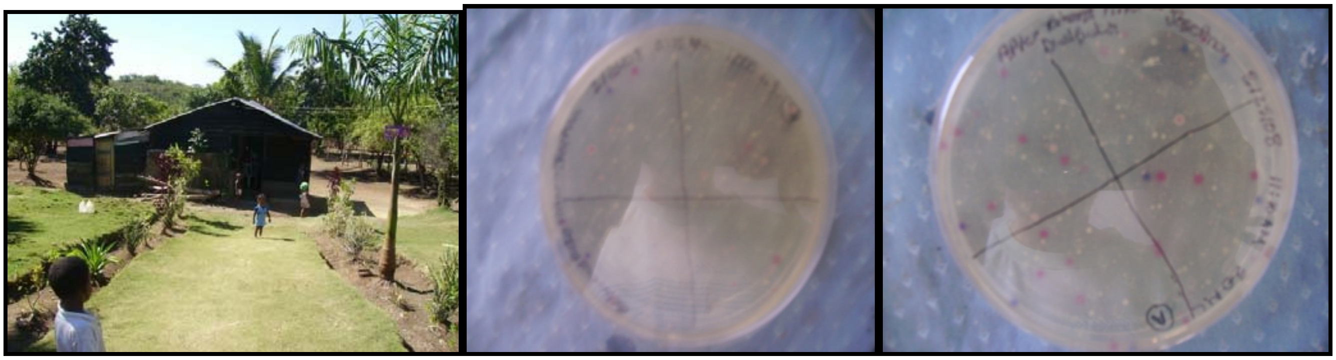

Figure 8: (left) Josefina's house where Biosand filter is located, (middle) Coliscan testing results before Biosand filter for 1.0 mL sample, (right) Coliscan testing results after Biosand filter for 5.0 mL sample

Unfiltered Well Water

While the team was in Rancho Al Medio, they noticed that a majority of the community obtained their water from the well near the school. The team tested the water quality of this water taking 5.0 mL samples. The results of two separate tests are shown in Figure 9.

Figure 9: (left) Coliscan testing results for unfiltered well water, (right) Coliscan testing results for unfiltered well water

Bottled Water

The team also tested bottled water purchased at the local store to ensure that the Coliscan Easygel test kits were working correctly. The bottled water should have no total coliforms or *E. coli*, therefore this test served as the negative control. There were no total coliforms or *E. coli* found in the bottled water Petri dishes. The team was confident in the results of the Coliscan Easygel testing.

Appendix C: Biosand Information Sheet

Friends Who Care Charities Ltd
Rod and Ingrid McCarroll, Directors
fwc@friendswhocare.ca www.friendswhocare.ca
Mexico Cell: 044-331-118-2876

The BioSand filter is a 'point of use' device. The water to be filtered can be obtained from the closest water supply point, whether river, stream or well, carried physically to the filter and used immediately thereafter. The water supply, water treatment and water distribution are therefore all within the control of the individual householder

Design Parameters
• Household (6-15 users)
– Concrete filter body
– 60 litres/hour or 1 litre per minute
– Specific Loading Rate- 10 liters/min/m2
– Adaptation of slow sand filtertechnology
– Biological layer forms onsurface of sand media
– Pathogens consumed, absorbed and strained out ofthe water
• Intermittent Operation
– Shallow and constant water layer
– Run and pause periods (water level maintained during pause)
• Consistent supply water quality
• Intermittent Cleaning
• Flow rate controlled by sand size (Sieving and washing)
• Pause period (Micro-organisms consume pathogens - bacterivore)
• Water – Sand levels
– Too shallow – biolayer dries out
– Too deep – insufficient oxygen for biolayer
• Start up time required to establish biological layer
• Maintenance
– Ensure cleanliness of filter body and spout
– Simple agitation process to restore flow rate
• Filtered water quality
– > 90 % removal efficiency
– Disinfection recommended

Removal Mechanisms
• Combination of biologic and mechanical
• Fine sand traps organic material at surface of sand and forms a layer where microorganisms grow
• 4 main mechanisms
• Mechanical trapping between pores
• Adsorption – onto each other and on to sand grains
• Predation- bacterivore
• Natural death of pathogens

Start-up Time
It normally takes a period of one to three weeks for the biological layer to develop to maturity in a new filter. During that time, the removal efficiency of the filter increase as the biological layer grows.

Water Source
The water supplied to the filter can be from rain water, deep wells, shallow wells, rivers, lakes, reservoirs or surface water. It should be consistently taken from the same source. The turbidity or amount of suspended particles in the water is also a key factor in the operation of the filter. It should be relatively free of suspended particles to prevent premature fouling of the filter. If the turbidity is greater than 50-100 NTU, the water should be pre filtered before it goes though the BioSand filter.

Flow Rate
The BioSand filter has been designed to allow for a filter loading rate of 1 litre/minute which has proven to be effective in laboratory and field tests. The amount of water that flows through the biosand filter is controlled by the size of sand media contained within the filter. If the rate is too fast, the efficiency of bacterial removal may be reduced. If the flow rate is too slow, there will be an insufficient amount of treated water available from the filter to meet the needs of the users.

Water Depths
Proper construction and correct operation of the BioSand filter will result in a constant water level over the pause periods. Changes in the water depth above the sand surface will cause a change in the biological zone disrupting the efficiency of the filter. A water depth of greater than 5-8 cm results in lower oxygen diffusion and consequently a thinner biological zone. A high water level can be caused by a blocked outlet spout or by an insufficient amount of sand media. As the water depth increases, the oxidation and metabolism of the micro organisms within the biological zone decrease. Eventually the layer dies off and the filter becomes ineffective.

Correct operation of the BioSand filter requires a constant water level of approximately 5 cm (2”) above the sand level during the pause periods.

Pause Periods
If the pause period is extended for too long, the micro-organisms will eventually consume all the substrate and then die. This results in a marked reduction in removal efficiency of the filter. The pause periods are also very important because they allow time for the micro-organisms in the biologic layer to consume the pathogens contained in the water, thereby increasing the hydraulic conductivity of the filter. Consequently, the BioSand filter is most effective and efficient when operated intermittently.

Fine Sand Filter Media
• Obtained from clean, crushed rock or quarry
• Screened through metal mosquito mesh screen
• Washed to ensure a Uniformity Coefficient of 1.5 – 3.0
• Non uniform sizing
• No beach sand; no river sand
• Avoid areas used by people or animals to ensure uncontaminated sand
• No substrate (clay, loam, organic material)

Concrete Filter Body

• Mix concrete (by hand or with mixer)

– 2 part Type 10 Portland cement (approximately 40 kgs (88 lbs)

– 3 part clean pea gravel (1/4”)

– 2 part clean sand

• Weight when empty – 150 kgs (330 lbs)

• Weight when full of sand and water - 225 kgs (500 lbs)

Diffuser

• Required to prevent the disturbance of the sand surface when water in poured into the filter

• Can be made of various materials that are suitable to be submerged in water such as heavy plastic, acrylic, plexiglass, or galvanized metal.

• 100 holes, no larger than 3/16” diameter, are drilled or punched in the material on a 1” x 1” grid

Tightly fitting lid

• Prevents contamination of source water and unwanted pests

• Outside lip

• Can be made from various material usually wood or galvanized metal

Maintenance

The operation and maintenance of the filter are simple. There are no moving parts that require skill to operate. When the flow through the filter becomes too low, the maintenance consists simply of washing the top few centimetres of sand. Over time, continued use of the filter causes the pore opening between the sand grains to become clogged with debris. As a result, the flow rate of water through the filter decreases. To clean the filter, the surface of the sand must be agitated thereby suspending captured material in the standing layer of water. The dirty water can then be simply removed using a small container. The process can be repeated as many times as necessary to regain the desired flow rate. After cleaning, a re-establishment of the biological zone takes places quickly, returning the removal efficiency to the previous level.

Biosand Filter Limitations

• Cannot remove dissolved compounds (e.g. salt, hardness, arsenic, fluoride)

• Cannot guarantee bacteria free water (Lab testing shows removal efficiencies of 97 – 99.7 %; Field testing show removal efficiencies of 90 – 97 %

• Recommended to use disinfection (bleach) in filtered water

• Cannot remove all organic chemicals (e.g. pesticides, fertilizers) and all colour from inlet water

Appendix D: Coliscan Easygel Test Kits

The HIA engineering team chose to use Coliscan Easygel test kits to test for total coliforms and *Escherichia coli* (E.coli) for several reasons. In 1999, Coliscan Easygel was approved by the U.S. Environmental Protection Agency (EPA) for bacterial monitoring of surface waters.[1] Coliscan Easygel was also found to be acceptable for use in National Primary Drinking Water Regulation compliance monitoring by the U.S. EPA in 2000.[1] Furthermore, the Coliscan Easygel test kits were affordable for HIA, known to pass through customs, and easy to use.

Autoclaves and water baths are necessary for agar preparation and they are not available in Rancho Al Medio. Coliscan Easygel is the agar replacement that is used for cell counts. Easygel is a pectin-gel method which comes as a sterile 2-part test unit consisting of a bottle of liquid medium and a petri dish. The Coliscan Easygel media utilizes chromogenic substrates for the enzymes glucuronidase and galactosidase that cause total coliform cell colonies to turn red and E. coli cell colonies to turn blue. Other non fecal cell colonies remain colorless in the media. When the bottle of liquid medium is poured in to the pretreated petri dish, ions diffuse from the pretreatment layer into the liquid causing it to gel. Complete gelling takes around 40 minutes.

Coliscan Easygel Testing Procedure

1. Either collect your water sample in a sterile container and transport the water back to the test site, or take a measured water sample directly from the source and place directly into the bottle of **Coliscan Easygel**
   Note: *Water samples kept longer than one (1) hour prior to plating, or any* ***Coliscan Easygel*** *bottle that has had a sample placed into it for transport longer than ten (10) minutes, should be kept on ice or in a refrigerator until plated.*
2. Label the petri dishes with the appropriate sample information. A permanent marker or wax pencil will work.
3. Sterilely transfer water from the sample containers into the bottles of **Coliscan Easygel** (Consult the following table for rough guidelines for inoculum amount). Swirl the bottles to distribute the inoculum and then pour the medium/inoculum mixtures into the correctly labeled petri dishes. Place the lids back on to the petri dishes. Gently swirl the poured dish until the entire dish is covered with liquid (but be careful not to splash over the side or on the lid).

Inoculation of Coliscan Easygel	
Water Sources	**Inoculum Amount**
Environmental:	1.0 to 5.0 mL
river, lake, pond, stream, ditch	
Drinking Water:	5.0 mL
well, municipal, bottled	

4. Incubate at 35° C (95° F) for 24 hours, or at room temperature for 48 hours. (See comments on incubation)

5. Inspect the dishes

    a. Count all the purple colonies on the **Coliscan** dish (disregard any light blue, blue-green or white colonies) , and report the results in terms of *E. coli* per ml of water. NOTE: To report in terms of *E. coli* per 100 ml of water, first find the number to multiply by. To do this: first, divide 100 by the number of ml that you used for your sample. Then, multiply the count in your plate by the result obtained from #1. For example, a 3 ml sample, 100 / 3 = 33.3. So, 4 *E. coli* colonies multiplied by 33.3 will equal 133.2 *E. coli* per 100 ml of water.

    b. Count all the pink and purple colonies on the **Coliscan** dish (disregard any light blue, blue-green or white colonies) and report the results in terms of coliforms per ml of water.

6. Do one of the following prior to disposal in normal trash:
    a. Place dishes and **Coliscan** bottles in a pressure cooker and cook at 15 lbs. for 15 minutes. This is the best method.
    b. Place dishes and **Coliscan** bottles in an ovenproof bag, seal it, and heat in an oven at 300° F for 45 minutes.
    c. Places dishes and **Coliscan** bottles in a large pan, cover with water and boil for 45 minutes.
    d. Place 5 ml (about 1 teaspoon) of straight bleach onto the surface of the medium of each plate. Allow to sit at least 5 minutes. Place in a watertight bag and discard in trash.

Comments on Incubation:
Micrology Laboratories, LLC in-house studies indicate that **Coliscan** can effectively differentiate general coliforms from *E. coli* when incubated at either room temperatures or at elevated temperatures (such as 90-98° F). However, some further explanation may be helpful.

There is no one standard to define room temperature. Most would consider normal room temperature to vary from 68-74° F, but even within this range the growth of bacteria will be varied. Members of the bacterial family *Enterobacteriaceae* (which includes coliforms and *E. coli**) are generally hardy growers that prefer higher than room temperatures, but which will grow at those temperatures. They tend to grow at a faster rate than most other bacterial types when conditions are favorable. It is therefore logical to try to place inoculated dishes in a "warm" place in a room for incubation if a controlled temperature incubator is not available. It is a very easy task to make an adequate incubator from a box with a 40-60 watt bulb in it to provide heat at an even rate. One can also use a heat tape such as it is used to prevent the freezing of pipes in the winter as your heat source.

Our general instructions indicate that incubation times for coliforms (including *E. coli*) are generally 24-48 hours at elevated temperatures (90-98° F) and 48 or more hours at room temperatures. At elevated temperatures, no counts should be made after 48 hours as any coliforms present will be quite evident by that time and if new colonies form after 48 hours as any coliforms present will be quite evident by that time and if new colonies form after 48 hours they are most likely not coliforms, but some other type of slow growing organisms that should not be included in your data. At room temperatures, the best procedure is to watch the plates by checking them at 10-12 hour intervals until you observe some pink or purple colonies starting to form and then allowing another 24-30 hours for the maturation of those colonies. Since the coliforms (including *E. coli*) are generally the faster growing organisms, these will be the first to grow and be counted. Colonies that may show up at a later time are likely to not be coliforms. As you can see, there are advantages to incubating your dishes at elevated temperatures. First, you can count the results earlier. At 95° F, it is often possible to do accurate counts at 18-20 hours of incubation. There is also less probability of variation from batch to batch when the incubation temperatures are kept at one uniform level. And a higher incubation temperature will tend to inhibit the growth of non-coliforms that may prefer lower temperatures.

**E. coli* is the primary fecal coliform, however, *Klebsiella* is sometimes of fecal origin. Other general coliform genera include *Enterobacter* and *Citrobacter*.

Interpretation of Results
This test method utilizes well established, widely accepted criteria for the recognition of coliforms and *E. coli* and proper application of the method will result in accurate results. Therefore, if you suspect that your water is dangerously contaminated based on the results you get using **Coliscan Easygel**, you should contact your local health department and ask for their help in performing an official assessment of water.

Non-fecal coliforms are widely distributed in nature, being found both as naturally occurring soil organisms, and in the intestines of warm-blooded animals and humans. Fecal coliforms are coliforms found naturally only in the intestines of warm-blooded animals and humans. Fecal coliform contamination is therefore the result of some form of fecal contamination. Sources may be either animal or human.

General Notes on Differentiating Coliforms and *E. coli*
Generally, water containing *E. coli* (the fecal contamination indicator organism) should not be used for drinking water unless it is sanitized in some manner. Colonies which have the blue-green color are not exhibited any ß-galactosidase activity (which is evidenced by the pink color). Because of this, they are not considered to be either coliforms or *E. coli* and therefore should be ignored when counting your coliform or *E. coli* colonies. Similarly, colonies which are white are exhibiting neither color-causing enzyme, and should also be ignored.

Colonies on the surface of the plate are exposed to the medium on only the underside of the colony. This causes these colonies to appear with much less of the indicator color. *E. coli* colonies may only have a slight purple tinge to them, and it may appear only in the center of the colony with the remainder of the colony being white. Similarly, coliforms on the surface may be light pink or white with a pink center.

[1] Coliscan Easygel Test Kits. 8-18-2005. Micology Laboratories. 3-23-08 <http://www.micrologylabs.com/Home>

Appendix E: Community Survey for Biosand Owners

Interviewer Name:________________________________ Date:______________

Demographic Data

First Name: ______________________________ Last Name: ______________________________

Sex: M F DOB:_________ Address:____

1) Do you have a Biosand filter in your home?
 ☐ Yes ☐ No

2) How many people use it per day?

3) Per month?

4) Do you let everybody use the filter in Rancho al Medio?
 ☐ Yes ☐ No

If yes, skip to question 6

5) Whom do you prohibit?
☐ Neighbors ☐ Friends ☐ Other community members ☐ Other_________________

6) Are you satisfied with the cleanliness of Biosand-filtered water?
 ☐ Yes ☐ No

7) Do you like the taste of the water?
 ☐ Yes ☐ No

8) When was the last time you had an upset stomach or diarrhea?

9) What do you do to maintain the filter?

10) How often do you place water in the filter?
☐ Daily ☐ Twice a Day ☐ Weekly ☐ Twice a Week ☐ Monthly
 ☐ Twice a Month ☐ Othe

11) Does having the filter make you more important in the community?
 ☐ Yes ☐ No

Nombre de Entrevistador:_________________________ Fecha:_______

Información Demográfica

1. Nombre: ______________________________ Apellido: ________________________________

Sexo: M F FDN:__________ Dirección Postal:____

1. ¿Tiene un filtro en su casa?
   ☐ Sí ☐ No

2. ¿Cuántos personas usan el filtro cada dia?

3. ¿Cada mes?

4. ¿Ustedes pueden usar el filtro en Rancho Al Medio?
   ☐ Sí ☐ No

Si, vas a pregunta seis

5. ¿A quién no permite usar el filtro?
   ☐ Vecinos ☐ Otros miembros de la comunidad ☐ Amigos
   ☐ Otra_______________

6. ¿Está feliz con tus salud para el filtro?
   ☐ Sí ☐ No

7. ¿Te gusta el sabor del agua?
   ☐ Sí ☐ No

8. ¿Cuándo fue la última vez que usted tuviera un estómago disgustado o diarrea?

9. ¿Qué hace para mantener el filtro?

10. ¿Con que frecuencia usted necesita poner el agua en el filtro?
    ☐ Diario ☐ Semanal ☐ Mensualmente
    ☐ Anual ☐ Otra: _______________________________

11. ¿Usted se hace mas importante en la comunidad por el filtro?
    ☐ Sí ☐ No

Appendix F: Community Survey for Non-Biosand Owners

Interviewer Name:__________________________________ Date:_______________

Demographic Data

Interviewee First Name: ________________________ Last Name: ________________________________

Sex: M F DOB:__________ Address:____

Source of money:

- ☐ Self Job_________________________
- ☐ Husband Job_________________________
- ☐ Son Job_________________________
- ☐ Other Job_________________________

Number of family members currently living together (circle): 1 2 3 4 5 6 7

Name/Relation:____________________________________ Sex: M F DOB:__________

Name/Relation:____________________________________ Sex: M F DOB:__________

Name/Relation:____________________________________ Sex: M F DOB:__________

Name/Relation:____________________________________ Sex: M F DOB:__________

Name/Relation:____________________________________ Sex: M F DOB:__________

Name/Relation:____________________________________ Sex: M F DOB:__________

***Past Medical History**

***Physical Symptoms that could be associated with poor water quality:**

Member of household		1	2	3	4	5	6	7
Stomach Pain	Severity (1=mild, 3=severe)							
	Duration (days)							
	Days/mo.							
Diarrhea	Severity (# of stools/day)							
	Duration (days)							
	Days/mo.							
Vomiting	Severity (# of days)							
	Duration (days)							
	Days/mo.							
Other symptoms:	Severity (1=mild, 3=severe)							
	Duration (days)							
	Days/mo.							

Water Quality Specific Questions

*What is your principle potable water source?

☐ River ☐ Biosand Filters ☐ Private faucet ☐ Rain water

☐ Community faucet ☐ Other____________________________

*Do you share this source with others?

☐ Yes ☐ No

*If yes, whom?

☐ Neighbors ☐ Other community members ☐ Other_____________________

*What do you use the water for?

☐ Cooking ☐ Cleaning body ☐ Washing dishes/clothes

☐ Other____________________________

*Do you treat it in any way?

☐ Boil ☐ Bleach ☐ Filter ☐ UV

☐ Other____________________________

Do you have problems with:

---

1. WATER QUANTITY? ☐ Yes ☐ No

*How often do you need to obtain more water?

☐ Daily ☐ Weekly ☐ Monthly

☐ Yearly ☐ Other: ________________________________

*How much potable water do you use a week in liters (if person is unsure, ask how many buckets and then try to estimate gallons or liters of bucket) ? ___________________

*Does the amount off water you have access to vary by season? ☐ Yes ☐ No

---

2. WATER QUALITY? ☐ Yes ☐ No

Does your water have any of the following characteristics?

Smell? ☐ Yes ☐ No If yes, what? _______________________

Color? ☐ Yes ☐ No If yes, what? _______________________

Taste? ☐ Yes ☐ No If yes, what? _______________________

Any known contaminants? ☐ Yes ☐ No If yes, what? _______________________

Any known bacteria? ☐ Yes ☐ No If yes, what?_______________________

Any known parasites? ☐ Yes ☐ No If yes, what?_______________________

3. DISTANCE TO WATER? ☐ Yes ☐ No

How far do you go to get potable water?

☐ < 1km ☐ 1km ☐ 1-5 km ☐ >5km ☐ Other ____________

How do you get there?

☐ On foot ☐ Car ☐ Bus ☐ Animal_________________________

☐ Other__________________________

*In what type of container do you transport the water?

☐ Plastic bags ☐ Plastic jugs ☐ Metal jugs ☐ Glass Jug

☐ Other__________________________

4. OBTAINING WATER? ☐ Yes ☐ No

5. STORAGE OF WATER? ☐ Yes ☐ No

*How do you store your potable water?

☐ Metal Tank ☐ Plastic bottles ☐ Other_________________________________\

*How long do you usually store the water?_______________________________

*What do people use for bathroom facilities and what is the approximate percentage of each?

☐ Flush toilet ☐ Indoors ☐ Outdoors ☐ Pit latrines

☐ Neighboring fields ☐ Other_________________________________

General Questions (open ended):

What is the primary health concern for you and your household? (rank if more than one)

☐ Water quality ☐ Access to healthcare ☐ Nutrition ☐ Recurrent disease ☐ Other________

What is the primary NON-health concern for you and your household?

☐ Education ☐ Money ☐ Politics ☐ Shelter

☐ Food Quantity ☐ Food Quantity ☐ Safety

☐ Other_________________________________

Nombre de Entrevistador:_________________________ Fecha:_______

Información Demográfica

1. Nombre: ______________________________ Apellido: ________________________________

Sexo: M F FDN:__________ Dirección Postal:____

Fuente de dinero:

- ☐ Uno Mismo Trabajo______________________
- ☐ Esposo Trabajo______________________
- ☐ Hijo Trabajo______________________
- ☐ Otro Trabajo______________________

Numero de miembros del hogar, incluyendo a si mismo (circule): 1 2 3 4 5 6 7

Nombre/Relación:____ Sexo: M F FDN:__________

Nombre/Relación:____ Sexo: M F FDN:__________

Nombre/Relación:____ Sexo: M F FDN:__________

Nombre/Relación:____ Sexo: M F FDN:__________

Nombre/Relación:____ Sexo: M F FDN:__________

Nombre/Relación:____ Sexo: M F FDN:__________

***Historia Médica**

Miembros de su familia	**1**	**2**	**3**	**4**	**5**	**6**	**7**

Dolor de estomago	Severidad (1=templada, 3=severo)							
	Duración (días)							
	Días/meses							
Diarrea	Severidad (veces al día)							
	Duración (días)							
	Días/meses							
Vomito	Severidad (veces al día)							
	Duración (días)							
	Días/meses							
Otros síntomas:	Severidad (1=templada, 3=severo)							
	Duración (días)							
	Días/meses							

Preguntas sobre la Calidad de Agua

*****¿Cuál es su fuente principal de agua potable?

☐ Rió ☐ Pozo ☐ Llave privada ☐ Lluvia

☐ Llave común ☐ Otra_____________________

*¿Usted comparte esta fuente con otras personas?

☐ Si ☐ No

*Si 'si', ¿con quien?

☐ Vecinos ☐ Otros miembros de la comunidad ☐ Otra______________

*¿Para que usa usted el agua?

☐ Cocinar ☐ Bañar ☐ Lavar (platos y ropa)

☐ Otra_____________________

*¿Cómo trata usted el agua antes de usarla?

☐ Hervir ☐ Cloro ☐ Filtro

☐ Otra_____________________

Usted tiene problemas con:

---

1. ¿Cantidad de Agua? ☐ Si ☐ No

*¿Con que frecuencia usted necesita conseguir agua?

☐ Diario ☐ Semanal ☐ Mensualmente

☐ Anual ☐ Otra: ____________________________

*¿Cuantos litros de agua potable usted usa en una semana? ________________

*¿La cantidad de agua que usted usa varia por época? ☐ Si ☐ No

2. ¿Calidad de Agua? ☐ Si ☐ No

Por favor indique si su agua tiene algunas de estas características:

¿Olor? ☐ Si ☐ No ¿Cual? ______________________

¿Color? ☐ Si ☐ No ¿Cual? ______________________

¿Sabor? ☐ Si ☐ No ¿Cual? ______________________

¿Algún contaminante conocido? ☐ Si ☐ No ¿Cual? ______________________

¿Alguna bacteria conocida? ☐ Si ☐ No ¿Cual? ______________________

¿Algún parasito conocido? ☐ Si ☐ No ¿Cual? ______________________

3. ¿Distancia al agua? ☐ Si ☐ No

¿A que distancia viaja usted para conseguir agua?

☐ < 1km ☐ 1km ☐ 1-5 km ☐ >5km ☐ Otra _______

¿Como viaja usted?

☐ A pie ☐ Carro ☐ Guagua ☐ Animal___________________________

☐ Otra______________________

*¿En que tipo de envase usted transporta el agua?

☐ Envase plástico ☐ Envase de metal ☐ Envase de vidrio

☐ Otra______________________

---

4. ¿**Consiguiendo Agua?** ☐ Si ☐ No

---

5. ¿Almacenamiento de Agua? ☐ Si ☐ No

*¿Como almacena usted su agua?

☐ Tinaja de metal ☐ Tinaja plástica ☐ Otra_____________________________

*¿Por cuánto tiempo usualmente almacena su agua? ________________________

*¿Que usan las personas en su hogar como sanitario e cual es el porcentaje de cada uno?

☐ Lavabo ☐ Tazón ☐ Afuera ☐ Letrina

☐ Otra______________________________

Preguntas Generales (abiertas):

¿Cual es la preocupación mas grande suya de salud? (marque mas de una si aplica)

☐ Calidad de agua ☐ Acceso a asistencia de salud ☐ Nutrición ☐ Enfermedad Crónica

☐ Otra______________________________

¿Cual es la preocupación principal suya que no tenga que ver con la salud?

☐ Educación ☐ Dinero ☐ Situación Política ☐ Su Casa

☐ Comida ☐ Seguridad

☐ Otra______________________________

Appendix G: Troubleshooting Biosand Filter Problems

The following materials were developed over 3 years of experience with the BioSand filter in the Dominican Republic. The author is Jan Tollefson, M.D., who is founder of the charity, Add Your

Light, of Calgary, Canada. See www.addyourlight.org. New problems and issues come up all the time with the BioSand filter, and a dialogue amongst participants in various countries would be welcomed.

HOW TO DIAGNOSE A PROBLEM WITH THE BIOSAND FILTER

1) You take out the diffusor plate and measure with the tape measure that there are 3” between the platform and the sand, but there are less than 2” of water on top of the sand. It is not completely dry, though.

Possibilities?

a) The filter is leaking from the bottom, through a crack in the concrete. The technician needs to repair or replace the filter.
b) The user has been connecting a hose or tubing to the exit tube, in order to direct the water easily into a container. As the container below fills, the end of the hose or tube ends up being immersed in water. This creates a siphoning effect, so the 2” of water above the sand is drained off. You have to educate the user again, and explain the siphoning effect that can occur.
c) The user has attached a screen or net to the exit tube to prevent the entrance of insects. The screen or net is touching the tip of the exit tube, and acting like a wick, draining the water, drop by drop. (At times, you’ll see a filter with a screen/net which is not causing the water to drip out. In this case, you only have to advise the user to check for dripping from time to time, and to make sure they clean the screen/net every day with chlorine, because it is a focus of contamination itself.)
d) The user hasn’t used the filter for a long time (weeks or months) and the water has evaporated to a certain level (it isn’t completely dry yet). If the user still wants to use the filter, they can refill it from above, as long as the sand is still quite wet. If there’s any doubt, refill the filter from the bottom up, through the exit tube, using the sanitization tube to do so. That will drive any air bubbles up and out.
e)

2) You take out the diffusor plate and can see that the sand it completely dry.

Possibilities?

a) The filter has leaked from the bottom until it is dry and the user has stopped using it completely. Call the technician. The filter hasn’t been used for a long time and the water has evaporated (this is really unusual unless the filter has not been used for months, for example, during the summer at a school). When a filter is completely dry, but the sand still looks fine, you can refill it from the bottom up, through the exit tube, using a large PVC tube (the sanitization tube will work well). But you MUST do it through the exit tube so that the air inside the dry sand is pushed up and out. If water is poured into dry sand from the top, the air in the sand will form bubbles that can be foci of contamination. If the sand looks dirty or damaged, talk with the technician, because he’ll have to come and do a complete reinstallation.

3) You take out the diffusor plate and see that there are three inches between the platform and the sand, but there are more than two inches of water on top of the sand. There is water coming out the exit tube.

Possibilities?

a) Trick question. Maybe the user just poured water in the filter and that water still needs to pass through. You should wait until the flow stops, and only then can you evaluate the filter to ensure that everything is fine.

4) You take out the diffusor plate and measure that there are three inches between the platform and the sand, but there are more than two inches of water on top of the sand. The filter is not filtering at this moment. No water is coming out of the exit tube.

Possibilities?

a) The external piece of the exit tube, which is a separate length of tube, has been cut too short or is pushed up inside the nose. If this is so, when you pour in more water, the flow will start again, but when the flow stops, you will again have more than two inches on top of the sand. You need to correct the length of the exit tube (pull it down if it is shoved up inside, or cut a new one). Talk to the technician if you need to.
b) The filter is obstructed somewhere along the exit tube (inside or outside). If this is so, when you pour in more water, nothing will come out. Try to find the blockage and fix it. If you can't, call the technician.

5) The user is complaining that the flow rate is really slow, but was fine before.

Possibilities?

a) The biological layer is too thick (in this case, though, the filter will still drip, little by little. The biological layer will never completely stop the flow of water.) You can see this condition with your eyes and a flashlight. Do a maintenance procedure and then measure the flow rate again. It should then be fine.
b) The filter is obstructed (partially or completely) somewhere along the exit tube. Check the tube for paper, an insect, or other things shoved inside. It you can't resolve it, call the technician.
c) The water poured in has so much sediment or soil in it that there is now a layer of mud in the filter instead of the usual fine sand. Call the technician to remove the mud and replace it with new sand. To avoid this problem, advise the user to let dirty water sit in a bucket for awhile, so that the sediment floats down to the bottom of the bucket. Then they can pour the water carefully into the filter, without the sediment. Also, they can pass the dirty water through some kind of material to trap the sediment first, and then pour the cleaner water through the filter. We have only seen this problem in the town of Esperanza, where the tap water can be very dirty. But, in the event of a natural disaster, like a hurricane or flood, the rivers overflow and the water can contain a lot of soil. During Hurricane George in Haiti in 1999, the users of these filters in the Artibonite Valley were the only ones there who still had clean water for drinking and bathing.
d) The user has moved the filter and the sand has compacted down a lot, lowering the flow rate. This is very common, unfortunately. If a filter absolutely must be moved, it must be done very, very gently, without bumping or tipping. This is almost impossible, unless there's a way to make it slide easily.

6) You take out the diffusor plate and measure that there are less than three inches between the sand and the platform.

Possibilities?

a) The technician has put in too much sand. You can take out some sand until the level is right. Then the user should wait three days again before drinking the water, because the biological layer needs time to grow again. Since you're probably not removing the whole biolayer, three days should be fine. If in doubt, wait seven days, especially if they refuse to use chlorine to disinfect the water after filtration.
b) At times, after an installation, the sand actually decompacts and rises up a little bit. Just remove some sand until the level is correct, as above.

7) You take out the diffusor plate and measure that there are more than three inches between the sand and the platform and more than two inches of water on top of the sand.

Possibilities?

a) the user has moved the filter and the sand has compacted. If it seems bad enough to affect the function of the filter, call the technician. A re-installation may be required. Use your judgement.
b) The user has taken out some sand, for some reason, maybe while doing a maintenance procedure. Put in more sand prepared by the technician, if there is some available. If there is none, call the technician.
c) The technician has not put in enough sand during the installation (we saw this in the past, with new technicians, but it would be uncommon now in the D.R.). Add more sand prepared by the technician, if there is some available. If there is none, call the technician.

8) You take out the diffusor plate and measure that there are three inches between the sand and the platform and there are two inches of water on the sand, but you cannot see the biological layer.

Possibilities?

a) The filter is new and hasn't had time to grow a biological layer which is visible to the eyes (the biological layer is visible with a microscope after three days, normally; with the eyes, after 1-3 weeks, depending on the quantity of organisms in the water entering the filter).
b) The water being poured in the filter is already quite clean and doesn't contain a lot of the organisms necessary for the formation of the biological layer. For example, if the water is from a municipal system and has chlorine in it, the water poured into the filter will not have many organisms and the biological layer won't grow well. If the municipal chlorine is killing the bacteria, the biological layer isn't as necessary as usual, but still the sand is essential for trapping and killing the encysted protozoans, and for helping remove chemicals and metals. Suggestions: if the chlorination of the municipal water is consistent and reliable, the users do not have to disinfect their water with chlorine after passing it through the filter. But if the chlorination of the municipal water is inconsistent, they must disinfect their water, after filtration, with chlorine, because they will never have a good biological layer and they have more risk for infection, in fact, than the users who never have chlorine in the water entering the filter.
c) The user is confused and is doing a maintenance procedure on the sand very frequently and is not letting the biological layer grow. Re-educate them.

9) You take out the diffusor plate and see that the sand is not leveled. It has a lot of holes and hills.

Possibilities?

a) The diffusor plate wasn't cut in a way to make it sit tightly along the platform, and for this reason, it is lifting up and floating when water is poured in, or water is flowing around the edges. If it isn't too serious, the user can simply use a rock, the size of a fist, to hold down the diffusor plate when pouring in water. Just wash the rock well before use. If the problem cannot be resolved this way, replace the diffusor plate. If there are no extras, call the technician to bring or send another diffusor plate.
b) The diffusor plate has been damaged by the user (with a knife, fork, or other instrument) and the water is flowing around the edges of the plate. Replace the diffusor plate.
a) The diffusor plate has too many holes or the holes are too big or are in a pattern that is incorrect. (We saw this a lot with the first filters done in 2000, and it is possible that there are still some filters out there with these bad diffusor plates, or other problems. If you find one, please let us know!! It is impossible to know where every single filter was installed during the first two years of the program, before we stopped the irreponsible technicians from making filters anymore. Esperanza, Montecristi, Santiago de Rodriguez, Zamba, Navarete, these areas may still have some bad filters that we are unaware of.

10) You take out the diffusor plate and note that the depth of water on one side is different from the depth on the other side.

Possibilities?

a) the filter isn't level (perhaps it was never well-leveled). You can use the cap of a sode bottle or a little piece of wood or something underneath the filter to level it.
b) The diffusor plate is leaking on one side, causing a hole in the sand on that side.

The filter has been installed and you measure the flow rate with a marked bottle and note that the flow is a lot faster than one liter per minute.

Possibilities?

a) The sand has been cleaned too much.
b) The grains of sand are too big (this can happen if the technician has used a screen of the incorrect size or if the screen is old and the holes of the screen have gradually enlarged).

Discussion: To measure the flow rate, it is correct to fill the filter to almost the top. At times, you will see that the flow rate is a little more than one liter per minute, and if it is not much more (eg. 1.1 or 1.2 liters), it is not a big problem. If the grains of sand look like they are the correct size, you can wait a few days to see if the flow rate will come down to one liter per minute, because the sand will settle a bit. But if the flow rate is more than 1.2 liters per minute, it is better to correct the problem immediately, if possible.

There are two options. If the flow rate is between 1.2 and 1.4 liters per minute, you can mix some super fine sand with the first 6-10 inches of sand in the filter, to lower the flow rate. The technician should have some superfine sand available when he arrives with the filters. But if the flow rate is 1.4 liters per minute or more, we suggest replacing all the sand, which means doing a complete reinstallation. You have to use your judgment, and consider the benefits and costs of each option, because it you are in an isolated place, it is not easy or cheap to replace everything. The technicians should test the flow rate of the sand before sending filters to sites, but at times, we will have surprises, especially with new technicians.

Meanwhile, we always recommend that the users never fill the filter up to more than 4-6 inches above the diffusor plate, even if the flow rate from the top is one liter per minute. Why? Because it is always better to give the most time possible to the biological layer to do its cleaning of the water, and if the water is pressured through the filter, the biological layer cannot do its job in the best manner. Remember that this filter has living organisms inside, alive like we are. Our digestion is better and more complete if we eat slowly also!! Tell the users to treat their filters like human beings with a stomach!

OTHER PROBLEMS WE HAVE SEEN, FROM TIME TO TIME:

All these problems have a resolution, except numbers 1 & 2. The filter cannot remove salt from salty water. Salty water requires a much more sophisticated and expensive process to remove the salt. In the case of number 2, we cannot change people's personalities, and it is better to take the filter out of their house and give it to someone who will appreciate it.

1. The water coming out of the filter has a salty taste. Look for the reason. Is the water being poured in salty? Why? Is the water from a well close to the sea? Look for other water sources for them to use and assure the users that the filter works well for many other things, even if it cannot remove salt.

2. The user thinks it is too much work to pour water in the filter, and for this reason, doesn't want to use it. Take it out and give it to someone else. Talk to the technician about how to move it. Normally, you will have to do a de-installation and re-installation with new sand and gravel.

3. The user does not have patience and does not like having a bucket or container under the exit tube until the flow stops. Then they have water on their floor and they don't like that either. Their solution is to stick a piece of paper or something else in the end of the exit tube to stop the flow. You need to re-educate them as to what happens to the biological layer when they do this, and assure that they never block the exit tube.

4. There are ants in the filter. Clean them out completely. Then, to prevent it happening, they can put a little kerosene gas on the floor under the filter (not in it!!). The smell makes the ants go away. They may have to repeat this from time to time.

5. There are cockroaches in the filter. Normally, if the filter is clean, without food or oil inside, or dirty items sitting on top, cockroaches won't come. But if it is dirty, or is too close to a stove, where the oil is splashing on the filter, cockroaches will appear.

6. There is food or oil inside the filter, floating on the water or mixed in the sand. This is really bad, and is a source of contamination of the water. It will attract roaches and ants. Explain this to the user and visit often to reinforce the education.

7. There are leaves or other organic materials in the filter. Again, this is a source of contamination and bacterial growth. Explain this to the user.

8. The filtered water supposedly has a strange color, like yellow, brown, or green. Often it isn't the water, but the container in which the user is storing the filtered water. Investigate!

9. The filter has a bad odor inside, or the water has a bad odor. Look for the reason and try to resolve it. Sometimes you can get a focus of contamination started up in a filter, and there's nothing you can do but de-install and re-install. We've only seen this once in the D.R., luckily.

10. The user thinks that the filter is leaking but it is just that the water from the exit tube is dripping on the wall of the filter or on the floor. Check it out.

11. The user doesn't have distinct, separate buckets or containers for filtered water and for dirty water. Educate the user as to the importance of having distinct buckets or containers for dirty and clean water.

12. The user has a very dirty, disorganized house. Difficult! They are going to have the best results with their filters either.

13. The filter is outside the house. This is not good, because too many people, animals, etc., can get into, touch, and affect the filter.

14. The user does not have a closed container to store the filtered water. The children or animals can touch or drink the water directly from the container. Educate the users well as to the importance of having a closed container, or one with a good tight lid.

15. The user never cleans their container or receptacle (open or closed) with a chlorine solution. Bacteria will start to grow within a few hours, and the filtered water becomes recontaminated inside the container. If users are going to use closed plastic storage reservoirs with spigots to store the water, they should follow manufacturer's instructions as to how to maintain the cleanliness of the container. It is possible that a solution of vinegar and water is sufficient and better for the plastic than chlorine. But to leave a reservoir sitting, even for a few hours, with filtered, unchlorinated water in it is an invitation for the growth of bacteria again.

16. The users do not want to put chlorine in the water after filtration. Their reluctance is understandable. It tastes and smells bad, and there is fear about possible cancer risk. On the other hand, the risk of cancer, at the doses of chlorine which should be recommended, are much lower than the risk of serious illness if the user should be infected with Hepatitis A, for example. And there is a risk of liver cancer for people who have had hepatitis too. We cannot claim that the filter is removing 100% of the bacterias and viruses, so our responsibility is to recommend the use of chlorine after filtration, as a final step for the best security. Since the water is

already well filtered, however, it isn't necessary to use the dosage of chlorine normally recommended in situations where the water is not being filtered through sand first. You can decrease the dosage of chlorine to two drops per liter or three drops per gallon, or 15 drops per five gallon container. They should put the drops of chlorine into the container first, add the water, and then mix it well by inverting the container several times. Let it sit a half hour and the water is good for drinking. If the water can be put in a refrigerator and left to get cold, the flavor of chlorine will decrease a lot.