Investigation on the use of water filtering units provided by Give Clean Water in Fiji

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ABSTRACT

Household hollow fiber membrane water filtering units distributed to rural communities and schools in the Western Division of Fiji by the non-governmental organization Give Clean Water were the focus of an investigation for this paper. Specifically, the investigation was carried out to determine how frequently the water filters were being used by communities who received them, measure the quality of water samples taken from filters in the field, and advise the Fiji Ministry of Health on the key findings. From June 20th to July 2nd 2011, 270 households and six schools were interviewed on use of the filters. In addition, 27 filter water samples and 37 storage container water samples were taken for bacterial testing. It was found from the investigation that the frequency of use of the filters in the field is low. 52% of respondents reported using the filters "always" or "most of the time" for drinking water, although this figure is likely skewed upwards by over-reporting. Only 8% of respondents reported filtering water "always" or "most of the time" for preparing kava, which is a traditional drink consumed regularly by adults in communities. As found out from the investigation, some of the probable reasons for the low usage figures include inconvenience of use, lost or broken filter parts, community perception that their source water is clean, weak community engagement from the onset and limited follow up support. The majority of the water samples from the filters and the storage vessels showed compromised water quality. Hydrogen sulfide paper-strip testing found that 71% of water samples taken directly from filters and 76% of water samples taken from storage containers in the field contained bacterial contamination. Improvements to the engagement process is needed by GCW if the filter is to be considered as a sustainable, long term household level water treatment option in rural areas of Fiji, including involvement of the Ministry of Health for effective community engagement and promotion of hygiene, sanitation and safe drinking water as a whole.

INTRODUCTION

Since as early as October 2008, Give Clean Water, Inc. (GCW) (http://www.givecleanwater.org), an American based non-profit non-governmental organization, has donated approximately 1,970 personal water filters to rural communities and schools in the Western Division of Fiji, as of April 2011, quoted by the Fiji Ministry of Health. A review of studies by Fewtrell *et al.* (2005) identifies the relative risk of diarrheal disease of an effective household water treatment intervention, such as the one proposed by GCW, as 0.65. This means groups not receiving a household water treatment intervention are approximately 1.5 times higher at risk of receiving a diarrheal disease than groups that receive the intervention. The filters, manufactured by Sawyer Products Inc., are intended to be used by individual households and schools to purify water of

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bacterial and protozoan contamination before consumption. This particular make of water filter has the proposed advantages of a functional lifetime guarantee by the manufacturer, providing relatively quick filtration flow rate, ease of operation and maintenance, and ability to decrease the turbidity of the water (Sawyer, 2008) over some other common methods of household water treatment (Lantagne *et al.*, 2007).

In April 2011, the Fiji Ministry of Health officially requested the Applied Geoscience and Technology Division (SOPAC) of the Secretariat of the Pacific Community (SPC) and the World Health Organization (WHO) South Pacific Office to evaluate the efficacy of the filters being used in the field in-country. Specifically, they requested an analysis of the frequency of use of the filters and of the quality of the water from the filters at the time of visit. This research aims to contribute to developing the Ministry of Health's knowledge of household water treatment options and add to international literature on household level water treatment options.

OBJECTIVES

The objectives of the research were to

- determine the frequency of the use of filters in the field,
- evaluate the performance of the filters by using hydrogen sulfide test kits (presence and absence test for bacterial contamination),
- investigate possible barriers preventing their use, and make recommendations to the Ministry of Health based on the key findings.

METHOD

A list of communities that received water filters donated by GCW as of April 11th, 2011 was provided by the Ministry of Health. The list included 32 villages or settlements, 14 schools, and one orphanage (Annex 1). The Ministry of Health quoted GCW as distributing 1,970 filtering units amongst these communities. The Ministry of Health also provided a Google Earth document containing GPS points of where each individual filtering unit was installed. For simplicity, Figure 1 shows the location of the Fiji Islands and Figure 2 shows the locations of the communities and schools within Fiji where the filters were distributed.

Figure 1: Map of Fiji Islands in South Pacific

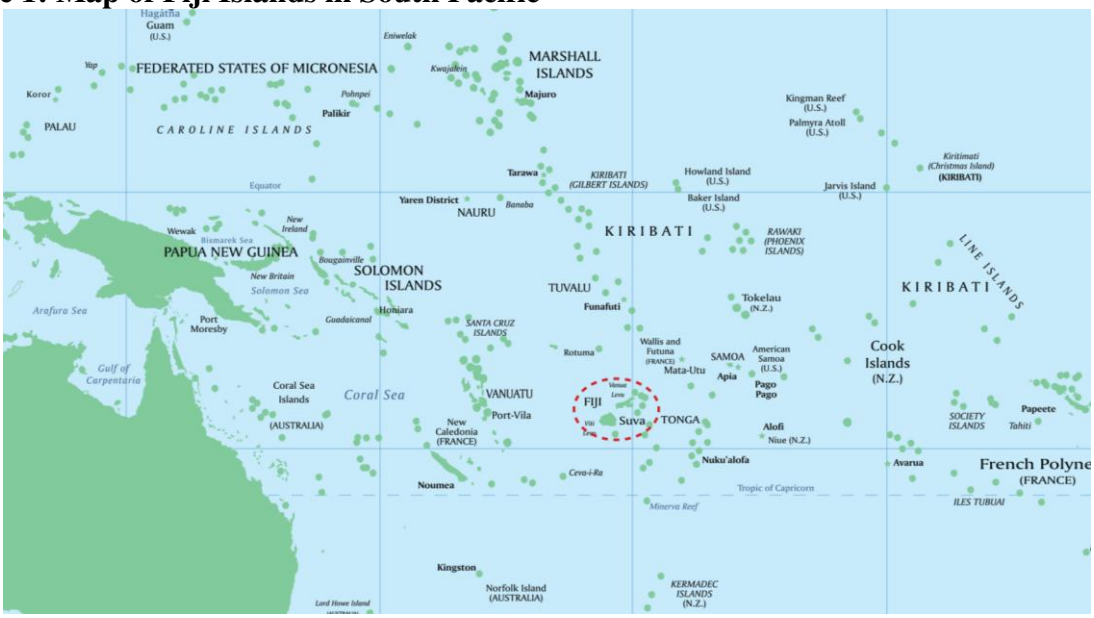


Figure 2: Locations of sites where *Give Clean Water* distributed filtering units on the western side of the main island of Viti Levu in Fiji

GCW's website identifies the Sawyer Point One Filter Bucket Adapter Kit and two plastic buckets as the complete filtering unit provided to their recipients. This unit includes a 0.1 micron hollow fiber membrane filter, a 3 foot long hose, a hole cutter tool, a hanger, a syringe, fittings, and two plastic buckets. Later visits to recipient households found GCW also provided a rubber band and cloth. Once assembled, the filter is connected to the hose which leads to a hole bored manually into the bucket by the user with the hole cutter tool. Water is forced through the filter by gravity by hanging it below the bucket. A hanger that connects to the top of the bucket is used to hold the filter above the bucket in an "off" position. The second bucket provided is intended for storage of the filtered water. The provided cloth, which is held in place by a rubber band, is intended to cover the top of the filtering bucket and screen large particulate from entering the filter. Figure 3 below shows the basic set-up. Annex 2 shows pictures of filtering unit parts.

Figure 3: Assembled filtering unit in a home setting in Navala village

Each one of the sites on the recipient list provided by the Ministry of Health (See Figure 2) was initially visited by a team consisting of two SOPAC staff and a Ministry of Health Official. During these scoping visits, the team met with at least one representative of each community or school to verify they were visited by GCW, obtain information on when and how many filters their community or school was given, and record the number of houses in the community and the school roll. The team also made preliminary observations on how communities and schools were using the filtering units. The information gathered during the scoping visits is summarized in the table in annex 3.

Selection of villages and schools

Based on the information gathered by the team during the scoping visit and considering the available resources for the evaluation study, 9 villages or settlements and 6 schools were selected to be a representative sample of the filter recipient population to be investigated. The villages or

settlements selected were Natanuku, Tauvegavega, Navala, Bavu, Yako, Sariyawa, Tau, Nukuilau, and Keiyasi. The schools selected were Varavu Muslim School, Ba Sangam College, Ratu Navula College, Nadi Special School, Lomawai College, and Cuvu District School. These sites were chosen because they represented recipients from three different geographic areas (Ba, Nadi, and Sigatoka), three different filter installation years (2008, 2009, and 2010), and sites with different predominate ethnic make-ups (Indigenous Fijian and Indo-Fijian). 50% of households that received filtering units at each selected site were targeted for the investigation study, a total of 284 households. The 284 households and 6 schools selected represented roughly 15% of total recipient households and schools which was deemed an appropriate sample size. All sites were targeted to be visited between June 20th and July 2nd, 2011.

Determination of frequency of use

Separate questionnaires were developed for households and schools to determine demographic information, types of water sources, frequency of filter use, and knowledge and perceptions of drinking water-related diseases and water treatment (Annexes 4 and 5). Surveys of this sort are commonly used by institutions such as WHO (World Health Survey), the United States Agency for International Development (Demographic and Health Surveys), and the World Bank (Living Standards Measurement Study) to assess household use of improved drinking-water among other practices (WHO/UNICEF, 2006). Relating to water consumption, interviewees were asked how frequently they filtered their drinking water and water for kava preparation. Kava is a traditional drink made by mixing water with the pounded root of the *Piper methysticum* plant and plays an important social and ceremonial role in Fijian culture. It is consumed regularly in rural Fiji by both men and women but not by children.

Each selected site was visited unannounced by a team of two SOPAC staff and one or two Ministry of Health Officials. The team broke up into two groups of two (one SOPAC staff and one Ministry of Health Official) and separately went house-to-house to interview family members in their own homes. The number of households interviewed was 50% of the households located at the site as recorded during the scoping visit. The groups divided this number of households equally between the two of them and started carrying out interviews on opposite ends of the site. While basically every alternate household was targeted, there were slight variations based on whether or not family members were home at the time of the visit. In the case of schools, the team interviewed the principal and/or senior management staff.

Each interview was conducted by the interviewer reading questions off the questionnaire and recording the interviewee's answers. Interviews were mostly conducted in the first language of the interviewee, although a small number were in English when it was decided the interviewee had sufficient English speaking skills. To encourage honest answers, the team explained to the interviewees beforehand that the surveys were for investigating the filtering units and families were not being judged on their practices. Following the interview, some family members were asked to show where they kept their filtering units and demonstrate how they filtered their water or how to backwash the filter. Observational notes were then taken on the state of the filtering unit, the apparent cleanliness of the unit and its surroundings, and whether or not the individual demonstrated proper filtration or backwashing techniques. After all the interviews were performed, the data gathered from the questionnaires were compiled and processed using Microsoft Excel 2007.

Evaluation of filter efficacy

To determine the efficacy of the water filters in the field, water samples from the source, direct from the filter, and from a storage container (where available at time of visit) were tested using the hydrogen sulfide (H_2S) paper-strip test. H_2S testing was done by filling a small vial containing a chemically treated paper-strip with 10 mL of the water to be tested. The vials were then kept in the dark for 3 days. The H_2S test detects hydrogen sulfide producing bacteria such as *Salmonella, Citrobacter, Proteus, Edwardsiella* and some species of *Klebsiella* (Mosley and Sharp, 2005). Testing a water sample contaminated with hydrogen sulfide producing bacteria will cause the water sample to change from yellow (original color due to reagents) to black within 1-3 days, depending on the degree of contamination. The test was used as it is ideal for remote and isolated rural communities in the Pacific because of its ease, simplicity and low cost (Mosley and Sharp, 2005). In addition, it has been shown that hydrogen sulfide producing bacteria are associated with faecal contamination (relatively good correlation) and can be used as indicator organisms (Tambekar *et al*. 2007). Each day after the samples were taken, the vials were checked to see the rate of color change and therefore the level of bacterial contamination. The results were recorded each day for three days.

A water sample was collected directly from each drinking water source for each site as well. If a site received its water from the Water Authority of Fiji, the source water sample was taken from a tap. Initially for villages and settlements, every fifth house was targeted to collect a water sample from the filter and from a storage container. However, houses infrequently had water in their filtering bucket or storage container at the time of the visits, so samples were taken whenever it was possible to do so. Samples were only taken if a household already had water in their filtering bucket or storage containers at the time of visit. Families were not asked to fill them.

Control samples were taken using bottled water. The bottle was allowed to sit with the cap off in the open air for approximately 5 minutes before a sample was taken for H_2S testing.

RESULTS

Frequency of use in villages

Out of the 284 households targeted to be interviewed, 270 were successfully completed. Table 1 below shows the responses of interviewees to questions regarding how frequently water was filtered with the GCW provided filtering unit before consumption.

Table 1: Frequency of *Give Clean Water* filter use

How frequently is the filtered water used for	% of households that responded "always" or "most of the time"	% of households that responded "half the time", "rarely", or "never"
Drinking water?	52	48
Drinking kava?	8	92

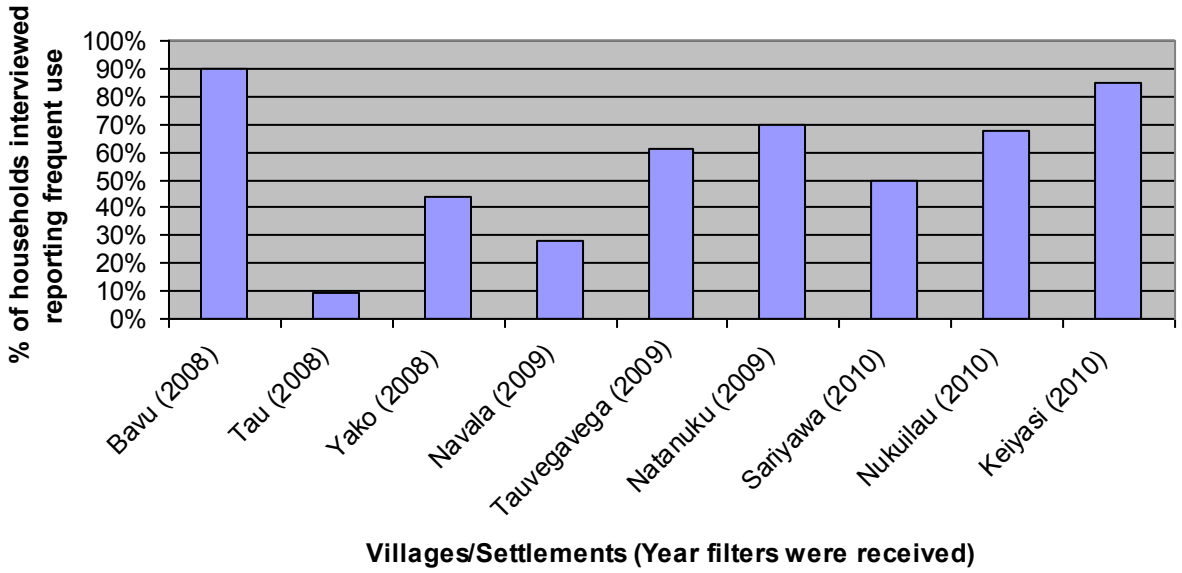
A significant number of interviewees responded they were not able to use the filtering units at all due to broken or missing parts. Table 2 shows the number of these respondents by year they first received their units.

Table 2: Households unable to use filtering unit due to missing or broken parts

Year filter was received	# of households unable to use filtering unit	% of households unable to use filtering unit
2008	25	32
2009	29	25
2010	5	6
Total	59	22

Usage of the filtering units varied widely over different villages and settlements. Figure 4 shows the percentage of interviewed households at each site that reported using the filtering units for drinking water "always" or "most of the time".

Figure 4: Percentage of households interviewed reporting use of *Give Clean Water* filters "always" or "most of the time" for drinking water



Frequency of filter use in schools

Schools that were interviewed received anywhere from 2 to 12 filtering units based on their size. Two of these six schools, Varavu Muslim School and Nadi Special School, were using the filters to treat their water before drinking on a regular basis. Nadi Special School gave the students the option of drinking the filtered water or drinking directly from the tap while students at Varavu Muslim were required to take drinking water from the filter. Cuvu District School and Ratu Navula College used the filters only a few times per year when water from the tap appeared turbid or if they needed to drink from rainwater catchments during times of government supply water shortages. Ba Sangam College and Lomawai College lost account of the filters due to staff turnover.

Perception on drinking water-related diseases

As shown in Figure 5, interviewees most often identified contaminated water (80%) as a cause for members of their community getting diarrhea while fewer identified contaminated food (25%) and an unhygienic living environment (10%) as a cause. 9% were unable to identify a cause of diarrhea. All other responses were each given by 5% or less of respondents.

Figure 5: Most common responses to the question "what causes people in your community to get diarrhea"?

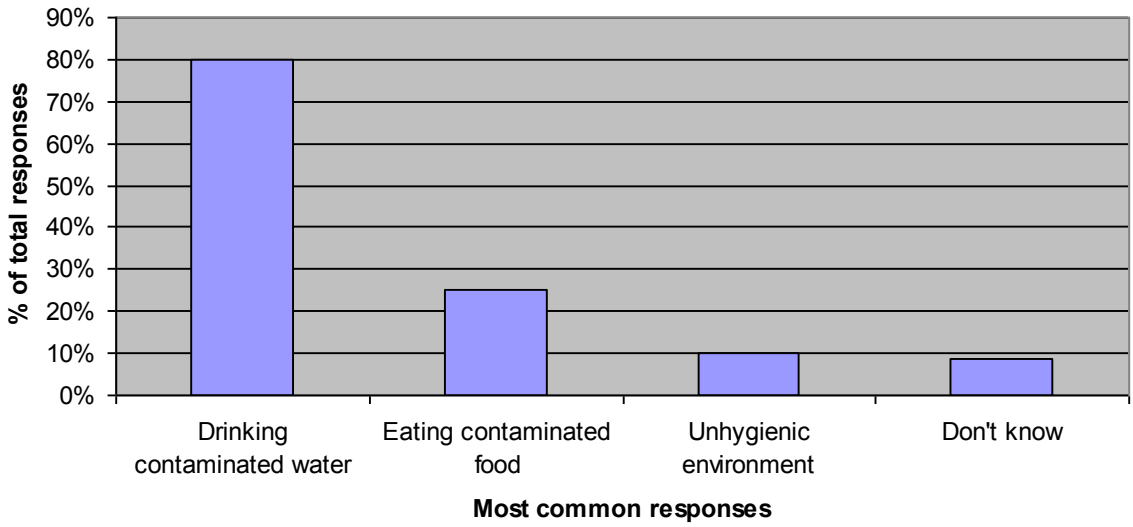
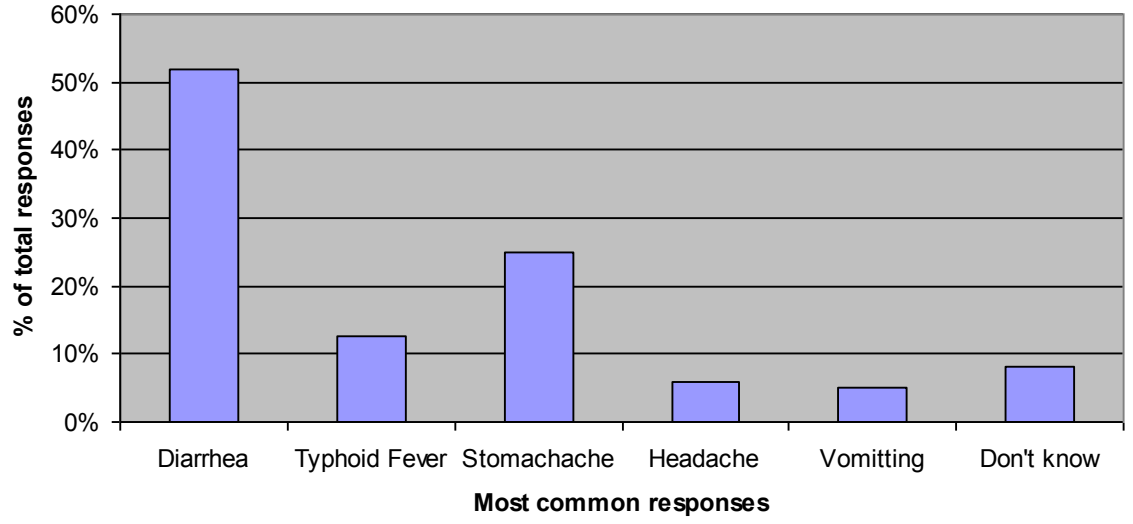


Figure 6 shows most interviewees identified diarrhea (52%) as a consequence of drinking contaminated water. Some symptoms of water-related diseases such as stomach aches (25%), head aches (6%) and vomiting (5%) were also mentioned. Typhoid fever was mentioned by 13% of respondents and 8% were unable to identify a consequence to drinking contaminated water. All other responses were each given by less than 5% of respondents.

Figure 6: Most common responses to the question "what are the diseases or health problems you can get when you drink water that is contaminated or dirty"?



87% of interviewees agreed with the statement "People can die from drinking dirty water" while 59% of interviewees agreed with the statement "The water in this community is clean and safe to drink without being treated" and 96% agreed "Filtering makes dirty/contaminated water clean to drink".

Filter efficacy in the field

A total of 27 water samples were taken directly from the filters and 37 samples were taken from storage containers in the field for H_2S testing. One sample was taken from each drinking water source for each site. Figures 7 and 8 show the breakdown of levels of bacterial contamination for samples taken from filters and from storage containers respectively. A "-" indicates no change and that the sample is free of bacterial contamination while "+" indicates possible contamination, "++" indicates some contamination, and "+++" indicates high contamination.

Figure 7: H_2S results from filters

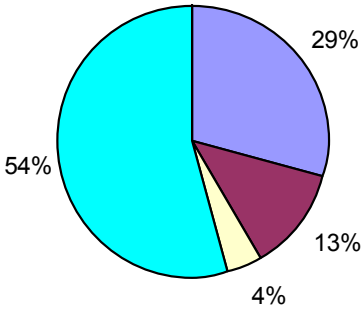
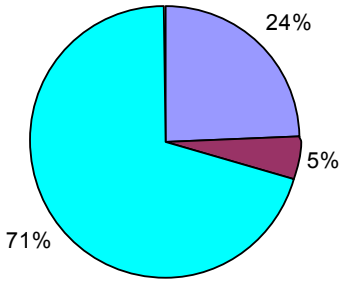


Figure 8: H_2S results from storage containers



The source of drinking water for the sites visited included borehole, well, surface water source, rainwater catchment, or the Water Authority of Fiji (WAF). Some sites had two or more separate sources of water. Table 3 gives the water sources for each site and lists the results of H_2S testing on samples from the source at the time of visit.

Table 3: Results from H_2S testing

Site	Type of Water Source	H_2S Results
Tauvegavega	WAF (Waiwai)	- No Change
Navala	Surface Water	+++
Natanuku	Borehole	- No Change
Bavu	Borehole	+++
Sariyawa	Well #1	+++
Sariyawa	Well #2	+++
Sariyawa	Well #3	+++
Yako	Well #1	+++
Yako	WAF (Nagado)	- No Change
Yako	Well #2	+++
Tau	Surface Water	+++
Nukuilau	Surface Water	+++
Keiyasi	WAF (Keiyasi)	+++
Ba Sangam College	WAF (Waiwai)	- No Change
Ba Sangam College	Borehole	+++
Varavu Muslim School	WAF (Waiwai)	- No Change
Varavu Muslim School	Borehole	- No Change
Ratu Navula College	WAF (Nagado)	- No Change
Nadi Special School	WAF (Nagado)	- No Change
Lomawai College	Borehole	+++
Cuvu District School	WAF (Matovo)	- No Change
Cuvu District School	WAF/Rainwater Mixed	- No Change

Water for Tauvegavega, Ba Sangam College, and Varavu Muslim School is collected from the Nadrau, Varaciva, and Waiwai Dams and is treated at the Waiwai Plant before delivery. Water for Yako, Ratu Navula College, and Nadi Special School is collected from the Vaturu Dam and is treated at the Nagado Plant before delivery. Water for Cuvu District School is collected from the Sigatoka River and the Qereqere borehole and is treated at the Matovo Plant before delivery. Finally, water for Keiyasi is collected from the Keiyasi River and treated at the Keiyasi pump station before delivery.

At the time of sampling, 45% of all samples taken from water sources were indicated by H_2S testing as being free of bacterial contamination. 7 out of 9 (78%) of water sources for schools were indicated as being free of bacterial contamination compared to only 3 out of 13 (23%) of water sources for villages and settlements. 7 out of 8 (88%) of water sources coming solely from the Water Authority of Fiji were found to be clean compared to just 3 out of 14 (21%) for all other sources. All the samples taken from well or surface water sources were found to be contaminated with bacteria.

DISCUSSION

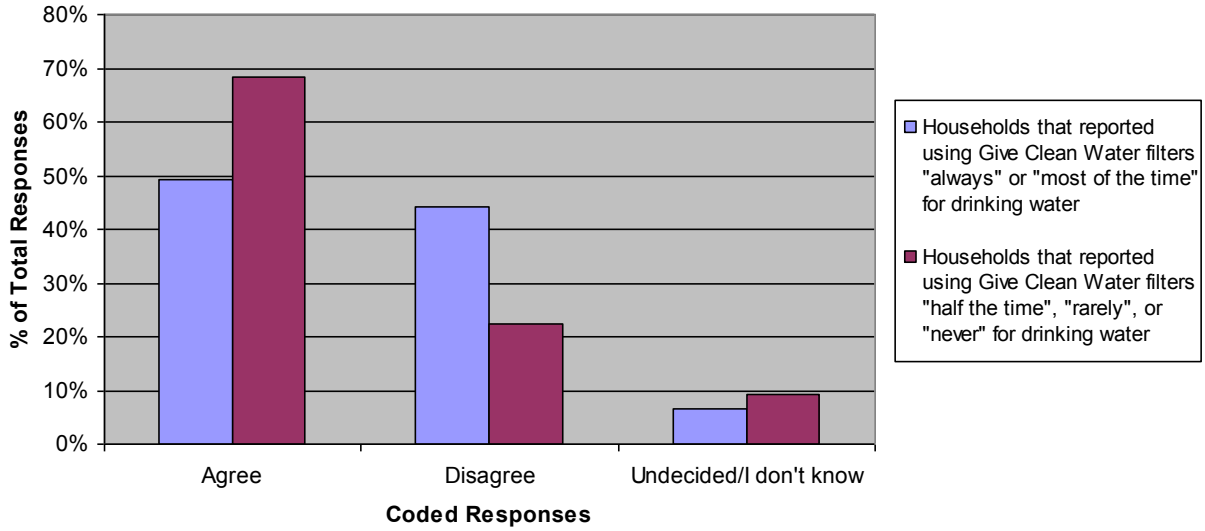
Frequency of use

Only around half of households interviewed reported using the filtering units "always" or "most of the time" for drinking water. When interviewees were asked what they liked about the filters (Annex 4), the responses ranged from the belief that water was being purified, to improved taste, and a noticeable reduction in turbidity. Furthermore, as noted, nearly all households (96%) believed the filter was capable of making contaminated water clean to drink. When interviewees were asked questions regarding what has prevented the filtering units from being used when they were present and functional (Annex 4), it was qualitatively noted that inconvenience, that is, the filling a bucket with water then waiting for it to filter, was the most common explanation for infrequent use. Some households also believed it was not necessary to treat the water before drinking, particularly ones that made up the 59% that agreed the water in their community is clean and safe to drink without being treated. A small number of households preferred boiling over filtration or complained that drinking filtered water gave them stomach aches or made them feel weak.

In the case of drinking kava, reasons for such a low incidence of usage may be that the filters are impractical for treating quickly enough the amount of water needed to prepare kava or that Give Clean Water unintentionally led communities to believe that the filters were intended or only necessary for normal drinking water.

A strong correlation was found between frequency of use and the interviewee's perception of how clean their source water is. Figure 9 compares how frequently the filters were used for drinking water between those who believed their water source is clean and those who do not. It shows that generally the usage rate of the filter is higher where people perceive their source water to be unsafe for drinking without any form of treatment.

Figure 9: Coded responses to the statement "The water in this community is clean and safe to drink without being treated"



As shown in Figure 4, the frequency at which filters were used varied widely over the villages and settlements that received them. There is a slight tendency that sites that received the filters more recently overall use them more frequently than sites that received them a while back. An exception to this is Bavu village which had the highest percentage of households frequently using the filters even though they were one of the earliest sites to receive them. On their site visit, the interviewing team learned from residents of Bavu that GCW liaises with a church based organization there in distributing the filters to other locations. It may be presumed then that Bavu has a closer relationship with GCW than other sites and thus may receive more attention in the form of monitoring, encouragement of using the filters, and replacements of damaged parts. Two other villages with high percentage of frequent use, Keiyasi and Nukuilau, have received the filters more recently than other sites. They are also located in a part of Fiji that has had frequent typhoid fever outbreaks in the past and thus have been the target of clean water and proper sanitation/hygiene awareness efforts. In addition, these are the only two sites found to have been visited by GCW accompanied by a Ministry of Health Official. The presence of a Ministry of Health Official may have lent credence and expertise to GCW's initiative in this area. Tau, Navala, and Yako villages which had the lowest percentage of frequent use also had the highest percentages of households with broken or missing parts. This is reflective of them having received the filtering units at earlier dates. Besides the year of installation of the filters, hygiene and sanitation education, and community perception of water source quality, there may be many other influential factors not investigated by this study that contribute to the wide disparity in frequent usage.

Table 2 further shows a tendency for sites that received the filters at earlier times to have higher percentages of households with missing or broken parts. Particularly after the first year, the number of occurrences of damaged or missing parts leading to complete disuse of the filtering unit rises considerably. Common reasons given by households for this included the filters becoming irrevocably blocked, rodents chewing holes through the hose, cracks in the filter casing leading to leaking, filtering units given to or borrowed by relatives and not returned, the buckets becoming cracked or punctured, and the filters being lost by a child or family member.

Infrequent use of filters by the interviewed schools was mostly due to the perception of a clean water source or the filters being lost during staff turnover. As shown in Table 3 the Water Authority of Fiji, which is generally trusted by the communities as a clean source of water, is the most common source for the schools

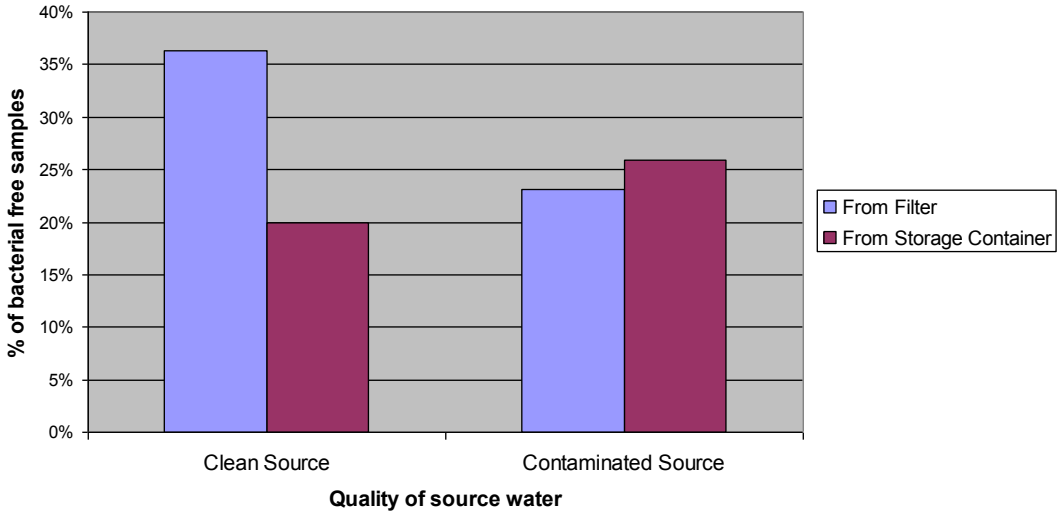
Multiple studies have shown that respondents often significantly over-report practices being evaluated such as household water treatment (Rosa & Clasen, 2010). Although care was taken to engage with the households explaining that the interview was to better understand the use of the filters and in no way judging or implicating non-use by households, over-reporting was suspected during this investigation. For example, at times the interviewing team observed filtering units that appeared to have not been used recently (that is, dust covering the unit or the homeowner not immediately knowing its location) despite the owner reporting frequent use. This indicates some inconsistency with reported usage figures and their actual usage. Thus, the figure of 52% of households reporting frequent use of filters for drinking water should be regarded as somewhat skewed upwards.

Filter efficacy in the field

Figure 7 shows that a large percentage of samples taken directly from filters in the field were indicated by H_2S tests as having at least a possible degree of bacterial contamination. Only 29% of samples from filters showed no bacterial presence while 54% of these samples were indicated as being highly contaminated. One possible explanation for this is the failure of the filter to perform in the field as claimed by the manufacturer. Controlled laboratory testing of the efficacy of the filter to purify water was not done as part of this investigation hence for discussion purposes it is assumed that the filters perform as guaranteed. According to the Sawyer Point One Filter instruction sheet (http://www.sawyerpointonefilters.com/downloads/pointONE-Filter-Instruction-Sheet.pdf) if the filter is backwashed with contaminated water, the first liter to pass through it after backwashing may be unsafe to drink. 61% of respondents reported using water from an unfiltered source for backwashing. However, after the first liter of water is filtered the rest of the filtered water should be free of bacterial contamination. Some households that were asked to demonstrate how to backwash their filter did so improperly. It is possible that repeated practices of improper backwashing may have permanently damaged their filter's capability to treat contaminated water.

Figure 8 shows that only 24% of the samples taken from storage containers were free of bacterial contamination. These results are only marginally worse than those of the samples gathered directly from the filter. Since the filtering units do not provide any residual disinfectant, the collected water is vulnerable to recontamination (Wright *et al.* 2003). Give Clean Water provided households with a bucket for storage but handling of these storage buckets was often observed as poor. Many storage buckets were observed to be uncovered and/or sitting on the floor where children and animals could tamper with them. Many households obtained drinking water by dipping a drinking cup into the bucket which also risks recontamination (Swerdlow *et al.* 1997 quoted in Clasen & Bastable, 2003). Figure 10 compares the percentages of bacterial free samples taken from filters and storage containers between sites that had clean source water and sites that had contaminated source water.

Figure 10: Percentage of bacterial free samples from sites with clean and contaminated source water



The graph shows that household storage and handling practices are areas of concern because around 80% of the water samples from storage containers with clean sources indicated bacterial contamination. This is assuming that the filters work as guaranteed by the manufacturer. In addition, the graph shows that only around 24% of the filtered water sampled produced bacteria-free water from contaminated sources and around 65% of clean water was getting contaminated after filtering through the unit, which is of concern. The reasons for this could include filter malfunction and improper backwashing by households. However, the H_2S test results are based on a relatively small sample size and conclusions could be strengthened with a larger sample size and laboratory based *E.coli* testing.

CONCLUSIONS AND RECOMMENDATIONS

The small size of the unit, ease of assembly, and relatively quick filtration rate (19.4 gallons/hour from a full 5 gallon bucket (Sawyer, 2008) may make the GCW filtering unit a useful household level treatment option. However, issues of durability, utilization by recipient families, and field performance of the filtering units need to be addressed to improve GCW's intervention as a viable day-to-day option.

Overall, 52% of households reported filtering their drinking water "always" or "most of the time". Water to be used for preparing kava was found to be filtered very infrequently. There may have been over-reporting by some of the interviewees, as noted in the discussion section, hence the usage figure may actually be lower. As found out from the investigation, some of the probable reasons for the low usage figures include inconvenience of use, lost or broken filter parts, community perception that their source water is clean, weak community engagement from the onset and limited follow up support.

32% of households that received their filtering units in 2008 are unable to use it due to missing or broken parts. The accessibility of related parts for the filtering unit would need to be

established in-country or made available to get high usage rates. This could be further strengthened by promoting the use of locally made or easily accessible replacement parts, especially the buckets, hoses and back wash syringe.

Community perception of the cleanliness of their water source was a strong determinant in the frequent usage of the filters. 59% of interviewees believed that the water in their community was clean and safe to drink without being treated. Some sites received their drinking water from a Water Authority supply which is generally perceived as a clean water source by communities. In such cases where the source water is actually clean, it would be more useful to ensure that the water supplier is implementing drinking water safety planning to ensure consistent supply of safe drinking water (Khatri *et al*. 2011) than perhaps intervention at the household level.

Where the water source was not from the Water Authority but the villagers still perceived it to be safe, educating communities on the quality of their drinking water through sanitary inspections (simple drinking water safety plans) would be useful in encouraging source water protection and household level water treatment where necessary.

The involvement of Fiji Ministry of Health Officials during village visits seems to have been realized late by GCW. It was noted that the two villages (Keiyasi and Nukuilau) where Ministry of Health Officials joined the GCW team had good usage rates of the filters as communities apparently received more attention in the way of hygiene, sanitation, and clean drinking water promotion as a whole. Keiyasi and Nukuilau are also typhoid hot spots identified by the Ministry of Health and hence have received more water supply, sanitation and hygiene education and awareness promotion as a result. It is highly recommended that any future interventions of such nature involve the Ministry of Health from the onset for effective community engagement.

Most of the schools visited in this study had access to a clean Water Authority supply hence implementation of drinking water safety planning would ensure consistent supply of safe drinking water. In addition, for larger schools with a roll of a few hundred students, the filtering units are not practical in the numbers they were distributed (8-12 units per school) because the buckets are estimated to hold only about 2-3 gallons or 8-12 liters.

H_2S testing results showed that at the time of sampling, performance of filters in the field was unsatisfactory overall. Better training of community members on backwashing practices may improve the quality of water produced by the filter if improper backwashing is actually responsible for a significant number of bacterially contaminated water samples. Laboratory testing needs to be done to verify the filter's performance as claimed by the manufacturer. More samples taken from filters in the field and further investigation of how filters are used and maintained by households may be needed to better explain the high rate of contaminated samples from the filters found. A high rate of bacterially contaminated samples was taken from storage containers and observations of poor storage were made in the field. Risk of recontamination could be reduced by promoting improved storage and handling practices (Nath *et al.* 2006).

As is seen from this investigation, the frequency of use of the filters in the field is low. Furthermore, the majority of the water samples from the filters and the storage vessels showed compromised water quality. While the intention of GCW is noble, improvements to their

engagement process is needed if the filter is to be considered as a sustainable, long term household level water treatment option in rural areas of Fiji. Further such evaluations should be undertaken by the Ministry of Health to monitor the effectiveness of the filtering units provided by GCW in the future. These recommendations should also be considered and taken on board for any new household level treatment option introduced in Fiji.

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ANNEX 1: Filtering unit distribution in Fiji from 2008 to 2011 by Give Clean Water

1. MOLOLO
2. YAKO INDIAN SETTLEMENT
3. YAKO VILLAGE
4. MALAMALA
5. NALOVO
6. UCIWAI
7. NAWAI
8. BAVU
9. SARIYAWA
10. MOMI
11. TAU
12. NAKOROKULA
13. BA HART HOME
14. TAUVEGAVEGA
15. NASOLO
16. NAVALA
17. VARAVU
18. WAVUWAVU
19. VADRAVADRA
20. NATALICAKE
21. SASA
22. SAROKOBA
23. NATANUKU
24. RARAWAI
25. KALELI SETTLEMENT
26. TAVARAU
27. VOTUA
28. KEIYASI
29. DRAIBA
30. KOROLEVU
31. NUKUILAU
32. NUBUYANITU
33. TREASURE HOUSE
34. WAI TUI PRIMARY SCHOOL
35. LOMOWAI COLLEGE
36. NADI SPECIAL SCHOOL
37. RATU NAVULA COLLEGE
38. NAMAKA PUBLIC SCHOOL
39. NAWAI SECONDARY SCHOOL
40. BA SANGAM COLLEGE
41. BA PRIMARY SCHOOL
42. BA SPECIAL SCHOOL
43. RATU FILIMONI VUKINAMAULEVU MEMEORIAL SCHOOL
44. VARAU MUSLIM SCHOOL
45. CUVU PRIMARY SCHOOL
46. NAKURAVAKARU KINDERGARTEN
47. NADROGA NAVOSA HIGH SCHOOL

ANNEX 2: Assembly parts of Sawyer Point One Filtering Unit Bucket Adapter Kit

Filter

Backwash Syringe

Hole Cutter

Filter Hanger

Fittings

Hose

ANNEX 3: Scoping Visit Notes

Ba				
Natanuku Village 2009 Installation 50 Houses All houses received filter	**Varavu Settlement** Jan 2011 Installation Mar 2011 Revisit ~100 Houses All houses received filter	**Varavu Muslim School** Nov 2009 Installation 197 Students Received 10 filtering units	**Sasa Village** Oct 2010 Installation 73 Houses All houses received filter	**Sorokoba Village** Sept 2009 Installation Apr 2011 Revisit 100+ Houses All houses received filter
Natalecake Village July 2010 Installation Nov 2010 Revisit 42 Houses All houses received filter	**Ratu Filimoni Memorial School** Early 2008 Installation 178 Students Received 8 filtering units	**Vadravadra Village** July 2010 Installation Sept 2010 Revisit 68 Houses 57 houses received filters	**Votua Village** Feb 2011 Installation 100+ Houses All houses received filter	**Wavuwavu Village** April 2010 Installation Revisit June 2010 10 Houses All houses received filters
Navala Village 2009 Installation 2010 Revisit 111 Houses All houses received filter	**Rarawai Settlement** Late 2010 Installation 7 Houses All houses received filter	**Ba Sangam Primary School** June 2010 Installation 200 Students Received 10 filtering units	**Ba Sangam College** June 2010 Installation 400 Students Received 16 filtering units	**Ba Special School** June 2010 Installation 56 Students Received 3 filtering units
Nasolo Village Late 2009 Installation 51 Houses 35 houses received filters	**Ba Hart Homes** 2009 Installation 43 Houses All houses received filter	**Tauvegavega Settlement** 2010 Installation 40-45 Houses 34-39 houses received filter	**Tavarau Village** Late 2010 Installation 2011 Revisit 63 Houses 10-15 houses received filter	
Nadi				
Bavu Village Oct 2010 Installation 50+ Houses All houses received filters Community member liases with GCW	**Momi Village** Jan 2010 Installation April 2010 Revisit 73 Houses All houses received filter	**Sariyawa Settlement** Early 2010 Installation Mid 2010 Revisit 30 Houses All houses received filter	**Nawai Secondary School** Mid 2009 Installation 140 Students Received 10-12 filtering units Filters no longer in use	**Yako Village** Late 2008 Installation 2010 Revisit 40+ Houses All houses received filter
Namaka Public School Principal and senior staff claim school was never visited by GCW	**Ratu Navula College** Early 2010 Installation 877 Students Received 12 filtering units	**Treasure House Orphanage** Early 2010 Installation 20 Staff members Received 1 filtering unit	**Nadi Special School** 2010 Installation 130 Students Received 2 filtering units	**Nawai/Nalovo/Uciwai Area** 2009 Installation 50-100+ Houses ~25 houses received filter
Sigatoka				
Korolevu Village Jan 2011 Installation 60-70 Houses 20-30 houses received filter	**Nukuilau Village** Jan 2011 Installation 50-60 Houses All houses received filter	**Nubuyanitu Village** Jan 2011 Installation 40+ Houses All houses received filter	**Draiba Village** 2010 Installation 34-35 Houses All houses received filters	**Keiyasi Village** Jan 2011 Installation Mar 2011 Revisit 69 Houses All houses received filter
Tau Village July 2009 Installation 75 Houses 70 houses received filter	**Nakorokula Village** July 2009 Installation 54 Houses 44 houses received filter	**Lomawai College** 2009 installation 600 Students Unknown number of filtering units received Filters no longer being used	**Cuvu College** Prinicipal claimed school was never visited by GCW	**Cuvu Primary School** Feb 2010 Installation 181 Students Received 2 filtering units
Nakuruvakarua Kindergarten Feb 2010 Installation 25 students Received 1 filtering unit	**Nadroga Navosa High School** Feb 2010 Installation 183 Students Received 4 filtering units			

ANNEX 4: Household Questionnaire for Drinking Water

Name of village: _____

Total number of people living in household: _____

Under 5 years old: _____ 5-60 years old: _____

Over 60 years old: _____

Number of females: _____ Number of males: _____

Begin these questions by explaining there are no correct answers, the interviewees names are not being recorded, and any answer to any question is fine as long as it's truthful. Assure them they do not need to feel embarrassed by any answers. Their honest answers will go towards improving the practices of the Ministry of Health.

What causes people in your community to get diarrhea?

Is diarrhea an avoidable illness or just a part of life?

☐ Avoidable illness ☐ Just a part of life ☐ I don't know/No opinion

What are the diseases or health problems that you can get when you drink water that is contaminated or dirty?

People can die from drinking dirty water.

☐ Disagree ☐ Undecided/I don't know ☐ Agree

Eating food that was cooked with dirty water is safe to eat.

☐ Disagree ☐ Undecided/I don't know ☐ Agree

Filtering water makes dirty/contaminated water clean to drink.

☐ Disagree ☐ Undecided/I don't know ☐ Agree

Why?:

The water in this community is clean and safe to drink without being treated.

☐ Disagree ☐Undecided/I don't know ☐ Agree

What do most people in the community think about filtering water?
☐ Positive views ☐ Indifferent ☐ Mixed views ☐ Negative views ☐ I don't know

What other methods do you use for cleaning your water?
☐ Solar Disinfection (SODIS) ☐ Boiling ☐ Chlorination ☐ Coagulation/Flocculation ☐ Other form of filtration ☐ None

Water source for the household: ☐ Surface water ☐ Borehole ☐ Rainwater catchment

☐ Municipal ☐ Other: _____

Date the filter was installed: _____

Is the filter still present in the house? ☐ Yes ☐ No

If so, is it still operational? ☐ Yes ☐ No

If so, is it still being used? ☐ Yes ☐ No

Are the accessories still present in the house? ☐ Yes ☐ No

If so, are they still being used? ☐ Yes ☐ No

Questions for people with functioning filters that are still in use

Again, reiterate the interviewee is not being personally tested and any answer is fine as long as it is honest.

Location of the filter unit within the house:

How frequently is the filtered water used for…

Drinking water?: ☐ Always ☐ Most of the time ☐ Half the time ☐ Rarely ☐ Never

Drinking kava?: ☐ Always ☐ Most of the time ☐ Half the time ☐ Rarely ☐ Never

☐ N/A (We don't drink kava, etc)

Cooking?: ☐ Always ☐ Most of the time ☐ Half the time ☐ Rarely ☐ Never

Other purposes?: ☐ Always ☐ Most of the time ☐ Half the time ☐ Rarely ☐ Never

What are the other purposes?:

How often do you forget to filter your water for drinking/kava/cooking?
☐ Always ☐ Most of the time ☐ Half the time ☐ Rarely ☐ Never

Do you ever store the water after filtration or just drink it straight from the filter? If you ever store it, where and how do you?:

Where does the water for backwashing come from?: ☐ Filtered/treated source
☐ Unfiltered/untreated source

How many times and when has Give Clean Water (GCW) staff visited the household since the time the filter was first installed?:

What was the outcome of the visit (anything replaced, filters cleaned by staff, additional training, etc.)?:

Do you know how to backwash/clean your filter? ☐ Yes ☐ No

How often do you backwash your filter?
☐ Daily ☐ Weekly ☐ Monthly ☐ Less frequently than monthly ☐ Never

How often do you ask for filtered water when you drink at other people's houses?
☐ Always ☐ Most of the time ☐ Half the time ☐ Rarely ☐ Never

What prevents you from using filtered water every time for drinking (including kava drinking) and cooking?

Do you like the filter?

☐ Yes ☐ No ☐ I don't know

If yes, what do you like about it? If no, what don't you like about it?

Questions for people who have lost, broken, or don't ever use their filters

Again, reiterate the interviewee is not being personally tested, no one is judging their actions, and any answer is fine as long as it is honest.

How were the filter/accessories lost?

How did the filtering unit break?

What has prevented the filter from being used?

ANNEX 5: School Questionnaire for Drinking Water

Name of school: _____

Type of school: ☐ Primary ☐ Secondary ☐ Special

Total number of students: _____

Total number of teachers: _____

Water source for the school: ☐ Surface water ☐ Borehole ☐ Rainwater catchment

☐ Municipal ☐ Other: _____

Date the filter(s) was installed: _____

Is the filter still present at the school? ☐ Yes ☐ No

If so, is it still operational? ☐ Yes ☐ No

If so, is it still being used at all? ☐ Yes ☐ No

Are the accessories still present at the school? ☐ Yes ☐ No

If so, are they still being used? ☐ Yes ☐ No

Location of the filter unit(s) at the school:

Do the students/teachers get drinking water from other sources than the filter? ☐ Yes ☐ No

Who is responsible for cleaning the filters?:

How frequently are the filters cleaned?: ☐ Daily ☐ Weekly ☐ Monthly

☐ Less frequently than monthly ☐ Never

Where and how is the water being stored after filtration?:

How frequently are the storage containers cleaned?: ☐ Daily ☐ Weekly ☐ Monthly
☐ Less frequently than monthly ☐ Never

Where does the water for backwashing come from?: ☐ Filtered/treated source
☐ Unfiltered/untreated source

How is the filtered water distributed to students and teachers?:

How many times and when has GCW staff visited the school since the filter was installed?:

What was the outcome of the visit (anything replaced, filters cleaned by staff, additional training, etc.)?:

Does the filtering unit filter water quickly enough to provide for all students/teacher?:
☐ Always ☐ Most of the time ☐ Sometimes ☐ Rarely ☐ Never

What difficulties have you had with the filter?:

Questions for schools that have lost, broken, or don't ever use their filters

How were the filter/accessories lost?

How did the filtering unit break?

What has prevented the filter from being used?

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