Ram Pump Water Filtration: Assessment and Filtration in Tres Hermanos

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Introduction

In conjunction with Alternative Indigenous Development Foundation, Inc. (AIDFI) and Green Empowerment, the Northwestern Ram Pump team successfully installed a hydraulic ram pump system that services the village of Tres Hermanos on the island of Negros Occidental, Philippines. While the team completed the goal of delivering water to the village, further research was necessary in order to assess the quality of the water and any measures that could be taken to filter and purify the water if necessary. The further research consisted of comprehensive water quality analysis, consultations with the NGO partners and villagers concerning water filtration, and ultimately the design and prototyping of possible filtration options.

Water Quality Assessment

For analysis, two rounds of water samples were collected from chosen sampling locations. The water quality tests were conducted through the use of an Industrial Test Systems Water Quality Test Kit and two local laboratories, Negros Prawn Producers Marketing Cooperative, Inc. Analytical and Diagnostic Laboratory (NPPMC) in Bacolod and the LIPA Quality Control Center on a neighboring island.

Initial water test samples were taken on June 25, 2010. Inorganic test results (Tables 1, 2, and 3) show that the water from the Anangue spring falls within the standards of potable water. Further analysis of the results from the separate sources reveals two trends (See Table 2 for sampling locations). The water sampled from the stream contains much higher concentrations of the inorganics tested for than the water captured in the ram pump system by the impounding tank, passed onto the catchment tank. However, as the water moves from the impounding to the catchment tank, there is an increase in concentration of inorganics. Both of these trends are also seen with the organic results; however the results also indicate that the concentrations of organics are higher than the standard for potable water. The trends of increasing values from the impounding tank to the catchment tank point to the possibility of a build-up of water contaminants in the ram pump system, which may stem from construction issues and may also become an increasing problem over time.

Tests of Total and Thermotolerant (Fecal) Coliforms indicate that both the stream water and the water flowing through the ram pump system contain coliform concentrations larger than the standard for potable water. These higher concentrations of coliforms indicate that harmful pathogens may be present in the water. Although all of the samples do not pass the standard for potable water in the case of coliforms, the Impounding Tank/Spring Source and Catchment Tank samples do fall underneath the 100 MPN/100 mL advised by the EPA for water to be used for human contact. Furthermore, all samples fall under the EPA advised 2000 MPN/100 mL level for water for domestic use to undergo further treatment, such as filtration or boiling. Pathogenic organisms are usually present in water samples containing over 200 MPN/100 mL. Thus, the results show that the water collected and pumped to the community from the Anangue Spring Source, through the ram pump is below levels containing pathogenic organisms, compared to the stream source whose water testing results point towards the possibility of pathogenic organisms in the water.

A second water sampling was taken on July 19, 2010 in order to more fully analyze the trend of increasing values along the ram pump system, however the results (See Table 4) returned did not provide further insight to the water quality assessment, as the unusually high results across a majority of the samples indicate possible invalidity of the test.

During the construction of the ram pump, some relevant observations were made regarding water quality. The first observed occurrence was the increased flow to the adjacent Anangue Catchment tank, indicating that as the water was dammed by the newly constructed impounding tank, the water level of the spring source was pushed farther back. The water may have been forced into areas of greater contamination or may even have caused new water flow into unknown areas. Another observation was the increased amount of water collected in the ram pump systems' catchment tanks after rainfalls, indicating that the source may not be a natural spring, but instead may be influenced by outside sources, such as rain. This observation may explain one mode for contaminants to enter the water.

Water Filtration Options

After completion of the water quality assessments, the focus of research turned to methods of water filtration for use in rural areas. Villagers currently filter their water through clean clothing or boil water, although the latter option is not preferred since it consumes precious fuel resources. The filtration options considered included an in-line filtration system, commercial filters, solar water disinfection (SODIS), household biosand filtration systems, porous ceramic filters, and ceramic/biosand combination filters.

Filter Option	Assessment
In-Line Filtration System	Discussed with AIDFI, but ultimately decided against due to the necessary appointment of a local water quality technician, who would assume responsibility for the water supply of the entire village population. Repair of the system would also require more tools and expertise. AIDFI would rather leave water quality as a family responsibility. Not recommended.
Commercial Filters (See Figures 1 and 2)	Commercial filters were used during the trip, yet for the average rural family, they are too expensive to purchase. Moreover, they are difficult to transport from the markets where they are sold and in the occurrence that they break down (sometimes frequently) or need replacement filters, the parts are expensive and difficult to attain. Not recommended.
SODIS	Method currently implemented by some rural villages due to its ease of operation. PET and glass bottles are easily accessible even in the rural villages. Currently, Red Cross volunteers and DOD volunteers are spreading knowledge of the water purification method. This method is highly recommended for use in the rural Philippines.
Household Biosand Filtration Systems (See Figures 3, 4, and 5)	No household biosand filtration systems were encountered in the Philippines, however, all of the necessary components of the filter- cement or plastic buckets, gravel, and sand - are easily accessible and even plentiful in the rural areas. A biosand filter was constructed at Northwestern and tested (See Table 5). Biosand filtration systems are highly recommended.
Porous Ceramic Filtration (See Figure 6)	The only porous ceramic filters encountered in the Philippines were commercially made filters. Clay sources were abundant in some rural areas, however, no ovens for clay firing were spotted, nor did any rural Filipinos report pottery experience, as they mainly work with weaving bamboo baskets. Porous ceramic filters were constructed at Northwestern and tested (See Table 6). However, even with the expertise and aid of a professional potter at ARTica Studios, the filters were fragile and difficult to construct. Therefore, they are not highly recommended for Filipino rural areas.
Porous Ceramic/Biosand Filtration Combinations (See Figures 7 and 8)	The combination of the two filters was hypothesized to facilitate greater overall purification and filtration. The filter combinations were prototyped and tested at Northwestern. However, for the same reasons as the porous ceramic filters, they cannot be highly recommended for communities in the rural Philippines.

Conclusion and Future Research

After water quality assessments indicated the need for water filtration in order to provide the village of Tres Hermanos with safe potable water, filtration methods were assessed and tested. From the filtration options assessed, the most highly recommended methods included SODIS and household biosand filtration, since they are low-cost, can be made from easily accessible materials, and effectively purify water. Since the second water assessment turned out inconclusive, instructions were left with AIDFI to conduct a follow-up water assessment and to forward the results to Northwestern. Furthermore, future research may be made into possible water filtration systems involving bamboo woven baskets and coconut husks, since these materials are easily accessible and abundant to rural Filipinos.

Tables

Table 1: Initial Sampling – Water Quality Test Kit – 06/25/10 – Organic and Inorganic

Sample: Anangue Impounding Tank (Spring Source)

Test	Maximum EPA Contaminant Level for Potable Water (MCL)	Result
pH	NA	6.0
Total Alkalinity (ppm)	NA	100
Total Chlorine (ppm)	4.0	0.0
Total Hardness (ppm)	NA	0.0
Free Chlorine (ppm)	4.0	0.0
Chloride (ppm)	250	0.0
Sulfate (ppm)	250	0.0
Total Nitrate and Nitrite (ppm)	10	0.0
Copper ([redacted] (ppm)	1.3	0.0
Iron ([redacted] (ppm)	0.3	0.0
Lead	NA	Negative
Pesticide	NA	Negative

Table 2: Initial Sampling – NPPMC Laboratory – 06/25/10 – Organic and Inorganic

Samples: Stream, Anangue Impounding Tank (Spring Source), and Catchment Tank

Test	Standard Values	Sample 1: Stream	Sample 2: Anangue Impounding Tank/Spring Source	Sample 3: Catchment Tank
Total Dissolved Solids (ppm)	< 500	69	34	66
Iron (ppm)	1	0.4	< 0.2	< 0.2
Sulfate (ppm)	< 250	79	39	51
Nitrate (ppm)	< 50	0.967	0.226	0.419
Phosphate (ppm)	NA	0.084	0.02	0.052
Total Coliform (MPN/100mL)	< 1.1	> 1,600	13	23
Thermotolerant (Fecal) Coliform (MPN/100mL)	< 1.1	300	8	13

Table 3: Initial Sampling – LIPA Quality Control Center – 06/25/10 – Inorganic Only

Sample: Anangue Impounding Tank (Spring Source)

Test	MCL	Result
Mercury (ppm)	0.002	< 0.001
Lead (ppm)	0.015	< 0.01
Arsenic (ppm)	0.010	< 0.003

Table 4: Second Sampling – NPPMC Laboratory – 07/19/10 – Organics Only

Samples: Boiled Water, Impounding Tank, Catchment Tank, Tres Hermanos Pipe, Tap Stand, Household Water Container, Ceramic Filter, and Stream

Sample	Standard Maximum Values	Total Coliform Result (MPN (most probable number of colonies) /100mL)	Thermotolerant (Fecal) Coliform Result (MPN/100mL)
Boiled Water	< 1.1	< 2.0	< 2.0
Impounding Tank	< 1.1	> 1,600	> 1,600
Catchment Tank	< 1.1	> 1,600	> 1,600
Tres Hermanos Pipe	< 1.1	> 1,600	> 1,600
Tap Stand	< 1.1	900	130
Household Container	< 1.1	> 1,600	> 1,600
Ceramic Filter	< 1.1	> 1,600	> 1,600
Stream	< 1.1	> 1,600	> 1,600

Table 5: Biosand Particle Filtration Test

Test run using fluorescent particles of size approximately 5 micrometers to mimic water contaminants

Time of Sample Collection	Concentration (counts/mL)
7:12 P.M (Initial Concentration)	13,728,726.64
7:32 P.M (20 minute interval)	1,371,209.95
8:12 P.M (1 hour interval)	1,790,547.69
8:42 P.M (1 hour and 30 minute interval)	21,594.824

Table 6: Porous Ceramic Filtration Results

Filter Prototype	Maximum Capacity (mL)	Flow Rate (mL/min)
Plate	800	0.824
Pot	13,500	6.579
Cylinder	23,000	0.870

Figures

Figure 1: Megafresh Commercial Filter Used During the Project Duration

Figure 3: Grades of Sand and Gravel Used to Construct Biosand Filters

Figure 2: Commercial Hand Pump Tested in the Philippines

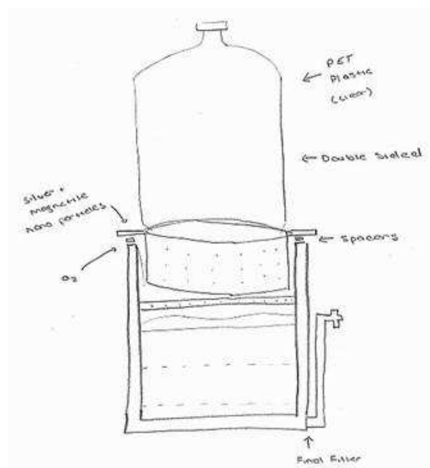

Figure 4: Household Biosand Filtration System

Figure 5: Testing the Biosand Filtration System

Figure 7: Combination Porous Ceramic and Biosand Filter

Figure 6: Configurations of Porous Ceramic Filters

Figure 8: Alternate Configuration of Porous Ceramic and Biosand Combination

Reference

"Ground Water & Drinking Water | Drinking Water | US EPA." EPA Office of Water Home | Water | US EPA. Web. 07 Oct. 2010. <http://water.epa.gov/drink/index.cfm>.