CAPSTONE EXPERIENCE 2011
Drinking Water Issues in Rural Colombia

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Abstract:

Access to sufficient amounts of clean drinking water is a serious problem in rural communities near Barbosa, Colombia. Because groundwater resources are not available, water for daily use in the three villages near Barbosa must be obtained from nearby surface sources and treated to remove disease-causing contaminants. Kimberly-Clark, our project sponsor, constructed a paper products manufacturing plant in Barbosa in 2008 and wishes to ensure a reliable supply of safe drinking water to the surrounding local population. For these small communities, slow sand filters (SSFs) may be a suitable means of drinking water treatment due to their simplicity, cost-effectiveness, and incorporation of locally available materials. Slow sand filters physically trap solid particles in the raw water (including micro-organisms), and also provide a matrix for the growth of a rich (non-pathogenic) microorganism community, which consumes organic matter, including material from dead pathogenic micro-organisms. Construction of SSFs requires only fine sand, gravel, and plumbing materials. To help address the water issues in the communities, the Purdue team designed and constructed several "bench-scale" SSFs using 5-gallon pails, designing each unit to process 10 L of raw water per day, and to cost less than $45.00. These small units were tested using water from the Wabash River, and treated water was analyzed to ensure that World Health Organization (WHO) standards for turbidity, chlorine demand, and *E. coli* prevalence were met. Once proven effective, replicas of these systems were installed in three elementary schools near Barbosa during a March 2011 visit. To address the needs of the greater community, the team has designed a scaled-up SSF system for use with the existing infrastructure near the schools, capable of treating 37 cubic meters of raw water per day.

Background Information:

Nearly one billion people worldwide live without access to safe drinking water. Waterborne diseases such as cholera, diarrhea, and parasitic infections, contracted through consumption of contaminated water, are responsible for approximately 1.5 million deaths each year, including a high proportion of children living in developing countries (Rossiter et al, 2010). Although naturally-"filtered" groundwater is the preferred water source in much of the world, a good source of groundwater is unavailable in some regions and depletion by overuse often necessitates the use of surface waters such as rivers. Practice has shown that slow sand filtration may be the cheapest, simplest, and most effective means of drinking water purification in such situations. A distinct advantage of this method is its use of both physical and biological processes to remove contaminants (Huisman and Wood, 1974).

Objectives:

1. Design point-of-use water filters
2. Deliver point-of-use water filters to communities near Barbosa Colombia (**Figure 1)**
3. Design community scale water filters

Figure 1. Barbosa is ~50 km Northeast of Medellin

Figure 2. Filters installed at Buga

Design/Results

1. *Point-of-Use Design & Operation*. We designed a point of use system that uses readily available materials found in Colombia. Each filter unit consist of two vertically-stacked 5-gallon buckets (**Figure 2**). The interior of the buckets are filled with coarse gravel, fine gravel, coarse sand, and finally fine sand layers on top of each other, so that the fine sand does not penetrate to the bottom of the bucket (**Figure 3**). At the bottom of the bucket a perforated tube ring is connected to a tube that goes through the side of the bucket above the sand layer. The location of the tube through the wall of the bucket is important because it determined the elevation of water in the bucket during static conditions. **Table 1** shows the reduction of different types of contaminates in water that slow sand filters normally achieve (Nat. Drinking Water Clearing House, 2000).
2. *Implementation*. Students traveled to Colombia over spring break to assemble and install several point-of-use filters at the schools in the communities of Buga, Graciano, and Las Peñas (**Figure 2**).
3. *Scale-up*, The large unit design is based on a community-wide solution to the water quality problems in the three communities. **Figure 4** is a profile view of the design and is very similar in concept to the point-of-use filters. More than one filter per community is recommended so that each filter may be cleaned while others continue to operate. The scaled-up filter design requires that at least two units are needed to supply each community with water filtered water (**Table 2**). The costs of both the point-of-use and scale-up designs are shown in **Table 3**. Disinfection with chlorine after filtration is required.

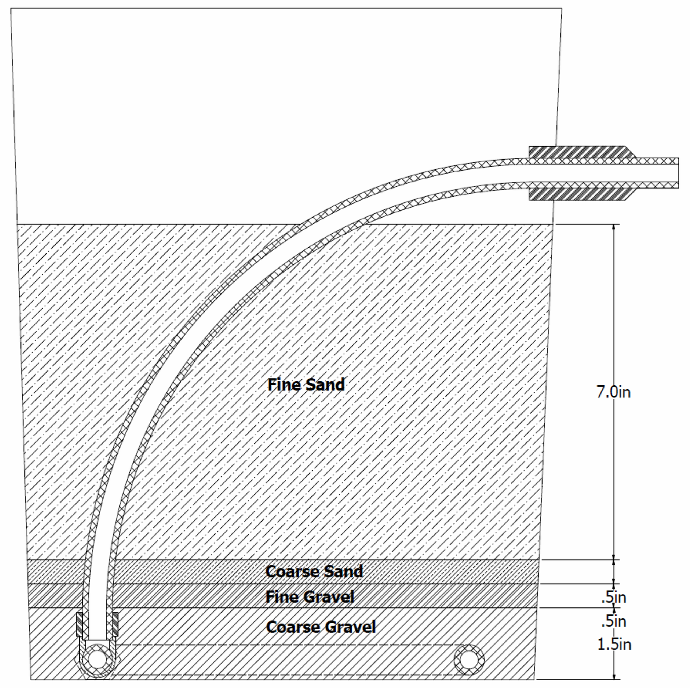

Figure 3. Cross-cut side view of point-of-use pail

Table 1.Slow Sand Filter Removal Rates

Turbidity	<1 NTU
Coliform Bacteria	1-3 log units
Enteric Viruses	2-4 log units
Giardia Cysts	2-4+ log units
Cryptosporidium Oocysts	>4 log units
Dissolved Organic Carbon (DOC)	<15-25%
Biodegradable DOC	<50%
Trihalomethane Precursors	<20-30%
Heavy Metals Zn, Cu, Cd, Pb	>95-99%
Iron and Manganese	>67%
Arsenic	<47%

Table 2. Scale-Up Design

Water Needs	
Number of Families	40
Daily Water Use (L/d/family)	844
Water needs (L/d)	33760
Design Parameters	
Flow Rate (m^3/d)	33.76
Desired Retention Time (d)	0.5
Porosity	0.385
Depth of Fine Sand (m)	1
Number of Units Needed	
Needed Land Area (m^2)	43.89
Area Required per Unit (m^2)	24
Units Needed	2

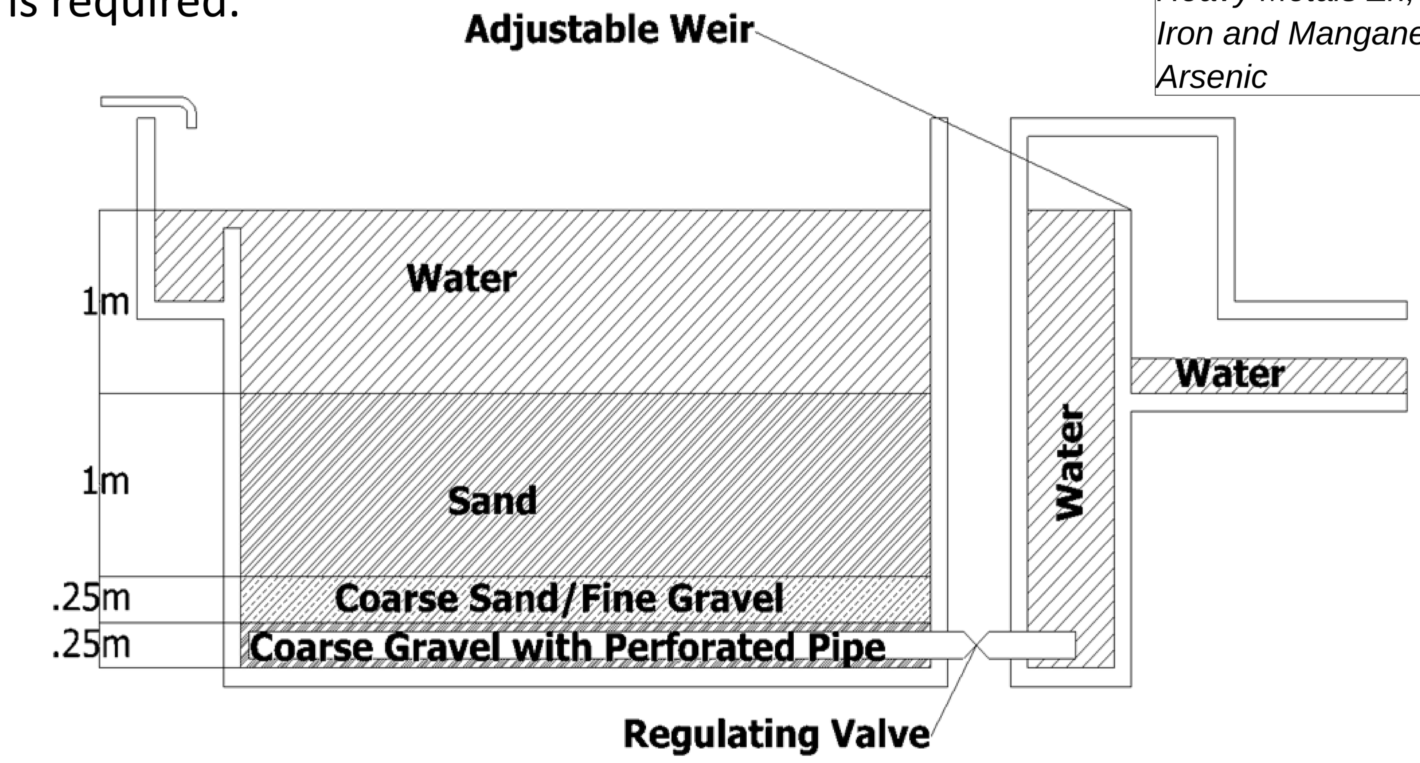

Figure 4. Profile view of community-scale slow sand filter

Table 3. BUDGET

Slow Sand Filter	*1 Unit*	*2 Units*	**Point-of-Use Filter**	
Concrete	$ 2,548.12	$ 5,096.24	Buckets	14.195
Fine Sand	$ 9,876.74	$ 19,753.48	Tubing/Fittings	20.455
Coarse Sand	$ 2,246.96	$ 4,493.92	Media	6.875
Gravel	$ 2,517.60	$ 5,035.20	**Total**	41.525
Subtotal	$ 17,189.42	$ 34,378.84	**Cost per Liter**	8.305
Clear Well		*1 Unit*		
Concrete		$ 2,919.05		
Total		$ 37,297.89		
Cost per Liter		$ 1.01		

Conclusions

1. Implementation of point of use filters was successful
2. Scale-up is feasible
3. Alternative solutions include point-of-use treatment methods, including fiber filters, ceramic filters, or boiling (current practice). Rapid sand filtration is an alternative solution for community-wide treatment.

References:

1. Huisman, L.; Wood, W.E. Slow Sand Filtration, World Health Organization, Geneva, 1974.
2. National Drinking Water Clearinghouse, Tech Brief: Slow Sand Filtration, #14, June, 2000
3. Rossiter, H., Owusu, P., Awuah, E., MacDonald, A., Schaefer, A. Chemical drinking water quality in Ghana: Water costs and scope for advanced treatment. Scieince of the Total Environment, 2010

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