December 20th, 2010

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
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Burnaby, British Columbia
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Re: Post-Mortem for the Portable Filtering System

Dear Dr. Rawicz,

The document presented here outlines the post mortem for our Portable Filtering System (PFS). Our system is a reusable, durable and easy-to-use solution to the ever-present problem of clean water in rural areas of developing countries. By creating a self-powered portable filter we feel that we will, if not accomplish our goal, definitely take a huge step in the right direction.

This document will cover the details in the current status of the prototype, deviations from our original specifications, budget, timeline differences, and future plans for our PFS. In addition, members of our team will describe their personal contributions to our project.

The AquaQuick team, which is comprised of Vaibhav Mal, Shivam Mathur, Adam Tanabouz and Jie Gu, can be contacted via the email address or phone number listed below and are more than happy to answer any questions you may have.

Regards,

Vaibhav Mal

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aquaQuick
Filtering Solutions

Proposal for
Portable Filtering System

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Glossary

Developing Countries/ Rural Areas	Any place where running water is not a norm and people have to walk to a source of water either man made or natural to acquire water
User	Any person pulling the PFS is the user of the PFS. If the person pulling switches, the user has switched as well. If someone was to use any other means, such as an animal, to pull the PFS that would be considered the current user.
UV	Ultraviolet Light used to kill bacteria and filter the water

Introduction

The PFS is a filtering device for users specifically for people who have to walk large distances in order to access water. The PFS allows the user greater ease while transporting the water due to being on wheels and also filters the water while it is being transported. Being powered by its own motion it saves energy and is a perfect fit for developing countries. This document provides the requirements for the PFS.

Over the course of the past 4 months, this system has been in development by a team of four Engineering students: Vaibhav Mal, Shivam Mathur, Jie Gu, and Adam Tanbouz. This document will summarize our learning experiences and outline our project evolution. With respect to the current state of our project, all the functional specifications have been met and exceeded.

Current State of System

2.1. Overall Stage

The overall System is briefly outlined below in Figure 1 and our prototype is shown in Figure 2.

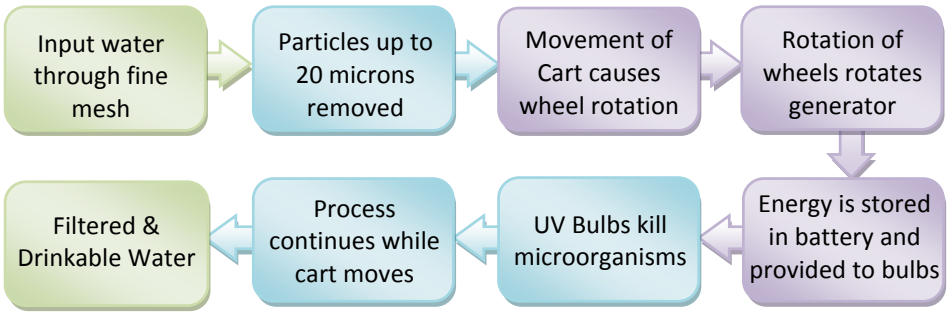

Figure 1: System Overview and sub-components

Green steps are input/outputs, blue are related to filtering and purple to Energy Generation

Figure 2: Prototype of our product

2.2. Deviations of Prototype

Even though the concept remained the same through our proposal to prototype, we did make few necessary changes and added new features to the product.

Primary Filtering

Our proposed method of filtering at the beginning was to use boiling as our primary method of filtering. This is what most people in developing countries do to purify water, so we wanted them so save both time and energy. However we soon realized that boiling 20L of water takes huge amounts of energy which is very hard to produce from wheel movement. Therefore we used the UV lamps instead. UV light is highly effective at destroying micro-organisms. In addition UV takes much less energy to work than boiling.

Sunlight Filtering

This is another additional method of water purification we added that was not part of our proposal. However, we realized that solar disinfection is free and there is enough of it in dry places. Exposure to sunlight has been shown to deactivate diarrhea-causing organisms in polluted drinking water [1]. We have created a simple window in the front of our container in PET material and used aluminum lining for maximum reflectivity.

Mesh Filter

We used a 20 micron sediment filter that reduces the amount of dirt, silt and other particles from water. The filter needed a container because initially the water does not flow through it fast. Therefore there needed to be extra space to contain the water. So the container on top of the mesh is there to contain water until the mesh filter is wet and can pass water faster.

Structural

We definitely underestimated the structural part of the system. Initially we planned on mounting the wheel, gear and generator and expected them to work together. After we built this part of the system we realized that the generator initially needs big torque to rotate. During our trial, our wheel and the carts and cart bent due to amount of force. Therefore we added about 5 additional supports to the wheel/generator to make them stable.

2.3. Testing the prototype

During the tests for our product we walked around with the cart. The force required to push the cart is not much and can be easily maneuvered around. At about average walking speed of 6.9km/hr[2], the voltage output from the generator is about 13V which is enough to charge the battery or run the UV lamps.

In addition to the physical tests we also did water testing of before and after treatment. The results were very successful with 99.987% of the bacteria destroyed. This sample was taken while leaving the cart stationary with UV lamps on. If there was movement in the water the results would have been even better. Figure 3 shows the before and after of our bacteria culture tests.

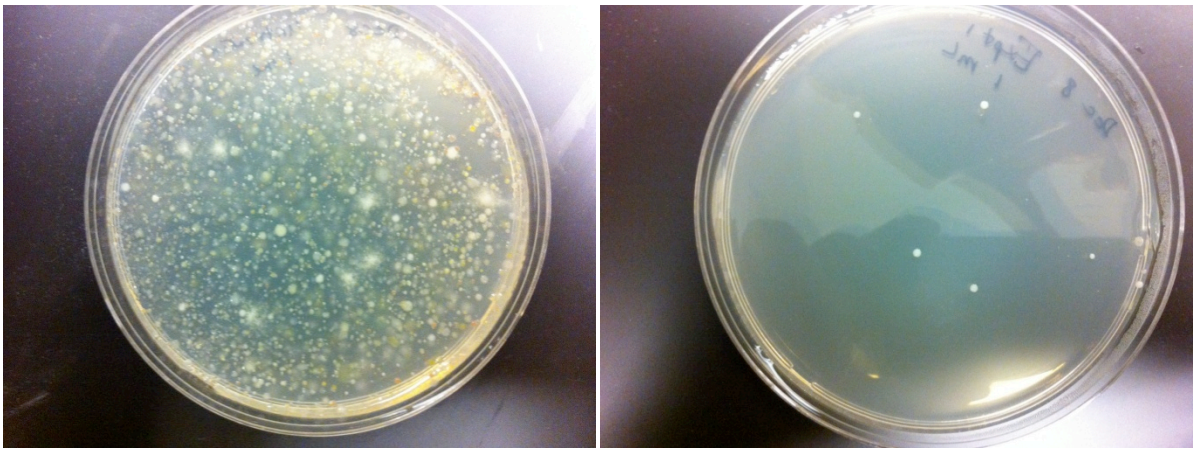

Figure 3: Results of treated and untreated water

Overall, we met our goal of bringing the idea to a real product. Even though this is a good working product we would work on some improvements (discussed in next section) that will make the system more effective.

Future Improvements

Quartz

Quartz is a material that can transmit low wavelength range of light (UV – 200nm and above). Our current solution has lamps directly in contact with water and our lamps circuit case is made of Plexi-glass. In future, we would have a protective quartz sleeve around the lamps and make the case out of quartz for better UV transmittance.

Active Carbon Filter

Our solution filters larger particles of up to 20 microns and the UV light destroys bacteria, viruses and other micro-organisms. However some sources of water may contain harmful chemicals. In future we will install a pump that will continuously pump water through the activated carbon. Sediment-Carbon filters combines sediment reduction of standard pleated filters with the chlorine taste and odor reduction

- Chlorine and sediment reduction
- Reduces fine particles like sediment, sand, silt, soil, and rust
- Reduces Chlorine Taste & Odor

Aluminum Mirror

Aluminum mirror have almost 99% reflectance for UV. It has a wide range of reflecting wavelengths 200nm - 10 μm. We have used aluminum foil inside the container and to reflect sunlight inside the container. Aluminum foil gives about 75% reflectance. Therefore these will be replaced by mirrors.

Bulb replacement and Water quality Indicators

Currently there is no accurate way of telling the user when to replace lamps or to inform them of water quality. The only way now is it estimate these by average walking distance and usage of the system. In future, we would implement an indicator that will show the user that the lamps have reached their life and not effective anymore. In addition, there are many products in the market that can measure chemicals in water. We will incorporate this in our system as well.

Automatic Switch

Once the minimum distance has been travelled to purify water through UV, the switch between lamps and battery/generator will be turned off so all the generated energy can we stored in battery for future use.

Budget and Timelines

4.1. Finances

The total amount of the expenses we had were $520. Table 1 gives the details of our proposed and actual spending. Red items indicate parts from our original idea of boiling water. Some of the big spending came from tools renting which we did not except as we thought SFU's machine shop would sufficient. In addition there were other smaller parts like screws/bolts and sealing that were not expected at first either.

Item	Proposed	Actual
Wheel Mechanism	**105**	**50**
Chain & Gears	0	10
Pulley & Belts	25	0
Wheels	50	10
Support	30	30
UV Components	**100**	**117**
UV Lamp	40	25
Plexi Glass	10	12
UV Circuit	50	80
Boiling Components	**200**	0
Magnets	50	0
Coil	150	0
Power Generation	**225**	**147**
Generator	200	50
Battery	25	67
Diode	0	4
Other Parts	**150**	**209**
Cart	0	32
Container	50	10
Mesh & Case	0	30
Cabinet	70	0
Screws, Nuts & Washer	30	27
Water Proof Seal & Tape	0	20
Paint	0	12
Tap	0	10
Tools Renting	0	72
Aluminum	0	6
Greese & Oil	0	5
Total	**$ 680**	**$ 520**

Table 1: Summarizes our proposed and actual expenses

4.2. Timeline

We met most of our proposed deadlines or were close except for a few. At first we thought that we would make a list of parts and just order from that list. However, as we developed our product further there was need for additional parts, so ordering parts was actually an ongoing process.
We especially under estimated the complexity of the gear and generator system. This sub system required about 3 weeks to complete which is about 10 days longer than our original estimate.
Table 2 summarizes our proposed and actual deadlines.

Item	Proposed	Implemented
Order Parts & Drafts	Oct-10	Ongoing
Generator & Power Circuits	Oct-30	Oct-20
Transmission(Gears, Wheels & Chain)	Nov-15	Nov-26
UV Circuit & Containers Functions	Nov-30	Dec-02
Mesh & Case	Dec-03	Dec-03
Integration	Dec-05	Dec-07
Testing & Debugging	Dec-10	Dec-10

Table 2: Summarizes our proposed and actual deadlines

Even though we missed some of the deadlines, at the end we caught up and were able to assemble, test and debug the product by the expected deadline.

Individual Reflection

Vaibhav Mal

These past four months have been an amazing experience which have not only challenged me but have taught me much more than I ever expected going into this course.

I started this course knowing only that this was "the" course that every engineer had to take and the one we had been hearing about since we first started the course. On the first day of class I met my other three group mates and we decided, out of necessity, that we would undertake this journey together.

From the first time we brainstormed ideas together, and I had to sell my teammates on the idea which we eventually ended up going with, to the last day this course taught us how to work and solve problems as a team and how to either convince or be convinced about a certain idea. We never moved forward till everyone was on board with an idea. This may have caused us to move a little slowly but it also made us minutely dissect every idea making sure that the ideas that did survive were worthy of doing so.

Since the main idea of the project was mine, I was tasked with the theoretical and overall design of this project. As we went along there were many ideas that turned out impractical to implement in the real world and I was tasked to come up with an alternate solution whenever such a situation arose. Also, since I did the design, I was in charge of overseeing the development of all the other components the group was working on and making sure that they all stayed compatible with each other. Even the slightest modification in one resulted in modifications in at least one of the other components since they are all interdependent and linked.

Looking back I realize now that we were very lucky in our group selection because we all, despite having very well defined roles, were always available to help each other out. No one felt belittled or ashamed to ask for help on his part and everyone else was always eager to help out.

To sum up, I think the most important things I have gained from this course is a lot of hands on mechanical experience which is invaluable and three friends which are just as invaluable.

Shivam Mathur

Coming from a Systems background I have had a lot of experience in the mechanical aspects of engineering and was therefore pleasantly surprised when the project that we chose had so many mechanical aspects to it.

My main role in the group was to take care of the UV filters. Once we decided to change our process of filtering and go with the UV bulbs, I was placed in charge of figuring out the ins and outs of the UV filtering process. It was a very fun and challenging experience because it was a whole new field that I knew very little about . We got some help when Vaibhav spoke to MetroVancouver and they gave us a good starting point and some guiding material about the process and after that I was regularly looking up everything about the process of making water drinkable and also coordinating with Linda, the micro biology expert who helped us immensely in our process.

Overall, I think this course was a very great experience. The team we had was a very good mix of individuals who came into this with a very open mind and were always ready to accept that their idea might not be the best. The meetings for the project were almost like a break from my normal routine not only because we had no pressing deadlines and were free to work on whatever problem we found interesting, but also because the atmosphere was always that of just friends hanging out more than a business meeting. I think this shows in the outcome of our work because we all completely behind the project and were dedicated to make it the best we could. I will always recall this as the most fun course at SFU.

Adam Tanbouz

In the beginning of this course I came into this project thinking that the project would usually involve a lot of coding or software manipulation. But I was very happy to realize that the project involved a lot of areas where I had previous experience in. I worked previously for 16 years in power generation and water distillation plant and was able to use a lot of that hands on experience. Many times my group members had ideas for a solution but did not know how to actually implement the idea. I was in charge of all mechanical aspects of the project and had to come up with real world implementations of the whole design of the project. It was made more challenging by the limited budget and the tools available to us in the machine shop.

I really enjoyed my time working on this project because it gave me a time to be very creative which is what I enjoy. We spent many hours in the lab and were always very shocked to realize that it was almost time for the last bus and that we may be stranded on the hill. The group that we formed on the first day of class was very lucky for us because we all had a similar way of thinking. Apart from that all the group members also had respect for my past experience and were always willing to learn from it. This made the project go very smoothly and resulted in a product that we were all very proud of.

Jie Gu

After working with a group in this entire term to design and produce AquaQuick, I enhanced myself from many different aspects. Our group started with all strangers and ended up a strongly bonded friendship. On our first meeting, we thought our project would be only easy mechanical works, but after we really started working on it, we realized that there are much more than that. The process of this course not only need creation and technical support to finish the project, but to deal the interpersonal relationship; to solve problems and to make decisions.

I think the most intense part throughout this term was we thought our project too simple. To produce the AquaQuick we need many different items and tools, however, there were not enough equipments provided in mechanic works workshop, and we spend many time figuring out what to buy, how much it costs us; what is the cheapest price, where to buy and so on. Fortunately, our group is a really democratic and respectful one. We discuss each part in detail patiently and choose the best solution for our group.

During the project, every step is perfectly completed following the schedule, except the transmission part. We started the transmission part 10 days earlier than we are proposed but we finished it 12 days later than proposed. This is because during we are pushing the cart, the gear and the wheels will bend with each other, and they are getting closer and closer. Finally, the chain will come off. To solve the problem, we bought many strong metals and bend them to support the cart.

I really enjoy participating in our group because our group members they are all self-motivated, considerate and determined. Before this course, we don't know each other, but right now we are good friends and we have different strengths and interests. It is a very wonderful experience and I really enjoyed working in the AquaQuick team.

Conclusion

Our model currently performs every function that we hoped it would at the beginning of the course. While the physical build of the product is of a standard below what we would like it to be (due to budget and time restraints) we feel that it is a definitely marketable product. The testing of the water shows that our results are as good and in some cases better than the products that our currently out in the market. If the product was furthered and assembled in a professional assembly line we firmly believe that it would give the competitors some stiff competition while also greatly improving the quality of people's lives in developing countries.

References

[1](2010). *Solar water disinfection*. Retrieved December 12th, 2010, from Wikipedia Web Site: http://en.wikipedia.org/wiki/SODIS

[2](2009). *Average Walking Speed*. Retrieved December 16th, 2010, from Answers Web Site: http://wiki.answers.com/Q/What_is_average_human_walking_speed