Hollow Fiber Membrane Project

Water Group

Darin Horst, Becca Ports, Jon Hepner, Toby Mea

Figure 1: HFM 1.0 located in the basement of Frey

Introduction

The Hollow Fiber Membrane (HFM) Team works to design, build, innovate, and implement cutting-edge water filtration technology in collaboration with Sawyer Products. The goal is to provide underprivileged communities around the world with an inexpensive and self-sustaining water filtration system. The HFM filter is gravity-fed and can be backwashed and reused for at least ten years. The team gathered feedback on the larger and more expensive HFM 1.0 system, and continue to provide support for systems like it that have been installed in Burkina Faso. The HFM 2.1 system was prototyped using several smaller, less expensive filters in parallel and eliminated the need for backwashing tanks.

Clients

Forward Edge International: Organization providing solutions to the urgent needs of those affected by poverty who currently requests and supervises HFM systems in Nicaragua.

SIM: A community development group monitoring and gathering feedback for the HFM 1.0 system in Burkina Faso

Matt Walsh: Missionary with SIM who helps in maintaining the HFM 1.0 system in Burkina Faso.

Chandra Reddy: Owner of SMT located in India who promotes the values and importance of the purity of water. He has contacted us and shown interest in the implementation of the HFM 2.1 system in India.

HFM 2.1

The HFM 2.1 systems contains a pre-filter which will eliminate large particles and bacteria from the system, four small hollow fiber membrane filters in parallel which will remove .1 micron particles and bacteria that get through the pre-filter, and a charcoal filter that will absorb odorous and/or colored substances as well as trap chlorine and other chemicals in the water. Solidworks models of all parts of the system have been created in order to produce a user-friendly manual for the assembly and operation of the system.

Prototyping the new HFM 2.1 system involved a number of tests in order to verify that it was as efficient (specifically in flow rate) as the published HFM 1.0 system and the previously prototyped 2.0 system, which never left the prototyping phase, to be published. In order to determine whether the system had a sufficient flow rate, flow rates were obtained and recorded for five seconds through combinations of one, two, three and then all four filters. The data was averaged to verify that the system was able to reach a minimum of 1.2 gpm, a flow rate of the HFM 1.0 system. This same data was also used to determine if each filter alone experienced the same flow rate. The slope of the graphed data indicated that after two filters, the system experienced a diminishing return with each added filter. In other words, the system achieved a great maximum performance with only two filters; however, the desired flow rate could not be achieved with so few filters. Testing was also used to verify that the system could sufficiently backwash itself without the need of backwashing tanks. A minimum backwashing pressure was determined by clogging the system with 50 mL of kaolin and measuring the pressure through each filter while backwashing. At extremely clogged conditions, a minimum backwashing pressure was 10 psi with a flow rate of .35 gpm. Sawyer, producer of the HFM .1 micron filter, claimed a maximum backwash pressure of 20 psi. According to Sawyer, the housing and fibers would break at this pressure. In order to verify and give our clients/users a definite number in order to better maintain a system the turbidity of the water was tested after running kaolin through a broken filter and then through an undamaged filter at varying pressures. One broken fiber, as presumed, does affect the turbidity of the water because all results were nonzero. After measuring the turbidity through an undamaged filter at varying pressure we concluded that 20 psi is not the absolute maximum pressure for backwashing before damage because a pressure of 30 psi was reached while still obtaining a zero value for turbidity. Just as Sawyer, we did give the recommendation to clients to not exceed a pressure of 20 psi while backwashing to keep the system running at optimum performance.

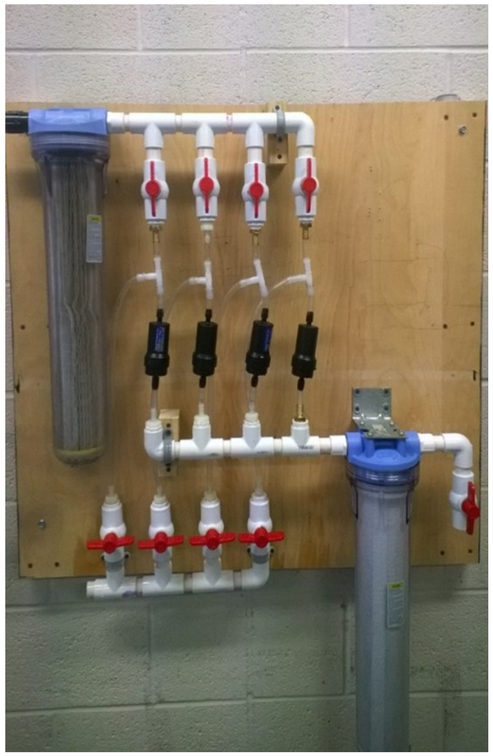

Figure 4: HFM 2.1

HFM 1.0

Our first system used a charcoal filter and a large Sawyer 10 inch filter in series. It also used two large backwash tanks. One tank filled up with the filtered water while the other tank was pressurized with air. The pressurized air would therefore force the clean water backward through the system which enabled us to clean the HFM filter. This system has already been implemented in several countries. We also created a user manual for the system so anyone around the world could buy the parts and put the system together. However, we still felt like we could design a better system that had reduced costs and a smaller footprint. Currently our original system is set up in the basement of Frey for people to use and provide feedback. Please feel free to try out our system. Afterwards, please fill out a paper form located next to the system in the basement or scan the QR code located on this poster to take the online survey.

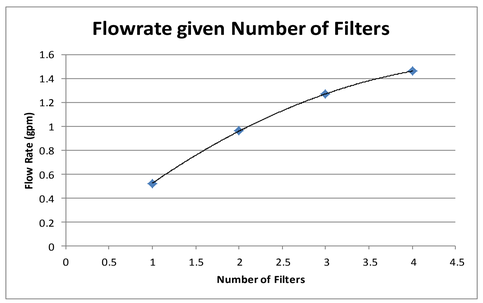

Figure 2: Flow rate data showing an exponential decrease in efficiency as # of filters increase

Future Work

- Complete user manual for HFM 2.1
- Continue to receive feedback from HFM 1.0
- Monitor our systems in Nicaragua and Burkina Faso

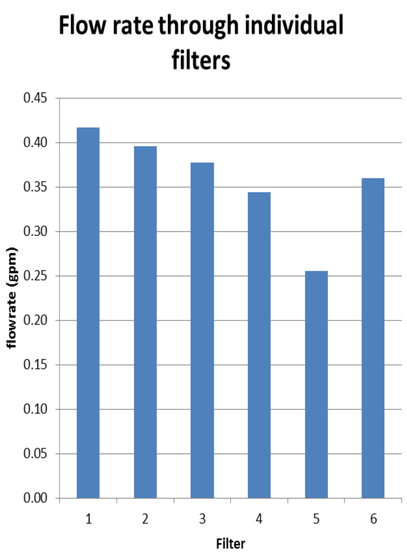

Figure 3: Flow rate data showing how individual filters have varying flows

Acknowledgements

- Messiah College
- Dr. David Vader and Dr. Timothy Whitmoyer
- Sawyer Filter Products
- Brad Fleming, Ray Derk, Linda Blaine
- Everyone who provided feedback

Conclusions

In order to provide people access to clean water, systems that are inexpensive, efficient and smaller are ideal. The progression of our project shows how we have worked on satisfying these three vital qualifications for a viable filtration system. Now that we have a successful system design, our final goal is to implement and distribute this design around the world. We currently have systems functioning in Burkina Faso and Nicaragua. We also are in contact with potential clients to get the system functioning in parts of India.

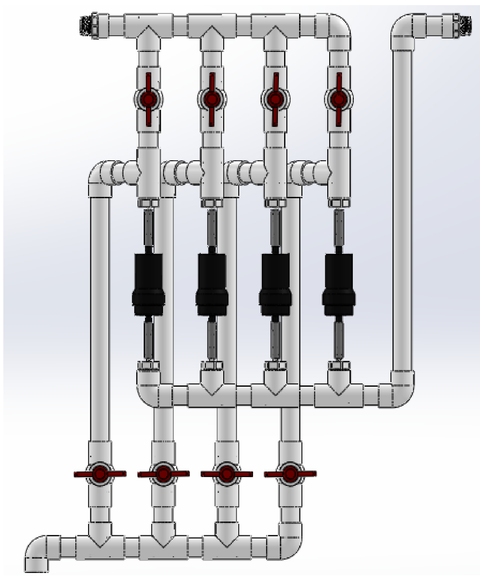

Figure 5: Solidworks model of HFM 2.1

Feedback on Demonstration System:

- "Tastes cleaner, less like chlorine"
- "Easy to use for a water bottle, very good flow rate"
- "Tastes pure"
- "Cleaner & superior tasting to fountain"

Messiah College — Department of Engineering — the Collaboratory for strategic partnerships and applied research

For More Information, please visit the Collab wiki page. Scroll over "application groups" on the left side of the screen followed by "water" and finally "Hollow Fiber Membrane System."

The Hollow Fiber Membrane presentation will be given at 2:00 pm in Frey 110