Filtration

AguaClara Filtration Team

Abstract

The challenge for the AguaClara Filtration Team is to design a filtration system for the AguaClara water treatment plant. The filtration system must meet the following requirements: reliably treat the current AguaClara effluent water with a turbidity ranging from 5 to 10 NTU to an effluent turbidity less than 1 NTU, not require any electricity, make minimal use of specialized components that would be difficult to acquire in remote communities, and the system should be easy to construct and to maintain.

Currently, the filtration team has conducted research in four fields: stacked filtration, clear well backwash, foam filtration, and siphon-aided backwash. For each subject, we conducted a literature review of existing technology and research. We then developed initial designs based on our research and proceeded to test the fundamental theories behind our design. For example, the foam filtration sub team tested the effectiveness of foam in reducing the turbidity of the water while the clear well backwash team developed a bench scale model to test the empirical equations behind the design. We have currently ruled out further research in clear well and siphon-aided backwash design for economic reasons. Table 1 Filtration Design Tracker summarizes our current progress in filtration research.

	No Electricity	Effluent 1 NTU	Open System	No Special Parts	Cost Less Sed Tank & Floc Tank	Minimize Use of Water	Easy To Operate
Clear Well Back Wash	✓	✓	✓	✓	✗	✗	✓
Siphon-Aided Back Wash	✓	✓	✗	✓	✗	✗	✓
Foam Filtration	✓	✓	✓			✓	✓
Stacked Filtration	✓		✓	✓		✓	✓

Table 1 Filtration Design Tracker

These are the guidelines that the filtration team will follow:

• The operator needs to be able to observe the backwash process, so the filter media must be visible. This is likely to be impossible with pressure filters.
• The improvement in water quality from filtration is perceived by the community to be small compared to the improvement from the flocculation and sedimentation processes, so the filters need to be less expensive than the flocculation and sedimentation equipment.
• A large tank to hold water for backwashing is not economically feasible.
• The distribution tank is not a viable source of water for backwashing because it is impossible to guarantee that there will be enough water in the distribution tank.
• Many of the communities that will be using our water treatment plants do not have enough water to meet their needs, so the quantity of water that is wasted to clean the filters must be minimized. Stacked filtration and foam filtration may be good options for achieving this.
• If we cannot use stored water for backwash, then the maximum flow of water required for backwash must be at most 50% of the design plant flow rate. This will make it possible to run the water treatment plant at a lower than design flow rate and still be able to operate the filters. This requirement means that if we use 7 filters to backwash 1 filter, then we would need to have another set of 8 filters that could potentially be turned off so that plant could function at 50% of design flow capacity. The requirement of being able to backwash at 50% of design flow rate makes the option of using multiple filters to backwash a filter impractical.
• All of the basic principles of AguaClara apply to the filtration research. These include not using electricity, using inexpensive and easily obtainable materials, and training the community members how to build, operate, and maintain the plants.

Conventional Filtration

There are many requirements with conventional filtration methods that make them incompatible with AguaClara. This section illustrates some of those incompatibilities.

Method & Result and Discussions for each sub team

Foam Filtration

Currently, an AguaClara plant can produce effluent water after sedimentation with a turbidity of about 5 NTU. Our goal is to reduce the effluent turbidity to less than 1 NTU. One potential method of accomplishing this is adding a filtration unit to the AguaClara plants.
Numerous techniques of water filtration are in use today, most of which involve the use of sand as the porous media. After preliminary research revealed a lack of information on foam filtration, our team has decided to focus on investigating the actual filtering capacity of a polyurethane foam material as opposed to the traditional method of sand filtration. With proper implementation, a foam filter could reduce the amount of water that is wasted during the backwash cycle of a traditional sand filter. A foam filter could also potentially require less area, and be less expensive to build than a traditional sand filter.

Stacked Filtration System

So far, we have created a preliminary design for a stacked filtration system for the Agalteca Plant. It is a granular, mixed (or vertical) flow filtration system consisting of four separate rapid sand filtration units. The basic concept of our design is to make the backwash flow rate equal the filtration flow rate in order to use the effluent water from the sedimentation tank to backwash. We have chosen this concept because of the following benefits:
1) Relatively small size of the entire filtration system compared to other granular filtration systems researched.
2) Availability of the materials that would be involved in its construction.
3) Relative ease of operation.
4) If given full plant flow, the ability to conduct backwash while maintaining normal filtration operations in at least half capacity.

Basic Design:
Each separate unit consists of 5 planes of sand filtration stacked vertically on top of each other. Each plane consists of a set of inlet tubes, 20 cm layer of sand for filtration, and a set of outlet tubes. Currently, for each layer of tubes except for the bottom layer, we have selected eighteen ½ inch PVC tubes separated by a distance ½ inches. This is most likely more PVC tubes than necessary for reasons that will be explored more in detail in the Theory section. We have selected the bottom layer of tubes to be 3/4 inch in diameter. All of the manifold that connects to these filtration tubes will be 3 inch in diameter. All pipes and tubes used are schedule 40. This filter is designed for sands with typical characteristics of D60 of 0.55 mm, porosity of 0.4, and specific gravity of 2.65. It will filter at rate of 1.4 mm/s and backwash at 14 mm/s with expected 30% bed expansion.
Future Challenges:
The design is based on a several assumptions that need to be validated with experiments.
Specifically, we need to test the water quality effects of using effluent sedimentation water to backwash the filter, efficiency of 20 cm layer of sand to filter settled water, clogging time of 20 cm of layer when exposed to typical sedimentation effluent water, the effect of the number of tubes per plane on filtration efficiency, bench scale model to test backwash effectiveness with regards to bed expansion and effectiveness of our backwash procedure. All of these will be covered more in detail in the Future Challenge Section.

Advice and Future Challenge to the Future Filtration Team

Past Research - Terminated Methods

- Spring 2010 Terminated Filtration Methods

Spring 2010 Filtration Team Teach In

Spring 2010 Filtration Team Final Presentation