Demonstration Plant Team Final Report

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Abstract

The Demonstration Plant (Demo Plant) is an important educational tool to explain and publicize AguaClara technologies. In the Spring of 2012, a new Demo Plant was constructed, tested, and documented which included the two lastest AguaClara technologies, a chemical doser and a stacked rapid sand filter (SRSF), as well as the older flocculator and sedimentation tank. In the summer of 2012 the demo plant structure and system was completely revised; the SRSF was fixed so that it can completely backwash all four layers, the chemical doser was labeled to include coagulant concentrations, and the overall plant was streamlined for transport and assembly. This semester we finalized construction materials and methods and built four more demo plants to be used at Cornell and abroad.

Project Objectives

The goal of the Demo Plant team is to create a demo-scale version of the technologies used in full-scale AguaClara plants in several rural communities in Honduras. The Demo Plant is an important tool used to promote AguaClara in the Cornell community, at national conferences such as the EPA P3, and for community workshops in Honduras. It is also used to train plant operators. This semester we built several more plants that can be sent to other countries where AguaClara is hoping to grow. We also improved the current design so Monroe could take the Demo Plant to Nepal over Fall Break in just a carry-on suitcase.

Background

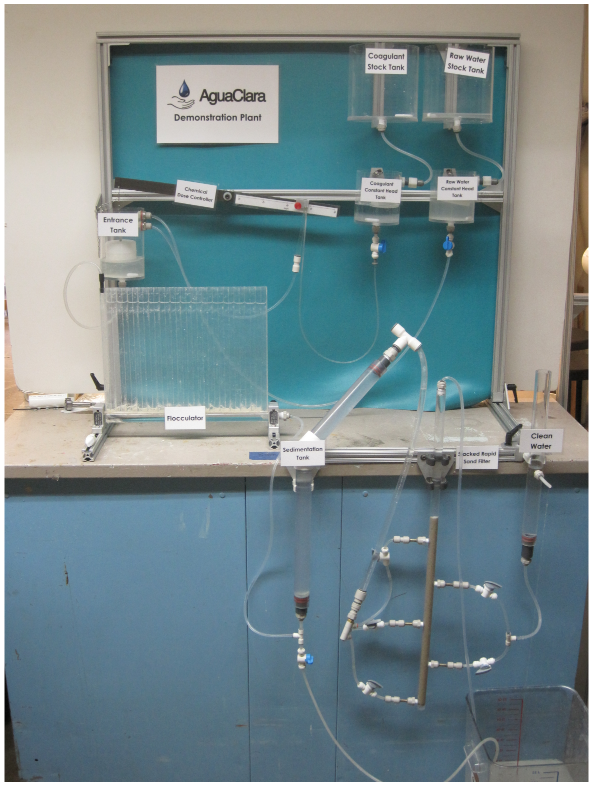

Figure 1: Demo Plant from Summer 2012

The Demo Plant from the summer of 2012 is shown in figure 1. The plant frame is made of extruded aluminum (80/20). This modular material is extremely strong, relatively light, and allows for easy adjustments. There are hinges added that allow for the entire frame to be folded into four large pieces. The plant contains a chemical dose controller, a flocculator, a sedimentation tank, and a stacked rapid sand filter all of which have been updated to reflect current AguaClara technologies. The entire plant fits into a small rolling suitcase and lacrosse bag.

Construction Materials

After consulting with Monroe and Paul Charles, we decided on making the plant frame out of PVC pipe instead of extruded aluminum (80/20). This is because the aluminum is much stronger than necessary, heavier, and more costly. We purchased materials and constructed a basic frame. It was very easy to construct because the PVC can be cut with a handheld pipe cutter instead of the bandsaw in the machine shop. It also is still structurally stable and is able to support the weight of all of the tanks. The finished plant can be seen in figure 2.

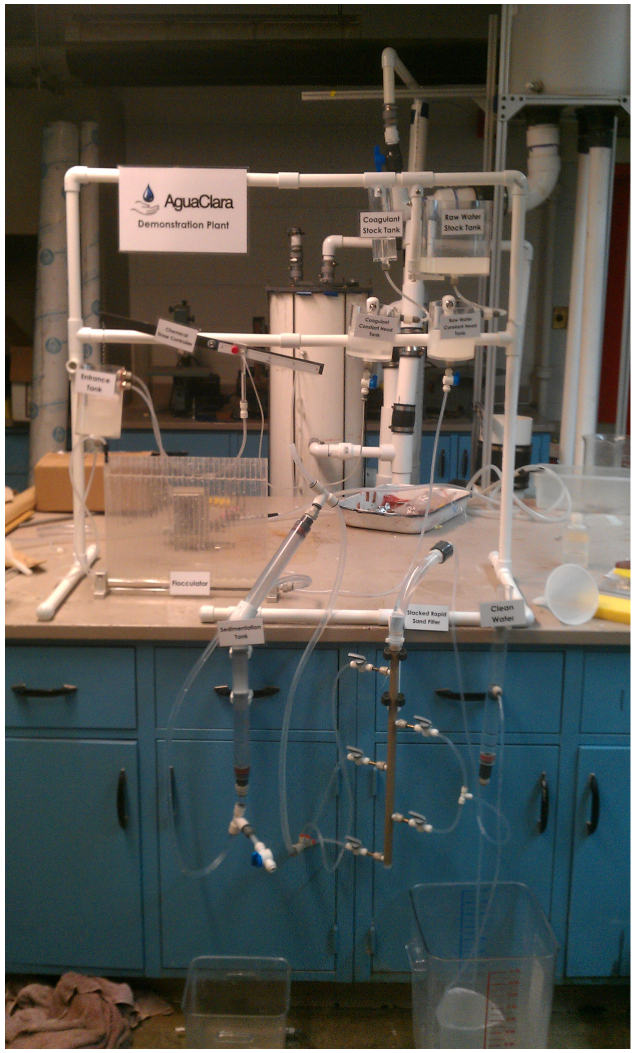

Figure 2: New PVC Frame

Trip to Nepal

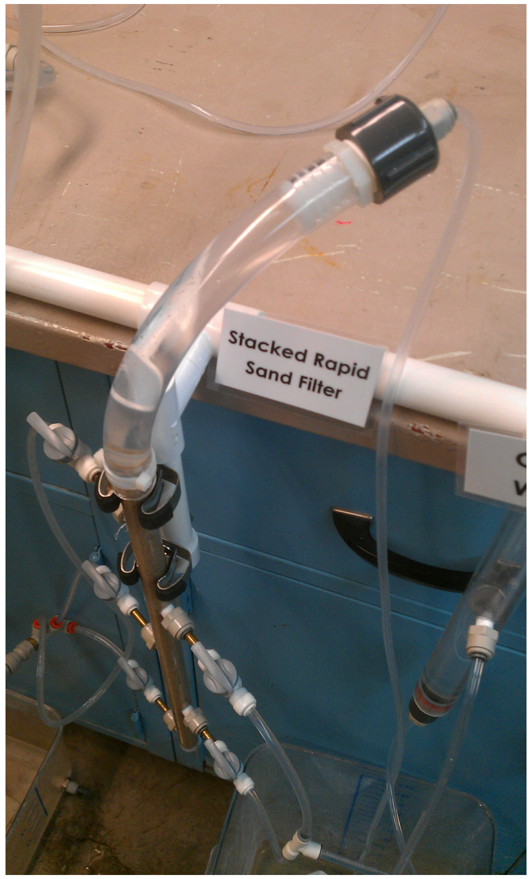

Figure 3: New Stacked Rapid Sand Filter

In order for Monroe to take the Demo Plant to Nepal over Fall Break, we needed to fit the entire plant in the given Eddie Bauer suitcase. For this to work all parts of the plant needed to be 20" or less. The longest pieces of the frame were 38-1/2" so they were cut in half; this was easy to do with the new PVC frame. The SRSF was 30" so we shortened it by switching to the old sand filter column used in the Spring of 2012. We attached a 1/2" ID flexible rubber tube to the top of the column using a zip tie. This extends for about 8" and then there is a connection to 1/4" tubing which leads to the backwash valve. After experimenting with the filter we found the flexible tubing also acts as a diaphragm that can be pumped to remove air bubbles from the sand or jump start sand fluidization. The new filter in shown in figure 3.

Another way to ensure that everything fit in the suitcase was to shrink the coagulant stock tank because it was much bigger than necessary. We used a column 6” long and 2” in diameter and constructed a new tank similar to the other tanks with a clear acrylic cylinder glued to the bottom. This tank can be seen in figure 4.

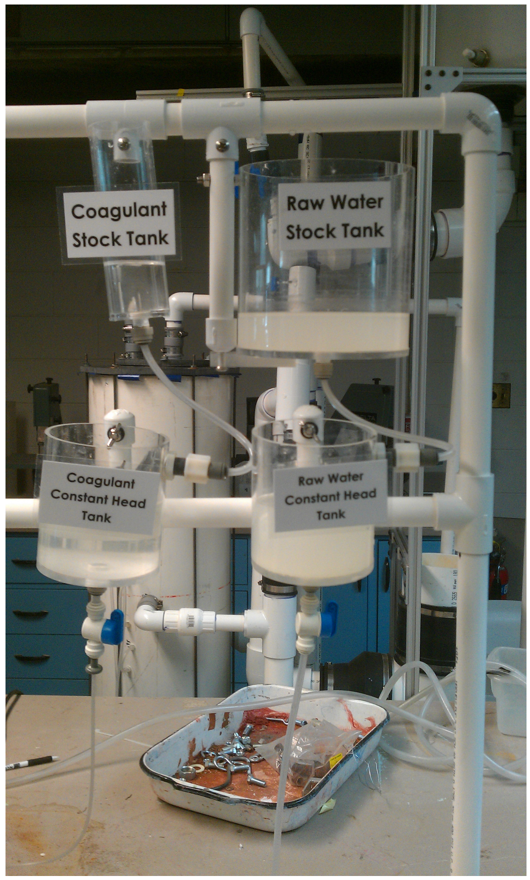

Figure 4: New Coagulant Stock Tank

In the aftermath of the Nepal trip various parts of the plant were broken due to the rough handling of checked items. The main broken parts were the flocculator, PACl container, and SRSF. For the PACl container, we replaced it with a sturdier container with a screw on lid (rather than a snap on). Solutions for the other items are discussed below in each corresponding section. Other than reinforcing the parts of the plant, we also looked into specific packing methods in order to ensure that the plant reaches its destination in one piece.

Finalizing Flow Rates and Doses

While preparing for Monroe's Nepal trip, we finalized the flow rates and coagulant doses. The plant flow rate is now 75 mL/min, the coagulant stock concentration is now .8 g/L (6 scoops), and the coagulant flow rate at the maximum dose is now 2.34 mL/min instead of 9.9 mL/min. The flow rate was changed by lengthening the tube from the coagulant constant head tank to the drop tube by four times the previous length.

Flocculator

Monroe recently acquired more polycarbonate siding, from which the current flocculator is constructed. With this in hand we have started to build more flocculators, including replacing the current one that was broken on the trip. Our new design involves replacing the 1" diameter rod base with a 1" square rod because the clamps for the current flocculator are expensive and not necessary in this new configuration. This is important because one of the possible reasons for the current flocculator breaking is because the feet previously stuck out, allowing for stresses to be applied to them.

Although we previously were leaning towards finding a new construction method that will allow us to make the bottom of the flocculator curve around the baffles, we decided that it is much easier and cheaper to just mount in it a channel cut into the base, as before. Although it does not solve the problem, the problem is usually not evident if the proper dosage is used and the plant runs for less than half an hour (which is usually the case). Furthermore, the distance between the bottom of each baffle and the bottom of the flocculator is currently larger than the space between the individual baffles. This might be part of the problem, so we will cut the new baffles so that the mentioned distances are the same.

Stacked Rapid Sand Filter

With the old SRSF breaking in the trip to Nepal, we switched the material we used for the column. Previously it was acrylic, which was brittle and fractured easily, so we switched to clear PVC, which although is not as transparent, is more sturdy. In order to make sure that the new one would still work, we kept the same inner diameter though increased the wall thickness (schedule 80) just to make sure that the new filter holds up. We have constructed the new one and tested it and it works just as well and is still clear enough to see the individual sand particles. This has been decided as the final design and will be replicated as such.

Cost Analysis

	Cost per Plant
Old Version (80/20)	$512.62
New Version (PVC)	$276.43

Table 1: Cost Comparison

In table 1 above a comparison between the costs of the old (80/20) and new (PVC) versions of the plant can be seen. The new version is considerably less expensive than the previous version. This is mostly due to the difference in price between 80/20 and PVC.

Machined Parts

Several key components of the Demo Plant need to be machined. For the past month or so, the machine shop has been backed up, so it is taking a lot longer to complete parts than we expected. We are trying to find ways to make the parts ourselves, and are now focusing on just finishing two more plants instead of four more.

Future Work

As of right now there is a definite possibility that not all the parts will be ready by the end of the semester. We were trying to make four more plants, so we would have a total of five. However, as mentioned above, it is taking a lot longer than we expected to get the machined parts finished. Because we know three plants will be needed over break, we are going to focus on finishing at least two more. Future work will include finishing the other two plants.