New Ideas for AguaClara teams

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1 Flow meter for measuring the flow of water supply systems.

We need something that can easily measure a wide range of flow rates and that is easier to use than the bucket and stopwatch method.

We could use an LFOM type system. Height could be larger than 20 cm so that the diameter could be reduced. The water could be injected into the top of the LFOM and flow OUT of the pipe (reversed from how the LFOM works in an AguaClara plant). Begin by exploring what options are available for flow measurement. Would it work to create a vertical jet and measure the height of the jet?

Are there any options that could be installed in the water distribution tanks so that it wouldn't be necessary to cut the pipe and waste water during the flow rate measurement?

2 Inlet Manifold Fabrication

We need to speed up this fabrication process. Drew Hart described a long process for building the inlet manifold systems. One of the problems is that using hole saws creates holes that are not accurately sized. There are two fabrication methods. The first is to reduce the diameter of the drop tubes by heating them and forcing them into a smaller diameter mold. The second method uses two saw cuts into the end of the pipe that make it possible to compress the end of the pipe and slip it into a smaller diameter hole. The fabricators in Honduras currently prefer the compression slot method because it can create a tight fit even with a hole created with a hole saw.

3 LFOM

The LFOMs fabricated in Honduras for the last few plants have not been very accurate. This inaccuracy is due to two effects. First, the hole saw that creates holes that are larger in diameter than the hole saw. Second, the holes were deburred and this rounding effectively increases the hydraulic size of the hole.

Figure 1: Flow measurement at Las Vegas, Santa Barbara, Honduras.

We need a method of fabricating LFOMs that creates precise diameter holes with very sharp entrances.

Test orifice meters built using different types of drill bits and determine which drill bit produces the most accurate and sharp edged hole. Test the orifice meter using the hydraulic test apparatus. Devise a means to measure the flow rate by using the bucket and stopwatch method. The bucket and stopwatch method can be improved by using a pressure sensor in the side of the "bucket" to measure the depth of water over time.

4 Dose Controller for a hand water pump

Low flow chlorine dosing system needed in Ethiopia range of viable flow rates needs to be determined. Designs need to be refined and analyzed for failure modes "digital flow control valve" need to be developed or chlorinator needs to operate accurately at very low flow rates (situation where someone draws off a couple of liters slowly, LFOM will not work-> no chlorine dosing). Prototype needs to be built and tested extensively marketing to aid organizations? Other applications in water treatment? Dose Controller for a hand water pump?

Develop a way to dose chlorine to intermittent, low flows. This chlorinator would attach to a hand pump system which draws from a well. The chlorine will need to be in contact with the treated water for a certain amount of time before the water is safe to drink. This time will be determined by the amount of residual chlorine that is tolerable to the local population, the degree of contamination of the water, and the amount of mixing (if any). To achieve this time, it might be possible to teach the local population to wait before consuming the water, or it might be necessary to add a storage tank that the pump empties and which water is drawn off of. The dosing system should be fully automated, meaning that once the dose is set, the system will regulate the chlorine without any input from an operator. It should also be designed to require minimal maintenance and be refilled no more than once a day.

5 High Flow CDC Challenges

5.1 Introduction

AguaClara plants use a linear chemical dose controller (LCDC) system to add coagulant and chlorine to the plants. The current technology uses a linear flow orifice meter (LFOM) to maintain a linear relationship between the height of water in the entrance tank and the flow rate of the plant. The height in the entrance tank is translated via the LCDC to set the driving head for the chemicals. The flow rate of chemicals is set through major losses in small diameter tubes. The current design for the system begins to break down at higher flow rates. The first thing to break down is the LFOM. The current design calls for the LFOM to be made out of PVC pipe. At flow rates around 39 l/s the design begins to require pipe sizes that are no longer available or are too large. To handle this, it is possible to transition to using and Sutro weir which would enable significantly higher flow rates than with a pipe. The next system to break down will be the slider on the LCDC system. At some point the current design will begin to incur unacceptable minor losses and need to be made of larger diameter materials. This will add weight to lever arm and begin to affect the linearity of the system. At some point, flow rates will become high enough that it no longer makes sense to try and use a linear dosing system to control the chemical feeds to plants. It is uncertain exactly where this point will occur but it will require a new suite of non-linear technology to maintain an acceptable chemical flow rate that self adjusts to the plant flow rate.

5.2 Challenges

- The current manifold system is made of 1/2" PVC pipe with 1/8 NPT threaded fittings attached. This works well up to about five or six small diameter tubes, after that, the manifold becomes prohibitively long and may be difficult to locate in the plant. A new manifold system needs to be developed that can accommodate up to 12 small diameter tubes. This should allow the system to run up to 100 l/s with a coagulant stock concentration of 200 g/l and small diameter tubes around 4 m long.

- The delivery tube from the small diameter tubes to the drop tube currently enters perpendicular to the drop tube. It is possible to zero this configuration because the diameter of the delivery tube is small relative to the maximum height used to send flow through the dosing tubes. With larger diameter delivery tubes, this will not be the case and it will be difficult to set an accurate zero. It may be possible to have the delivery tube pierce the drop tube and have flow exit out of the top of the delivery tube in some fashion. This would allow a more accurate zero of the device.

- Create an algorithm to size the diameter of the flexible tubing that connects between the manifold of dosing tubes to the drop tube.

5.3 High Flow CDC

- For very high flow rate plants it no longer makes sense to try and control chemical flow rates using major losses through small diameter tubes. Another control strategy might be to use minor losses through a valve. In this case the flow rate would be a function of the square on the height in the entrance tank. This will require a square relationship between height in the tank and the flow rate through the plant. This can be done with an orifice. There are flow control valves in existence that have a linear relationship between their K value and the angle which the valve is turned. These are called Metering Ball Valves and can be purchased for a variety of flow rates. The challenge would be to design a system using these valves and a lever arm that is accurate and effective for high plant flow rates and evaluate for what flow rates this design makes sense.

- If it makes sense to move to a non-linear control mechanism for chemical dosing, the LFOM will be eliminated from the design and replaced with an orifice. An orifice cut directly into the wall of the entrance tank will not work because at low plant flow rates the orifice will not be submerged and will transition to weir flow. If the orifice transitions to weir flow, the relationship between height in the tank and flow rate will break down. It may be possible for the orifice to be oriented horizontally in the tank and either spill into or flow up into a channel.

- The challenge is to explore this geometry and design an entrance tank and rapid mix channel that will work for high flow rates along with the non-linear chemical dose controller. Current ideas include some sort of weir arrangement though the wall of the entrance tank or an orifice through the floor of the entrance tank. It turns out that rapid mixing is extremely important to effective flocculation. A new method of mixing needs to be developed to accommodate higher flow rate plants. The solution to the mixing problem will depend on the way that water exits the entrance tank. Current ideas include orifice plates, inducing a hydraulic jump, causing free fall from the exit point from the entrance tank, and vertical slots across the channel.

- Explore the idea of using a floating constant head tank instead of a lever arm to change chemical flow rates in high flow plants. [fig:floating CHT] shows a possible design for such a system. The float is constrained by a large diameter pipe and is hydraulically connected to the entrance tank. The push rod moves the constant head tank up and down as the height in the entrance tank varies with flow rate. Because there is no lever arm, there is no multiplying factor, which means that this system must instead be governed by minor losses through a valve. It is not obvious how the system would be calibrated, so if building this system seems feasible, some method for calibration will have to be developed. This could involve modifying the controls on the chemical control side of the system or possibly modifying entrance tank geometry such that you calibrate by varying plant flow rate at various heights.

- Develop a design for a very high flow plant for the doser, flow measurement, and chemical mixing. Once a good design is achieved, then work backwards toward lower flow rates to see when this high flow rate design begins to run into trouble. Figure out where the transition should occur between the current design and the high flow rate designs.

- Build the linear orifice metering device and test flow rates at various settings. Evaluate its potential for use in plants and determine what its shortcomings are.