

Sedimentation Tank Hydraulics*

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Abstract

The goal of this research is to evaluate sedimentation tank bottom geometry, jet location, and the design requirements for a flocculation hopper in an AguaClara sedimentation tank. Inlet jet geometry along the bottom of the sedimentation tank is critical in the resuspension of flocs. The inlet end of the sedimentation tank needs to be redesigned to re-suspend flocs. A flocculation weir will be needed to set the upper limit of the flocculation blanket level and a flocculation hopper will be needed to consolidate the wasted flocs.

students 3 MT

skills fabrication, experimentation, fluids, process controller

1 Sedimentation tank geometry

AguaClara sedimentation tanks have evolved rapidly from

1. flat bottom with 3 large pipe inlets (Ojojonca)
2. sloped bottom with 3 large pipe inlets (Marcala 1 and Tamara)
3. sloped bottom with inlet ducts under the sloped bottom (Cuatro Comunidades)
4. sloped bottom with simple inlet manifold (Agalteca)
5. sloped bottom with inlet manifold with diffuser drop tubes (Marcala 2)

The evolution of the sedimentation tank design continues as we learn more about what is required to produce flocculation blankets and as we improve how we handle the sludge. The focus of our current research is to carefully design the interaction between the flocs that settle on the bottom slopes as they return to the central valley of the sedimentation tank and the jets produced by the diffuser drop tubes. The design of the interaction between the settled flocs and the inlet jets

*This team has potential for the EPA P3 competition and should consider a submission in the fall of 2011

is critical because it is the jets that re-suspend the settled flocs and thus create the floc blanket. As we improve tank geometry to reliably create floc blankets it will necessary to also control the depth of the floc blanket (with a floc blanket weir) and use a floc hopper to provide time for the wasted flocs to consolidate or dewater to reduce the amount of water that must be wasted with the resulting sludge.

The manifold currently doesn't have diffuser drop tubes below and behind the elbow in the inlet manifold. It may be critical for rapid floc blanket formation to develop a method of fabricating an inlet manifold with diffuser pipes that extend all the way to the end of the tank or it may be possible to add a slope to return flocs to the first drop tube. We need a method to assess which approach should be used and we should implement these changes in the design tool as soon as possible.

We have preliminary evidence that floc blanket formation and performance is negatively influenced by any consolidation of the flocs before resuspension by the jet. It would be useful to confirm this observation with overall performance data for a sedimentation tank including residual turbidity after plate (or tube) settlers. This will require setting up the tube settlers on the 2D sedimentation tank apparatus (Figure 1 and 2). The tube settler effluent turbidity should be compared for different bottom and jet geometries to see if tank geometry has a significant influence on overall performance. We are particularly interested in comparing bottom geometries that cause floc consolidation prior to resuspension and bottom geometries that resuspended flocs without floc consolidation. If floc consolidation is shown to negatively influence performance then the AguaClara sedimentation tank bottom geometry should be redesigned. The experimental conditions could be 100 NTU raw water and 1 mm/s up flow velocity in the sedimentation tank. The coagulant should be PACl and the appropriate dose can be supplied by the Tube Floc team.

2 Floc hopper geometry

The parameters of interest are the ratio of the plan view area of the floc hopper to the plan view area of the rest of the sedimentation tank, the volume of the floc hopper, and possibly the angle of the bottom of the hopper. We are also interested in knowing how the geometry of the floc hopper influences the required sludge flow rate. The depth of flow and flow rate over the floc hopper weir is also of interest. The depth of flow over the floc hopper weir is not expected to be significant design constraint.

The critical design constraint is expected to be during high turbidity events when the floc volume fraction is high and hence the flow of flocs into the floc hopper will be the greatest. The fractal flocculation model predicts that at 500 NTU the floc volume fraction is 0.08. Thus the flow over the weir would be $0.08Q_{SedBay}$. The floc volume fraction is proportional to the turbidity for high turbidities and thus at 1000 NTU the floc volume fraction is 0.16. Without consolidation of the flocs it would be necessary to waste 16% of the flow during

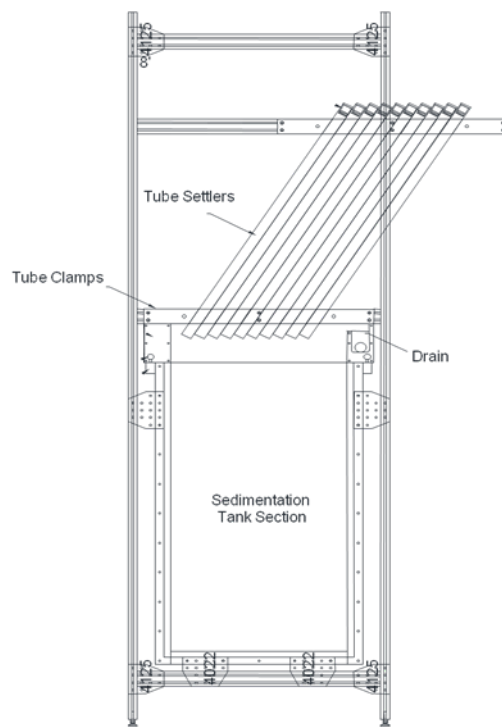


Figure 1: 2D sedimentation tank apparatus

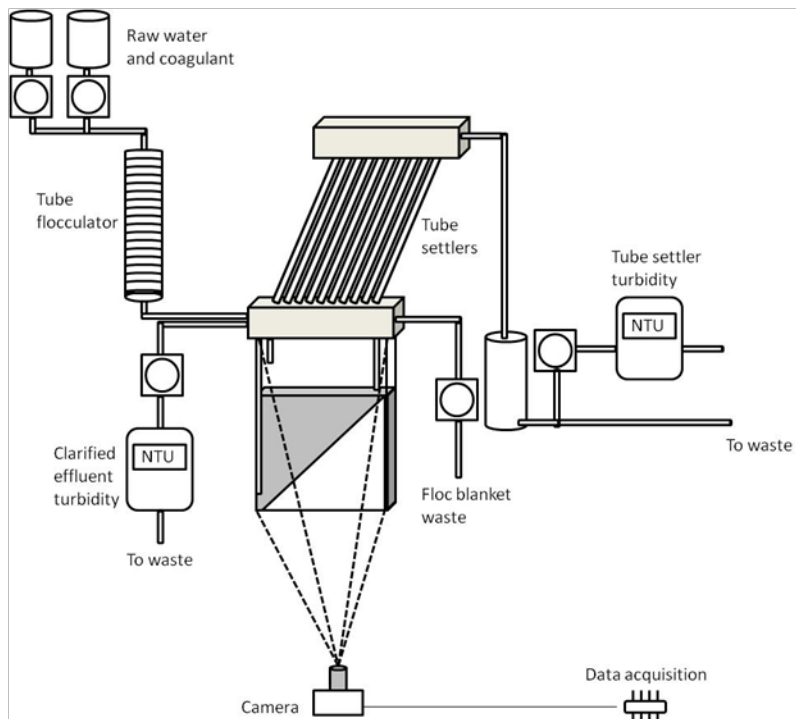


Figure 2: Schematic of apparatus including turbidimeters, camera, source water, flocculator, and sedimentation tank.

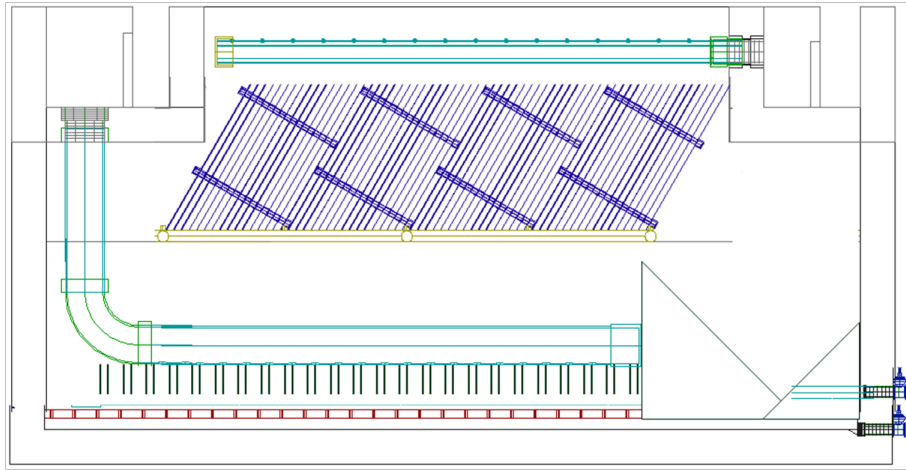


Figure 3: Preliminary sketch of a flocculation hopper with a double bottom slope.

a 1000 NTU event. AguaClara plants have already treated water in excess of 700 NTU and so it would be reasonable to design the flocculation hopper to handle a 1000 NTU event.

A flocculation hopper can be installed in the 2d sedimentation apparatus (Figure 2). You could start with a flocculation hopper that occupies 15% of the plan view area of the sedimentation tank. The bottom slope could be very steep so that the flocculation hopper extends all the way to the bottom of the sedimentation tank. A peristaltic pump can be used to remove sludge from the very bottom of the flocculation hopper. The flow rate of the pump can be slowly varied and the depth of the flocs in the flocculation hopper can be measured. This will give a relationship between the required plan view area of the flocculation hopper and the corresponding required sludge wasting rate. The steady state depth of sludge in the flocculation hopper will increase as the sludge wasting rate decreases. There may be problems with this experimental method because the sludge may consolidate so well that the pump won't be able to remove it.

The plan view area and time required for flocculation consolidation is not easily estimated. The fractal flocculation model predicts that at 1000 NTU the flocculation volume fraction is 0.16. Thus the flow over the weir would be $0.16Q_{SedBay}$. Does this mean that the area of the flocculation hopper should be about 16% of the sedimentation tank area? We need some modeling work here to understand what controls this consolidation process. A literature review would be useful and experimental work may be needed.

The goal is to develop an understanding of how flocculation consolidation works and to determine the top width of the flocculation hopper.

1. Z.SedFlocculationWeir - The height of the top of the flocculation hopper weir that will then set the depth of the flocculation blanket. It is probably best if the flocculation blanket doesn't reach the bottom of the plate settlers and thus we may

want to set the top of the flocc hopper weir to be approximately 10 cm below the bottom of the plate settlers.

2. AN.SedFloccopper - The angle of the flocc hopper could be 60° or perhaps as low as 45° . The goal is to be able to have the sludge slide down the incline easily. It may be best to make this 60° to reduce the risk that sludge will accumulate and not slide into the drain.
3. ND.SedFloccopperValve - Ten state standards suggests that the minimum diameter for any sludge valve should be 3 inches. That seems rather large given what this valve has to handle. I believe we have used 2 inch valves on sedimentation tanks and they performed well. The flow rate for this valve will be very low. We should estimate the sludge flow rate. My intuition is that the valve should be at least 1 inch in diameter so that it won't clog too easily. In normal operation the plant operator may leave the valve open slightly with a low continuous flow rate discharging the sludge as it accumulates and consolidates in the flocc hopper.
4. L.SedFloccopper - distance between the drain end wall of the sedimentation tank and the flocc hopper weir. This would be estimated based on the flocc hopper plan view area required to consolidate the flocs.