Technology Overview

The AguaClara Technology

A Brief Overview of the Technology

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The AguaClara technology is an innovative form of flocculation-sedimentation that has been adapted at Cornell University to operate without electrical input. Unlike conventional flocculators, which rely on large motor-driven stirring devices, ours create mixing solely with gravitational forcing through turning channels. The chemical dosing for the plants is all accomplished by using simple float valve-regulated constant head devices, and the plant flow rates are measured and controlled using riser pipes with calculated patterns of holes drilled through.

Sites for AguaClara plants are selected based on the presence of a distribution system and the apparent commitment of the town to the project. Candidate sites must have a distribution system in place that will be able to deliver the treated water to homes. AguaClara is responsible for the research, design, capacity building, and training going into each plant, but construction is supervised by a partner organization and plant operations and maintenance are the responsibility of the municipality or local water board.

A Detailed Plant Tour

The entrance tank to the rapid mix

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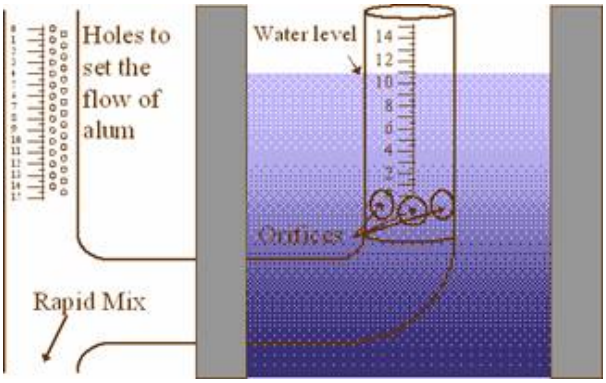

Source water flows via the pre-existing transmission line to the entrance tank for an AguaClara plant. This entrance tank contains riser pipes with orifices of calculated size and spacing to obtain a linear relationship between the depth of water in the entrance tank and flow rate of water through the plant. This design mimics the shape and function of a Sutro Weir. The water leaving the entrance tank is mixed with alum, a coagulant, en route to the flocculator.

When alum is added to water it decreases the net charge on suspended dirt particles in the flow. When particles collide in an un-coagulated stream (one not treated with alum), they tend to repel one another. Conversely, particles in a coagulated stream are more likely to actually stick together and form larger conglomerates. These larger clumps of particles are referred to as flocs.

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Alum and chlorine are dosed using a flow controller (FC) developed by AguaClara. The FC is a small jar fitted with a plastic float valve on the inlet, and a calculated length of tubing on the outlet. The float valve ensures a nearly constant head, while the elevation of the discharge of the exit tubing determines the total head loss, and hence flow rate.

Plant operators adjust the alum dosing by adjusting the height at which the exit tubing discharges into the raw water stream. The operators have a chart that relates influent turbidity to required alum dose, and required alum dose to the required tubing exit height. Chlorine is dosed similarly, except that the chlorine FC exit tube discharges into the plant exit stream. The dose delivered by the FC is therefore a function of the (constant) head in the bottle, the (constant) length and diameter of the outflow tubing, and the elevation at which the tubing discharges.

The rapid mix through the flocculator

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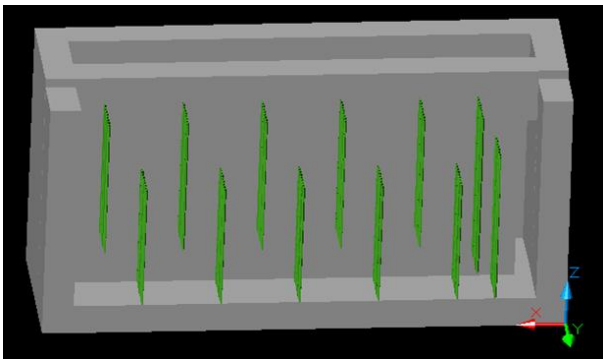

Alum and raw water flow through a short series of pipe elbows acting as a rapid mix. This disperses the alum throughout the raw water stream, ideally coating a significant number of the suspended particles. This mixed solution then enters the vertical flow hydraulic flocculator. The vertical flocculator for treatment of small flow rates was also developed by the team at Cornell University. The flocculator is comprised of a series of channels with alternating up and down baffles. The baffles force water to change direction through an amount of space that is calculated to provide target mixing.

This mixing is vital to the water treatment process because it is the engine that drives floc formation. At the beginning of flocculation the suspended particles are small. The vertical flocculator has many more tight turns in the early sections of the tank as compared with the later sections. As the stream mixes and larger flocs form, the number of baffles per unit length of the tank decreases to reduce the strain on the flocs. The exact values for mixing parameters at various stages of floc formation are currently a central focus for the AguaClara laboratory research team.

Earlier AguaClara plant designs employed the use of a horizontal flocculator instead of the vertical model now in use. The horizontal model is similar to the vertical one, except that the stream is forced to side-wind from left to right through the channels, instead of up to down. The vertical flocculator has a smaller footprint than its horizontal counterpart, which decreases the overall cost of construction. The vertical model also is less prone to premature sedimentation throughout the tank, which is another main reason why the team has shifted focus to vertical flocculation.

The sedimentation tanks to the customers

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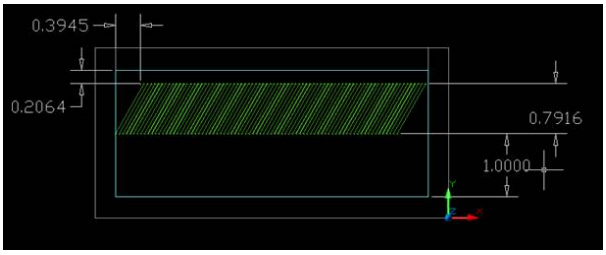

The stream leaves the flocculator and travels to the sedimentation tanks via a channel. The tanks have bottom-level entrance manifolds to distribute water evenly across the floor of each tank, and an effluent launder pipe collects water from the top of each tank. Tanks are fitted with arrays of lamella that are angled 60º from the tank floor. The heavy flocs settle out of the slowly rising water and onto the lamella. The size of the tanks and the positioning of the lamella are engineered to allow the water to rise up through the tank at a slower speed than the flocs take to fall out onto the lamella.

Sludge, made up of settled-out flocs, collects at the bottom of the sedimentation tanks and can create a diffuse filter for incoming water. Having some degree of sludge build-up is therefore desirable, but excess sludge will begin to rise through the tank if it builds up too much. The AguaClara team has recently begun to design weirs into the sedimentation tanks to control sludge levels to create a beneficial sludge blanket. In earlier designs plant operators isolated each sedimentation tank and opened a bottom drain to wash the sludge out. Current designs incorporate a system of sludge hoppers that remove the sludge only to a specific level in the tank, leaving some to act as a filter. Most of the initial turbidity is removed from the water by the time it exits the sedimentation tanks either way, but the sludge blanket filtering effect may help us achieve even better standards for effluent water.

From the launder at the top of the sedimentation tanks, clear water flows to a distribution tank. Chlorine is dripped into the stream of water entering the distribution tank to kill any bacteria that weren't eliminated by removing sediment. The chlorine is dosed using the same type of flow controller used for alum. Clean, disinfected water then flows from the distribution tank into people's homes along a series of municipal pipes.

The Case for Treatment Before Chlorination

Influent water straight from the source contains dirt, organics, and potential pathogens. Although chlorine is used as a broad-spectrum disinfectant worldwide, it is not necessarily an easy solution. Chlorine reacts with organics present in the water, forming carcinogenic compounds. This has the dual effect of not achieving disinfection because the chlorine is "used up" on the dead matter, while also creating a new health hazard. Flocculation is essentially the process of sticking solids in raw water together, while sedimentation is the process of letting those heavy solids sink out. The resulting water is clear of most solids, which allows us to add chlorine to kill remaining pathogens without producing excessive byproducts.

The Social and Cultural Side

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Social sustainability is of key importance to the AguaClara team. The first concern for plant design features is that they be practical for the communities using them. All AguaClara plants are built by locals through construction projects supervised by the Honduran NGO Agua Para el Pueblo (APP). Two Cornell graduates apply to spend a year as employees of APP while assisting with plant operator training and data collection. Groups from the Cornell team visit the sites of AguaClara plants several times each year, interviewing customers and plant operators to gain an understanding of how to better suit our research and design to the local needs.