Aqueous Solutions Technical Papers

Construction of the Pun Pun Farm Water Treatment System

By Nathan Reents
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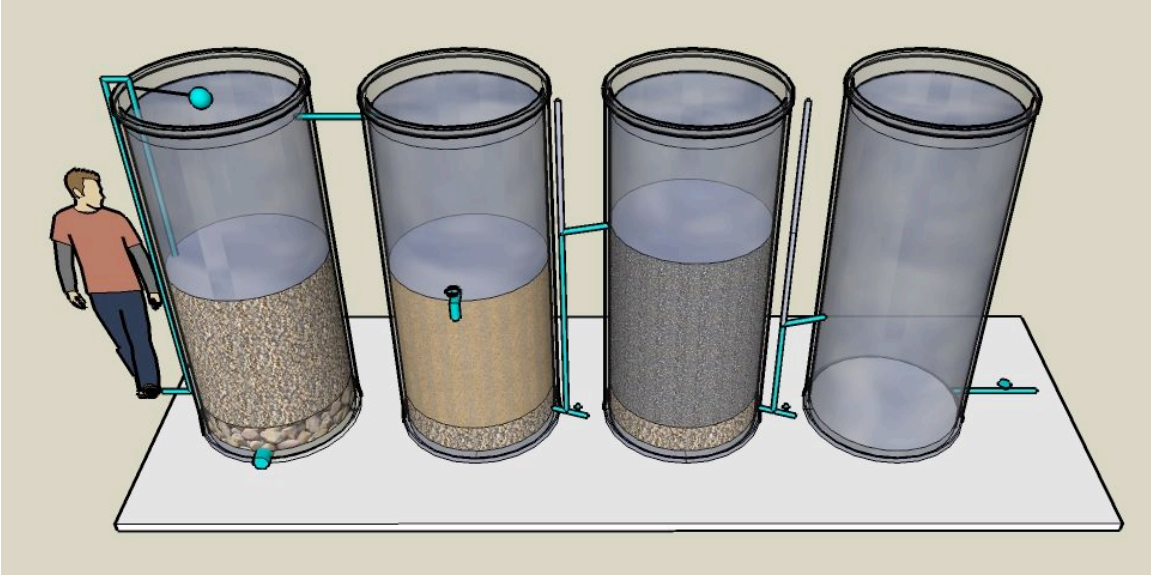
Illustration of the Pun Pun Farm Water Treatment System



In February of 2008 Aqueous Solutions and Pun Pun Organic Farm set out to build a water treatment system that would allow residents to consume water pumped from a storage pond located in the valley next to their rice fields. The water in the pond comes in part form natural filtration of surface and ground water and in part from an irrigation canal supplied with water from a nearby reservoir. We needed the system to remove turbidity, iron, synthetic organic chemicals used in pesticides and all possible pathogen contamination. It was important that the design require only locally available, affordable materials and that it demand very little skilled labor to build.

The general premise behind the design of the treatment system was to take water from existing irrigation tanks at the top of the hill and pipe it down to a series of four tanks. (see diagram above) In the first tank the water flows up through gravel to remove sediment and reduce turbidity. The water then spills over into a slow sand filter where microorganisms living in the top layer of the sand, called the *schmutzedecke* layer, break down and remove organic material and compete for nutrients creating a hostile environment for pathogens. From the bottom of the sand filter, water is piped into the charcoal filter where synthetic organic compounds attach themselves to the reactive surface area of the charcoal. Due to friction in the slow sand filter the flow rate through the system is limited. The fourth tank stores water filtered at night in order to provide enough water for peak loading during the day. In the kitchen treated water can be passed underneath a UV lamp disinfection system to sterilize any pathogens not removed in the sand filter.

Hydraulic Considerations

Beginning at the irrigation tanks at the top of the hill, the entire treatment system was designed to use gravity flow only. The entrance to the first tank is lower then the bottom of the irrigation tanks and is equipped with a float valve to maximize the flow into the system without allowing the tanks to overflow. The pipe entering the charcoal filter is lower than the entrance to the sand filter and the entrance to the storage tank is lower than the entrance to the charcoal filter to allow for frictional losses through the sand and charcoal. All the tanks were built to the same height so that while demand is low the tanks will fill to capacity causing the float valve to close. The elevation difference between the storage tank and the kitchen is enough to pressurize kitchen pipes and provide an adequate flow rate to all taps.

A clean pipe was placed at the bottom of the gravel filter for cleanout purposes and a tee joint with a valve attached to it was connected to the exit pipe of the sand and charcoal filters to drain the tanks. A tee joint was also placed before the entrance of the charcoal filter and the storage tank in order to extend a transparent hose to the top of the tank. This transparent hose allows us to monitor the height of the water in each tank and the head losses across the sand and charcoal. An additional clean-out valve was placed just above the level of sand for maintenance purposes. When the flow through the system becomes too low due to frictional head losses in the sand filter, the top layer can be racked causing fine silt and organic matter to be momentarily suspended in the water. By opening the valve this fine material can be flushed out of the tank. The advantage of this cleaning process, called "wet harrowing," is that the sand can be cleaned without destroying the colonies of microorganisms living in the top layer of the sand.

Concrete Tank Construction

In Thailand it is possible to buy tanks made from plastic, metal, fiberglass or cement. For this project we chose to build the tanks with concrete rings for several reasons. Building with this material allowed us to construct tall narrow tanks in order to obtain the head necessary to push the water through the slow sand filter. The rings are durable, locally fabricated, affordable and easy to assemble and fix. In fact they can even be taken apart, moved and reassembled.

The first step to building the tanks was to pour a bamboo reinforced concrete slab. After mixing and spreading out a 3 cm thick layer of concrete we pressed a grid made of woven bamboo strips into the surface. Once this was semi-dry, the bamboo was covered with another 3 cm of concrete to complete the

foundation for the tanks.

To begin building the tank walls we equally spaced four concrete rings on the slab and poured a 3 cm thick 1:3 cement sand mix along the bottom of each tank. The mix was made with a little extra water in order to fill the crack between the slab and the concrete ring. In the first tank we sloped the bottom toward the clean out pipe. To connect subsequent rings we placed a 1:2 cement fine sand mortar around the top of the ring and placed the next ring on top, twisting it slightly to fill rough surfaces. Once in place we used a trowel to fill any remaining cracks and create a smooth surface along the inside.

Once the tanks were three rings high we decided to install the plumbing, seal the inside surfaces and add the filter medium. By doing this we avoided having to lift the gravel sand and charcoal six rings high. The plumbing was installed by perforating holes in the sides of the concrete rings using a large nail and hammer. When the hole was slightly larger than the pipe diameter, we roughed the outside of the pipe to avoid slipping and secured it inside the hole using a 1:2 cement fine sand mortar. The mortar was applied in a cone shape along the pipe on the inside and outside of the concrete ring wall to give the connection added stability. To seal the tanks, a cement and water mix was prepared and several coats where painted on all inside surfaces.

When all the filter aggregates had been added, the tanks were extended to a height of 6 rings using the same techniques described above. The top rings required 6 people to lift and place. Because the filter medium had already been placed in the bottom 3 rings, we were able to stand on it while placing the top 3 rings.

Placement of Filter Aggregates

The up-flow gravel filter is designed to take out most of the solids, so it needs to be easy to clean. By opening the cleanout valve at the bottom of the tank the flow can be reversed and solids attached to the bottom of the gravel can be flushed out of the tank. To facilitate this process we placed a 30 cm thick layer of softball size rock in the bottom of the tank and a meter thick layer of gravel on top of that.

In the second and third tanks the water flows down through the sand and charcoal so a gradient of different sized aggregates were placed in the bottom of the tanks in order to prevent the sand and charcoal from flowing out the exit pipes. The bottom 30 cm were filled with gravel, which was followed by pea gravel, and then rough sand. To clean the sand while adding it to the tank, we first filled it with water and let the sand settle down to the bottom. The cloudy water above the sand was removed with buckets and replaced with clean water. This helped to remove some of the silt mixed in with the fine sand. The coal for the charcoal filter was added before the tank was filled with water. Initially some of the coal floated to the top, but within a week these particles became saturated with water and sunk to the bottom.

After draining the sand filter tank once a day for a week, the white cloudy water originally leaving the tank became transparent. The water drained out the bottom of the charcoal filter initially had a yellow tint to it. After a couple weeks of flushing water through the tank, the yellow tint was reduced to an acceptable level.

Future Work

The system is currently in use and water samples are periodically being sent to a lab in Bangkok for analysis. Over the next year, Aqueous Solutions will be testing the effectiveness of this treatment system and experimenting with ways to reduce building and maintenance costs.

For more information on pesticides and drinking water filtration using charcoal, see our website:
www.aqsolutions.org