Water Treatment Plant for Remote Village in Colombia – Model for Corporate Social Responsibility

David H. Manz, Ph. D., P. Eng., AOE
Manz Engineering Ltd.
Calgary, Alberta, Canada

Abstract

A community water treatment plant using a unique back-washable slow sand filter is providing safe drinking water to a remote seashore village on the Pacific coast of Chocó, in northwest Colombia. The village has a population of seven hundred persons and can only be reached by boat. They receive their drinking water from a mountain stream in the rain forest two kilometres away. The water is captured using a small dam, passed through a roughing sand filter and transported by pipe downstream to two slow sand filters together capable of producing four thousand, five hundred litres of water per hour. Filtered water is produced to a large storage tank and carried by pipeline down the hills to the village on the coast. When necessary the filters are backwashed using filtered water stored in nearby elevated tanks. Filtered water is pumped from the filtered water storage tank to the elevated tanks using a portable pump transported to the site by the plant operator, a local villager, and returned when the backwash process is complete. The plant requires no energy or chemicals and the filter sand is never replaced.

The package water treatment plant has been operated successfully for two years. It provides an excellent example of how remote communities in developing countries might be provided water safe for drinking using sustainable technology, minimal resources, and local operators.

Introduction

The Government of President Alvaro Oribe established the administrative department, Agencia Presidencial para la Acción Social y la Cooperación International, commonly known as Accion Social through Decree No. 4567 July 2005. In 2008 Accion Social initiated a pilot program to improve water supply and sanitation intended for remote Colombian communities with final funding anticipated to be in the hundreds of millions of dollars. (Note that after the last presidential election Accion Social was amalgamated into a new department known as Departament para la Prosparidad Social.)

A bid was submitted to provide a water treatment plant for the small village of Punta Huina, in the Municipality of Bahia Solano in the Department of Choco. The location of Punta Huina is shown in Figure 1. Travel to Punta Huina involves flying to Bahia Solano directly or through the departmental capital, Quibdo from either Medellin or Bogota and taking a boat launch (approximately forty-five minutes) to the village.

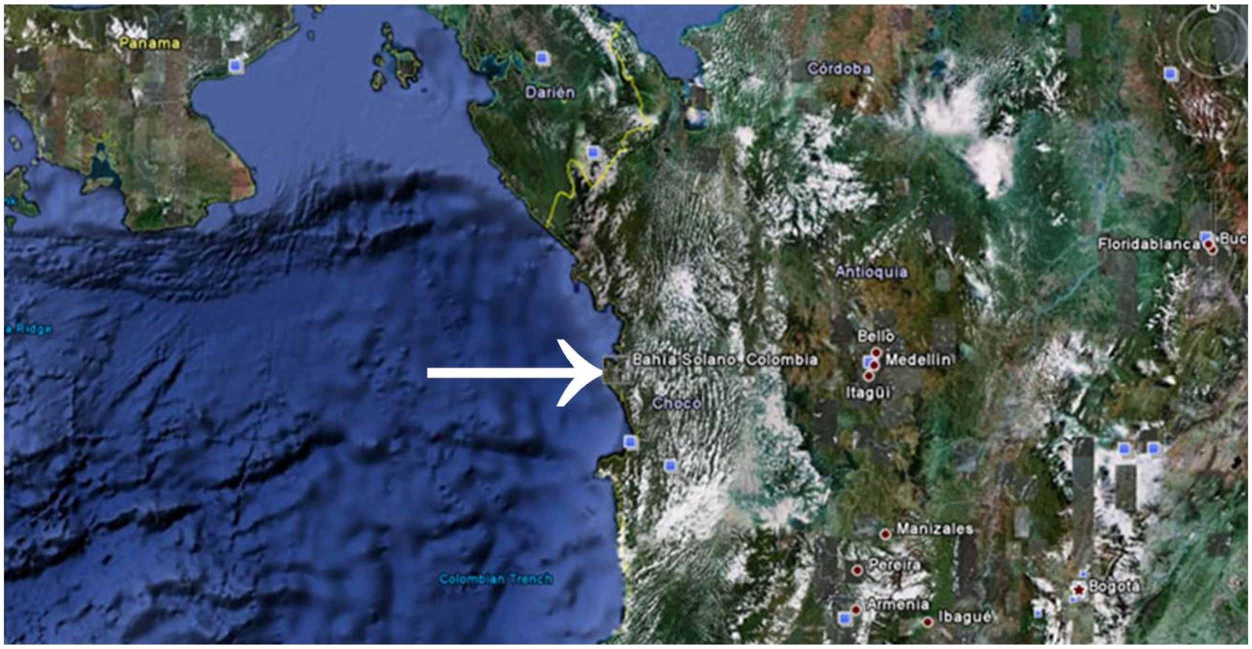

Figure 1. Location of Punta Huina water treatment plant.

In order for a water treatment technology to be considered it had to meet the following specifications:

1. The technology needed to be proven with a successful track record.
2. The primary treatment technology must be based on flocculation or filtration.
3. Filters should use granular media that will not replacement for at least five years.
4. The treatment plant must be able to be operated using one of the following energy sources:
    a. 110 VAC.
    b. Batteries and/or solar cells in 12 or 24 VDC.
    c. Gravity without use of electrical energy.

    If electrical energy is used the amount of energy should be kept to a minimum (minimum electrical energy consumption).
5. The treatment plant must be able to be stopped and started in response to need.
6. The filter media must be able to be cleaned.
7. Treated water should be disinfected using sodium hypochlorite in a precise manner.
8. Minimum use of chemicals.
9. Able to be installed by local community.
10. Able to be locally operated.
11. The treatment plant must provide approximately 200 litres of treated water per person.
12. The treatment technology needed to be affordable.

The Manz Engineering Ltd. slow sand filtration technology easily met these specifications and the Colombian licensee was awarded the contract to construct the Punta Huina water treatment plant with the assistance of Dr. Manz.   Construction was started in the fall of 2009.

February 2019 Manz Engineering Ltd., 2703 Cannon Rd NW, Calgary, AB, T2L 1C5 davidmanz@shaw.ca

Project management was provided by the Colombian Coffee Growers Association to minimize corruption.

Treatment Technology

The water treatment technology used in Punta Huina was based on an important recently developed variation of traditional slow sand filtration, a filtration method that was developed in the early 19th century. Since the water supply was a small jungle stream, the filter of choice was the Manz Engineering Ltd. Filter or MEL Filter which is designed to meet all of the specifications for slow sand filtration while able to be cleaned using a relatively gentle backwash process. The MEL Filter is operated on a demand basis (as required) and the media is able to be cleaned without impacting treatment capabilities, which are similar to those associated with traditional slow sand filtration.

The flow of filtered water is controlled using a 'weir-type' outlet system (outlet standpipe) connected directly to the filter underdrain system. This concept is similar to that used with traditional slow sand filters. The use of the outlet standpipe insures that the filter bed cannot be dewatered. The maximum flow from the filter (often specified by regulatory authorities) is established by the design of the media bed and the provision and adjustment of a production control valve when the filter is commissioned. During normal operation the flow of water into the filter and the maximum depth of water over the filter bed are established by mechanical float valves attached to the raw water inlet pipes within the filter itself insuring that the flow of water into the filter cannot exceed its production. The erosive power of the water from the raw water inlet system is eliminated by passing the water from the mechanical float-controlled valves into diffuser basins located above the minimum depth of water in the filter. When the treated water storage is full the flow of raw water to the filters is stopped and the depth of water in the filter is allowed to drop to a minimum level that allows sufficient oxygen to diffuse to the biolayer to keep it alive and healthy. The rate of filtered water flow, filter bed design and hydraulic head loss across the filter bed ensure that the filter will meet water treatment expectations consistent with that of slow sand filters performing the same treatment function.

The outlet system is also connected to a filtered water supply that is not chlorinated and can be used for filter backwashing. Once it is determined that filter production is unacceptably low, (perhaps determined by the examination of sight-glasses permitting observation of water depth in the filter and outlet head), filter production is isolated and backwash water is allowed into the underdrain system. An air-vacuum control valve attached to the top of the outlet standpipe ensures that the filter produces treated water with the outlet under atmospheric pressure and backwashes under full backwash pressure either from a overhead tank of pump (dedicated or distribution pump).

The backwash of a MEL filter is only intended to thoroughly break up the upper few centimetres of media (where virtually all of the material plugging the filter is collected), de-gas the media and re-suspend captured material. As mentioned only filtered water, that has not been chlorinated, is used for backwash. The flow rate is equal to the minimum backwash flow recommended for start-up of the backwash process used by rapid sand filters or pressure sand filters, approximately 1 $L/s/m^2$ of filter surface under less than 5 m of head (typically 3 m). Backwash of a MEL filter may fluidize and flush the entire filtering layer as well but much less aggressively than that used by rapid and pressure sand filters. Wastewater produced by a MEL filter is typically less than 1% of filter production.

When the backwash flow is stopped the fluidized layers in the collapse into layers resembling the original filter bed (post commissioning). Remaining backwash water is 'squeezed' out and upward from the filter media and the media bed settles cleaned. No untreated water can enter the media bed. The schmutzdeke will not be lost or damaged during the backwash process. The same fine particles that formed the top of the filter media when the filter was commissioned remain at the top of the media bed after each backwash. These are the same particles that formed biofilms and constitute the biolayer or active layer. The biolayer is in place after every backwash - no matter how frequently the backwash is required. The implication is that filter performance is not temporarily impaired by the backwash process. Removal of pathogens, parasites (Giardia and Cryptosporidium), bacteria and viruses can be expected to be similar to that prior to backwashing, flow rate considerations withstanding. Any problems associated with air binding are eliminated because the backwash process is used. Short-circuiting is not possible.

The wastewater produced during the backwash process is removed, after allowing the finest media to settle (about 30 seconds), using perforated pipes located along and attached to the interior walls of the filter. The holes in the pipe are slightly downward facing to avoid capturing any of the fluidized media and are located approximately five centimetres above the surface of the media (all of the water is not removed). The perforated pipes are attached to a siphon spillway system that also acts as an emergency overflow system. The rate of flow through this system is controlled by a dedicated waste water flow control valve (not greater than the capacity to take the wastewater to disposal). A second, waste water operations valve is used to alternatively prevent flow from the filter until backwash is completed and then opened to facilitate the siphon evacuation process. The same valve is left open after backwash is completed to provide emergency overflow protection.

Should the filter develop significant quantities of large, floating debris (not usually a problem if the filters are covered) it may be necessary to locate troughs slightly above the normal backwash which would allow surface skimming.

The backwash process used to clean the filters is expected to allow use of the same filter bed for at least ten years and likely much longer.

Project Description

The Village of Punta Huina is a fishing/ farming community with a population of approximately seven hundred people (See photographs in Figure 2.). It is located on the coast on a bay, Bahia Jella, on the northwest Pacific Coast of Colombia, just south of its border with Panama. The region is part of the rain forest that covers all of the Department of Choco. It receives up to nine metres of rainfall. The community is considered reasonably safe from rebel groups and associated risk of kidnapping and is protected from being co-opted in the cocaine production and transportation activity by the presence of a semi-permanent Colombian military detachment. The community if known for its expanse of beach, whale watching, fishing and relative remoteness (about 45 minutes from the larger community, Bahia

Solano). There is a school that provides education to grade eight, a small hotel and bar and a store. There is no cell phone coverage; however, there is a small land line to meet communication needs.

Figure 2. Photographs of Punta Huina.

A process flow diagram of the Punta Huina water treatment plant is shown in Figure 3. Water comes from a small jungle stream in the hills above the village about one kilometre from the closest human habitation.

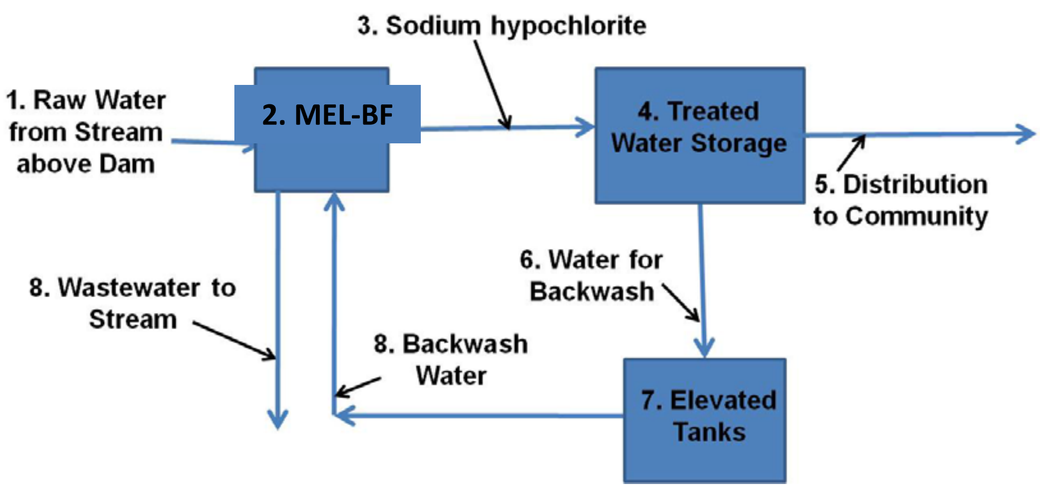

Figure 3. Process flow diagram for the Punta Huina water treatment plant.

The water is commanded (captured) by a small dam and filtered using a very coarse gravel filter to remove larger particles, the only treatment provided until the construction of the water treatment plant. Photos of the water collection point are shown in Figure 4.

February 2019 Manz Engineering Ltd., 2703 Cannon Rd NW, Calgary, AB, T2L 1C5 davidmanz@shaw.ca

Figure 4.   Stream where water is commanded by a small dam and coarse filter prior to transport to water treatment plant.

This water is transported to the slow sand filters by a buried PVC pipeline.   A schematic of the two ’s is shown in Figure 5. The combined capacity of the two ’s is 4,500 L/h.   A photo of the water treatment plant showing the two filters and treated water storage is shown in Figure 6.   Note the PVC pipe on the bottom of the photo coming from the dam and supplying the filters.   Filtered water flows by gravity into a large storage tank (capacity sufficient for one day’s consumption) and then to the village using a galvanized iron pipe (starts with a larger diameter PVC pipe).   Disinfection with sodium hypochlorite was not provided at the insistence of the Village – despite original government demands.

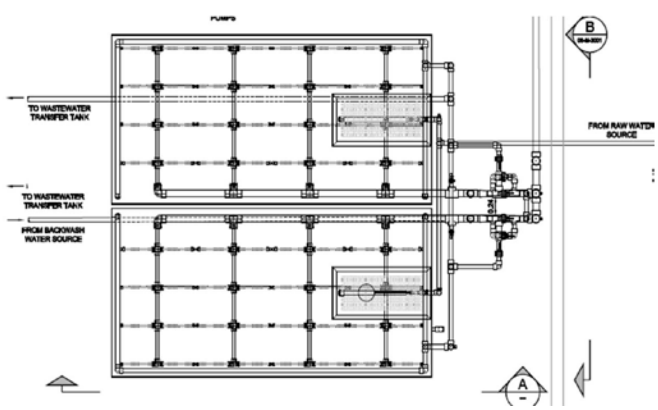

Figure 5. Schematic of two filters.   Figure 6. Photo of filters and treated water storage.

Figure 7 shows the entire water treatment plant including the two elevated tanks used to hold the backwash water.   All of the vessels are constructed of fibre glass elements; and, with the exception of the two backwash tanks, assembled on site. All construction was completed within four months.

Figure 7. Photograph of Punta Huina water treatment plant showing treated water storage tank, filters and backwash tanks.

Media for the filters was prepared in Medellin by a private company which has been in the media production business for more than thirty years. Several other potential suppliers were identified in Bogota. The technology requires media with concise specifications which includes meeting all of the American Water Works Association specifications for media selection and dimensions for use in sand filters and slow sand filters specifically. Media was prepared in Medellin and transported to a port on the Pacific Coast by truck. From there it was transported by a local coastal shipping company to Punta Huina where it was off-loaded into a launch to take it to shore and then carried inland the project site by locally hired porters.

Operator responsibility consists of simply opening valves allowing flow into the filters, cleaning the roughing filter at the point where the water is commanded and backwashing the filters (once every month or so).

When the filters require backwashing the operator arrives with a small gasoline powered portable water pump. Water is pumped from the treated water storage tank to the overhead backwash tanks. Once full appropriate valves are operated and the backwash is completed in less than thirty minutes. The operator cannot perform the backwash process incorrectly. The villagers have knowledge of these types of gasoline engines and pumps as a consequence of the extensive use of small motors associated with their fishing activity. Backwash might will be performed once every month or so.

The treatment plant has apparently performed very well over the past two years though very little information is available from the local government in Bahia Solano or the government agency responsible in Quibdo.

The capital cost of the project, approximately CDN $62,000. Operating and maintenance costs are very nearly zero, consisting primarily of the operator who is responsible for insuring proper operation and cleaning.

Conclusions

The small remote Village of Punta Huina has been provided a water treatment plant they can operate and maintain themselves and afford to operate and maintain for many years. The result is a significant reduction in gastrointestinal diseases and associated reduction in medical costs, significant reduction in infant mortality, increased income as a result of less sickness and overall improvement in quality of life. The water treatment plant is providing a service that is recognized and appreciated by the community who support it knowing that they will receive very little if any additional financial or technical assistance from any other level of government that might assume responsibility.

The water treatment plant is affordable and sustainable.

Discussion

It is possible to construct plants of other materials than fibre glass such as concrete (cast on site or prefabricated), medium density polyethylene, aluminum, stainless steel or even stucco coated brick. The treatment plants can be made much smaller and much larger depending on the size and water demands of the community. (There are household designs that can treat as little as 10 L/hour.) The treatment technology can be used to treat a variety of quality of surface water (rivers, streams, lakes or ponds), wells, springs and rainwater to remove suspended solids, pathogens, iron, manganese, arsenic and other heavy metals, and a variety of other substances. There are no other comparable treatment technologies – at any scale.

The MEL – BF technology provides an opportunity for mining and other types of resource extraction companies, in every community and environment around the world, to meet their corporate social responsibility (CSR) needs in a manner they can manage and deliver successfully. The MEL- BF technology can also be cost effectively used to solve other water treatment needs associated with mining activities such as arsenic and other heavy metal removal from waste water streams, treatment of surface and underground drainage water and provision of safe drinking water to the mine operation itself. There are opportunities for companies to use the same treatment technology in the communities they work in as are used in their operations.

Companies are in a position to assist communities using their own technical resources, with help from organizations that can support their interaction with the community. There are opportunities for major 'win-win' projects than demonstrate the ability to enhance both the business bottom line and provision of community support (satisfaction of CSR) – a concept known as 'shared value'. It may in fact be possible to establish small scale local commercial activities which can provide the treatment technology to surrounding communities and so meet a major local, regional and country need – provision of adequate supplies of water safe for human use – in a sustainable way long after the corporate operations have ceased.

It is important to emphasize that while the MEL – BF technology has been successfully demonstrated in Colombia there are several other successful examples of its use in Canada.