Sustainable Water Quality for Rural Ecuadorian Communities

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Abstract

Protected springs and wells used by rural Ecuadorian communities in Chimborazo Province can provide consistent water quality of a sustaining nature without water treatment. The range of water quality found in communities supplied by groundwater without further treatment is compared and discussed.

UN Millennium Development Goals (MDG) call for reducing child mortality rates two-thirds by 2015 and cut in half the percentage of those living without a sustaining supply of clean water by 2015. The World Health Organization points out that 884 million people lack an improved water source and 2.6 billion people lack access to improved sanitation. Sustaining water quality is crucial to accomplish this goal.

Studies of rural water systems in Ecuador (Solis, 2006) indicate that only 13% of existing rural water systems are sustaining. Adequate consideration must be given to the environmental, technical, organizational, economic, cultural/social and legal challenges of rural community water systems to improve sustainability and fulfill the UN Millennium goals.

Background

Rural Ecuadorian communities generally build and manage their own water system with limited help from government agencies. Most communities are of indigenous background, Quichua being the most predominant. In the 1960's the indigenous people were granted citizen status in Ecuador allowing them to acquire water rights. As a result, many rural community water systems have been built in recent decades with varying levels of success. In spite of the obvious importance of water quality, many rural water sources are not adequately protected complicating the difficulty of providing clean water of sustaining quality.

Water sources for these rural water systems are commonly springs, dug wells, or remote streams. Seemingly, the strategy of using remote surface water sources is to escape the levels of contamination found in nearby water sources. In spite of the remote nature of these water sources, they are inevitably contaminated by the feces of wild and domestic animals. Soil erosion and turbidity are especially problematic for surface water sources during periods of intense rainfall. Although many of the water systems funded or directed by government agencies intend to include water treatment to resolve water quality issues, the water treatment function is normally the last aspect to be funded or summarily eliminated due to cost. When water treatment is included for surface water systems it is most often reduced to merely slow sand filters because of financial limitations. Slow sand filters are not normally adequate to resolve the widely varying water quality conditions of surface water sources.

Government designed water systems frequently aggregate communities into regional water systems which can further complicate water quality and treatment issues by interjecting political challenges. It is quite apparent that responsibilities are defined with greater ease when each community manages and administrates its own water supply.

Sustaining Spring Protection Methods

Protected ground water sources, normally provide consistent water quality throughout the year even during intense rainfalls. Springs, hand dug wells and drilled wells can all be protected to provide a water source of this type. It is important however, that adequate precautions be taken in the construction of the well or spring protection structure to completely isolate the incoming ground water from possible contamination paths. If rough fitting concrete covers or ill fitting steel covers are used to close access openings to the spring protection structures or wells, the water quality can easily be compromised. This is especially true if the access to the tank is not adequately elevated to protect it from surface drainage or floods.

Secondly, it is important that springs be excavated to a sufficient depth so that the water is collected from the pervious gravel, sand or fissured rock where water is flowing before coming into contact with the topsoil. Organic soils tend to lower the PH of the water and introduce undesirable tastes and minerals. In addition, contact with the topsoil will allow the entrance of coliform and perhaps other bacteria to enter the water supply.

Experience protecting almost 100 springs in Ecuador indicates that it is normally best to collect spring water using slotted plastic pipe and fine gravel filter pack rather than building a so-called spring box. Often it is advisable to enclose the filter pack with a buried concrete wall wrapping to the sides of the water production area and extending down to an impervious soil or rock layer underlying the spring. Spring water collected passes through the concrete wall in a regular PVC pipe without slots. Pipe slots are only required on the filter pack side of the wall. Often it is necessary to place the concrete for the buried wall by displacing water as a tremie concrete pour.

When the collector pipe, gravel pack and the downstream concrete wall are complete; the gravel pack can be rinsed multiple times with clean water to force out any fine material lodged in the filter pack. Rinsing should continue until the effluent water runs relatively clear. Then the gravel pack should be doused with chlorinated water (50 to 100 ppm) to disinfect the filter. The filter pack is then covered with plastic sheeting and 8 to 10 cm of concrete to shield the filter pack from any contamination.

Spring protection is an art best learned in the field rather than in the class room. In essence, the soil acts as a water filter. A well designed and built spring collector simultaneously;

- allows spring water to flow freely from the aquifer into the collection pipe,
- inhibits the spring water from contacting the topsoil, and
- prevents water not filtered by the soil from entering the water source.

Often spring water is produced over an extensive area rather than at a point source. The collector pipe approach allows adapting the collector design in situations which water is produced over a large area or collecting spring water from multiple areas. Although spring boxes are commonly shown in technical literature, they are difficult to build under upwelling water conditions. Another disadvantage of spring boxes is that they can be circumvented by the groundwater flow. Simple spring collectors as described above are more economical, reliable, simpler and quicker to build.

Sketches of a typical spring collector are shown both in plan view and cross-section in figures 1 and 2. This simple methodology is easily learned and replicated by resourceful rural farmers. Vozandes Community development routinely employs this technique in building rural water supplies.

In cases where the spring water supplies a water distribution system, a collector tank should be built nearby to provide a stable water surface and to insure that any fine sand or sediment produced by the spring does not enter the water system. The collector tank can be located where dry easier building conditions exist and all openings should be above the surrounding ground surface and above maximum flood levels. Where the tank is built near a water course, it is sometimes necessary to extend the overflow pipe downstream or use a check valve in the overflow pipe so that floods do not flow into the tank via the overflow pipe. The overflow should be at a level below the spring so that water flows freely. If water flow from the spring is restrained it may tend to erode or circumvent the spring collection structure.

The collector tank should include the following features;

- Drain to allow for tank to be emptied and cleaned
- Solid tank cover with access hatch
- Interior ladder (if the depth requires one)
- Overflow
- Valved outlet to water system.

In instances where pumping is required, the collector tank should be of sufficient depth for the type of pumps used. In these cases, often a super structure is built above the collector tank to house the pumps and electrical equipment.

Figure No. 1

Spring Collector

Plan View

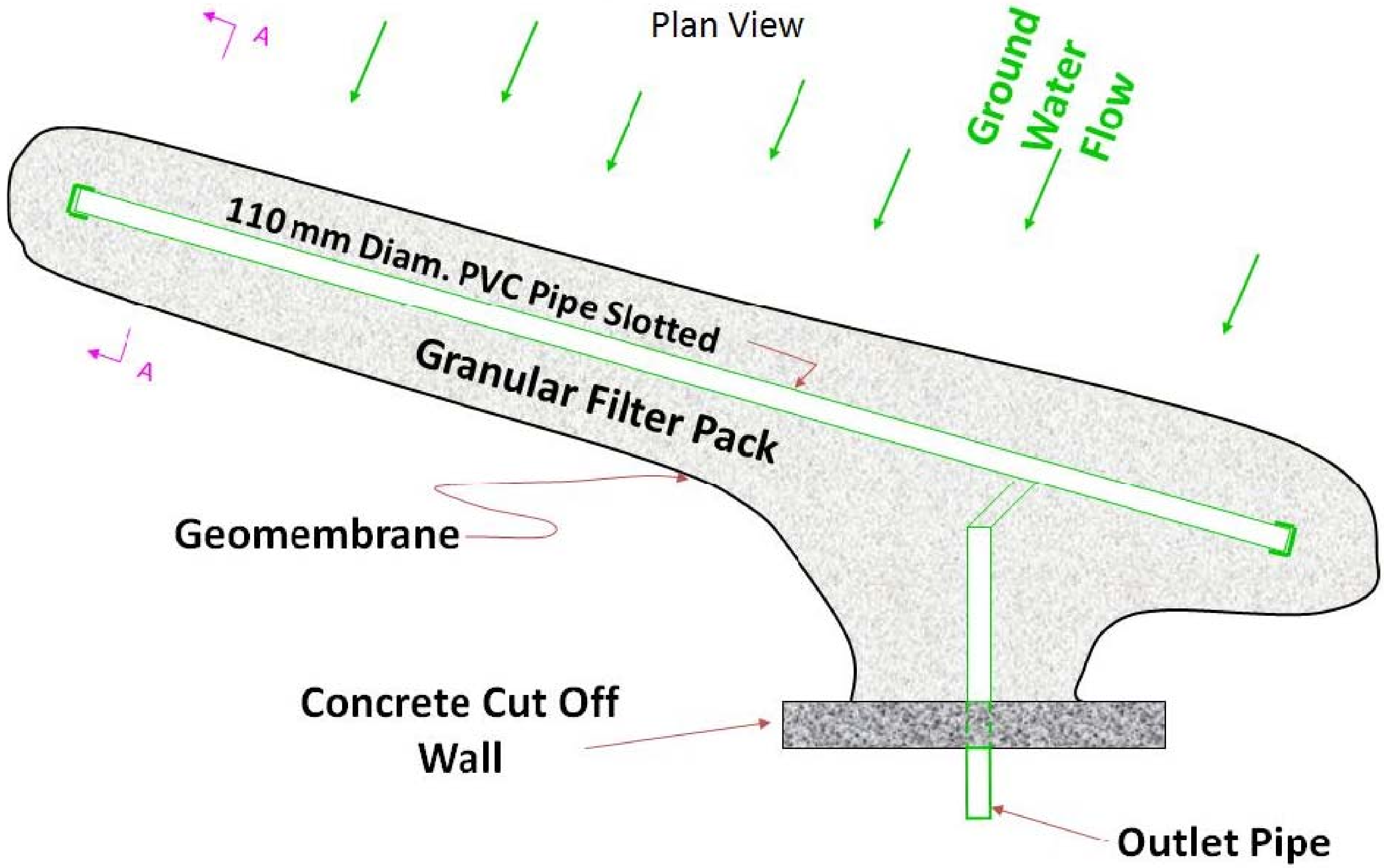
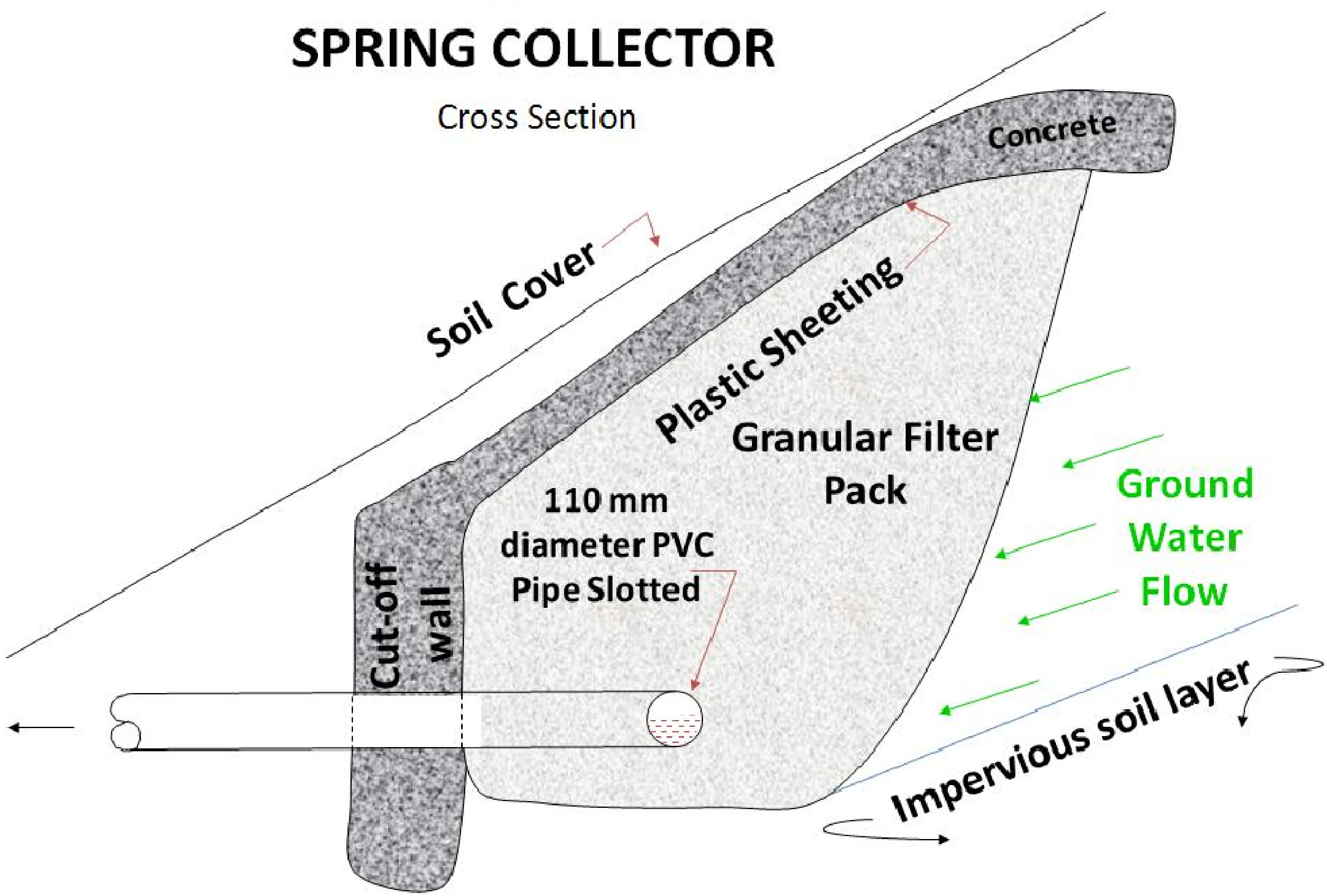


Figure No. 2

SPRING COLLECTOR

Cross Section



Protection of Wells

Hand-dug or drilled wells must also be adequately protected in order to provide water of sustaining quality. Wells should normally be sealed to a depth of 3 meters to prevent the entrance of surface water or low quality ground water. The top slab of the structure should be above flood level and all openings properly sealed to prevent contamination. Often sanitary well seals are difficult to obtain in developing countries. Well seals are necessary to protect the water quality and to protect pumps from physical damage.

Surface Water Sources

Surface water sources are more difficult to protect than springs or wells. Even if the immediate area around the intake is fenced, the feces of wild or domestic animals can be transported in surface runoff contaminating the water supply. During intense precipitation and runoff, surface water sources often transport large quantities of sediment and debris presenting a significant operational challenge for water treatment.

Roughing filters can be employed to remove the excessive sediment, mud and debris transported by surface water sources, but often the capacity of these filters is exceeded during significant runoff events shutting down the treatment facility. Roughing filters are laborious to clean and rebuild.

Adequate treatment of surface water often requires sedimentation tanks, coagulation, flocculation, filtration, and disinfection. Rarely do small rural communities have the preparation, time, and financial resource to deal with these complications. As a result, water quality suffers.

Most rural Ecuadorian communities tend to use spring water when available rather than surface water. Often communities are formed in the vicinity of a spring due to the advantage of easier water accessibility.

Water Sampling & Testing Methodology

Water samples were taken as close as practical to the water source in 12 communities in the county of Colta in Chimborazo Province. The communities are all located in the Andes Mountains and range in elevation from 3200 to 3400 meters. Six samples were collected in each community from a disinfected water tap, dipped from a collector tank, or dipped from the first reservoir in the water system. A 100 ml volume was filtered from each sample and the filter paper incubated in a Petri dish culture to measure both the total and fecal coliform present. The average of the three tests each for total and fecal coliform is shown in figure no. 3.

Water Testing Results

(see Figure No. 3 on the following page)

Figure No. 3 - Average Coliform Test Results of 12 Community Water Sources						Physical Characteristics of water				
Community	Sample	total coliforms per 100mL	fecal coliforms per 100mL	water source	notes	PH	Temper-ature ºC	Total Disolved Solids ppm	Conduc-tivity	% salt
	30-Aug-11									
Ocpote la Merced	1	35	3.7	protected spring	dusty conditions	7.2	17.1	301	622	0.3
Miraflores Cochapamba	2	2	<1	protected spring		7	13.4	105	220	0.3
Miraflores San Jose	3	183	1	protected spring		7.2	17.3	415	851	0.4
Quishuar Maria Elena	4	33	<1	protected spring		7.2	16.3	393	805	0.4
Lupaxi Grande	5	19	<1	protected spring		7.3	18.1	291	600	0.3
Castug Tungurahuilla	6	9	<1	protected well		7	18.8	238	505	0.2
Sisapamba	7	57	<1	spring box		7.6	16.3	419	768	0.4
Bellavista	8	217	16	poorly protected spring	spring located in peaty soil	7.2	16	350	661	0.4
	7-Sep-11									
San Antonio de Columbe	9	37	6	poorly protected spring		7.4	16.8	68	128.2	0.1
Columbe Chico Cruzpungo	10	1	<1	protected spring		6.8	15.9	88	164.4	0.1
San Francisco de Columbe	11	7	2.7	poorly protected springs		7.6	17	95	180.2	0.1
Lupaxi Bajo	12	1120	790	poorly protected spring	fish in cistern	8.2	15.4	344	631	0.3

Figure No. 4

Samples being dipped from the spring collector tank in the community of Bellavista.

Figure No.5

Samples are collected from a disinfected spigot at the pump house for the community of Ocpote la Merced.

Discussion of Water Quality Testing Results

The water testing results demonstrate the range of values of coliform bacteria in spring water. Only two of the protected springs tested positive for the presence of fecal coliform, Ocpote la Merced and Miraflores San Jose. The testing in Ocpote la Merced should be re-done since the results were likely affected by the dusty field conditions created by road work in the area. The spring protection for Miraflores San Jose is located in a stream bed and has been rebuilt twice due to erosion. It is likely that some surface water is penetrating the protection allowing the high total coliform count and the presence of fecal coliform. All of the seven protected spring water sources and the protected well were built by the communities with supervision by field technicians with over 10 years experience.

The last six springs tested, with the exception of Columbe Chico Cruzpungo, did not have the benefit of well controlled construction to our knowledge. The Sisapamba spring, which is a simple spring box, is free of fecal coliform, but water from the remaining four springs contained fecal coliform. The fecal coliform levels are particularly high in Lupaxi Bajo, which has fish in the spring water collection tank. The fish could indicate that the cistern has a flow path from the adjacent river which is fostering the presence of the small fish.

Chlorination Disinfection Issues

Less than 5 % of the 265 rural communities in the county of Colta, chlorinate their water. Disinfection by chlorination has a very low acceptance level in rural Ecuadorian communities. The rural population generally rejects the water because of the taste and odor which chlorinated water can have. This issue underlines the importance of using an uncontaminated ground water source providing consistent water quality without the need for further treatment.

Rural Ecuadorians have used taste buds as their laboratory for centuries. Bad tasting water or water with a chemical taste is summarily rejected. This protected them to some degree from unnecessary sickness due to biological or chemical contamination. Since drip chlorination is the only dosing method available to them, the chlorine dose level of chlorinated varies widely when water is chlorinated and hence disinfection of rural water supplies by chlorination is generally not sustained due to taste issues.

The problem of the chlorine dose level precision is further complicated by the wide swings of water demand in small communities and the varying chlorine demand of surface water sources. Untreated surface water can contain a significant level of organic material that combines with chlorine adversely affecting the water taste and hence the public acceptance of the water supply for drinking.

The non-sustaining nature of water treatment and chlorine disinfection for rural Ecuadorian community water supplies, underlines the value of using protected springs or wells as water sources. Clean spring water which is fully protected to the point of use should be free of disease causing pathogens even if some non-fecal coliform are present. Spring water is normally free of organic material which can adversely affect taste when the water is chlorinated.

Conclusions

Adequately protected springs and protected wells are favorable water sources for small communities in Ecuador to produce water of consistent sustained quality. Spring water sources must be protected from surface water and water produced in the upper soil layers to avoid coliform entrance to the water supply. Protected ground water sources alleviate rural communities of the demanding discipline of water treatment and provide water of suitable quality for disinfection. In order to secure high quality water of sustaining quality, it is important to use experienced field staff that understand the importance of safe drinking water and are able to adequately protect the water supply from surface water contamination and adverse soil conditions.

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