

**Water and Sanitation Investigation and Improvements
at Escuela Bilingüe Abraham Calazacon
in Comuna Búa de los Tsachilas**

*Summary of work undertaken in Búa between 1st August and 7th September
2007.*

*Report prepared by Nick Bundle for Fundación Yanapuma
on 13th September 2007*

Introduction

This report is a summary of the work undertaken in the Comuna Bua de los Tsachilas at the Escuela Bilingüe Abraham Calazacon, between 1st August and 7th September 2007. The two main areas of focus in this period were as follows:

1. Setting up a recycling and waste removal programme at the school with the view of using it as a flagship project before attempting to encompass the entire community in the future.
2. An investigation of the water and sanitation situation in the school, and subsequent improvements to the existing system of water in the school to provide running, potable water with adequate drainage, as well as identifying areas for future improvement pending sufficient funding and engineering expertise.

The overall objective of the two projects outlined above is an overall increase in the standard of health in the school and the community as a whole. For the sake of reporting, however, they shall be treated as two separate projects. The second project is discussed in this report, and the first is discussed in a report entitled "070912_Solid Waste Management Programme in la Comuna Búa de los Tsachilas."

The work described in this report was undertaken by the author in his capacity as intern at Fundación Yanapuma. Azalia Cruz, Coordinator of Volunteers at Fundación Yanapuma and with the responsibility for overseeing volunteer activity in Búa, operated both from Quito as well as making a number of short visits to Bua during the period. All activities undertaken at the school were with the full cooperation and prior consent of the director and teaching staff.

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1. Comuna Búa de los Tsachilas and Escuela Bilingüe Abraham Calazacon at a glance.

The Comuna Bua de los Tscachilas runs from Km 13 to Km 21 along the Via Tsachilas del Bua, which is the paved road to the recinto Umpe Chico (Km 23) from Santo Domingo. There are some 800 people living in the community, with a certain number of houses located directly along the paved road, but with a great deal more accessible by unpaved tracks which lead off from the road. The land has traditionally been the property of the Tsachila (alternatively known as Colorados) community, but a number of “Mestizos” have moved into the area, either as illegal colonists, or through the practice by Tsachilas of selling or renting areas of land. Such practices are in contravention of Tsachila law, but despite this have continued unabated for many years. Búa is the largest of the 7 Tsachila comunas that exist in the Santo Domingo area, comprising approximately 120 Tsachila families and around 100 Mestizo families.

Escuela Bilingüe Abraham Calazacon is located at Km 15 on the Via Tsachilas del Bua. There are 10 teachers in the school, including the director, Guillermo Aguavil, and 248 students in total, in grades 1 to 9. (from ‘el Jardin’ to the ‘Colegio’). The number of students has increased by approx 25 each year over the last few years, with many students travelling from recinto Umpe Chico (km 23), recinto Atahualpa (Km 4 – 13), Cooperativa la Victoria (Km 2) and Cooperativas Brisas del Colorado (Km 0 – 3), in addition to those that attend from the Comuna Búa. The reasons for families choosing to send their students to this school instead of their local schools are varied, but on the whole they relate to the higher fees being charged by other schools, as well as poor relations between families and the schools’ directors. Despite its being a Tsachila Bilingual school, the Director Guillermo Aguavil has opted out of the direction of the *Direction Intercultural Bilingüe de Santo Domingo de los Colorados*. Administration of Bilingual Education in Santo Domingo, due to poor relations with its Director, Marco Aguavil. Instead they have opted to receive support from the *Direction Intercultural Bilingüe de Cayambe*, also located in the Pichincha province but administered from Quito.

2. Background of the water and sanitation situation at Escuela Bilingüe Abraham Calazacon, description of water related infrastructure, sources of contamination and related health risks to the students.

Background

In "Public Health Report: Los Tsachilas del Bua, May 2007 Survey Results,"¹ Jennifer Ramkissoon gives an account of the situation in the school under the headings: Toilets, Water, Illnesses. The situation she describes had not really changed between May and the time of the author's arrival in August.

Infrastructure as at 14th August 2007²

The following section summarises the results of a sanitary survey carried out around the main water/sanitation infrastructure at the school site on 14th August 2007, as well as general observations of the practices of the students over the entire period spent in Búa. Reported in the present tense, it is intended that a description be given of the infrastructure as it was before any work was carried out, with a list of possible sources of contamination and related health risks.

(i) Toilets and septic tank

A block of 6 flush toilets (fig 1), with a hand washing station on one end and a urinal on the other. Due to the discontinuation of the use of the water tower (see (iii) below) there is no running water available to fill the cisterns in the toilets, so a pour flush system is employed. Water for this is collected in buckets from the outlet from the pump behind the comedor, some distance from the toilets. The hand washing station (fig 2) has no running water reaching it and all of the taps are broken. Grey water from the hand washing station and sewage from the toilets are both piped to a septic tank located behind the toilet, built into a bank of earth (fig 3). This has never been de-sludged in the eight years it has been in use, and there is a foul smell around it, particularly on hot days. The outflow pipe is very short, approx 1m in length, and flows out directly onto the football field below, with no system of drainage in place other than limited soaking through the surface soil.



Fig 1: Block of latrines



Fig 2: Hand washing station



Fig 3: Septic tank. Note that the outflow runs down the bank onto the playing field

¹ See appendix 1.

² Figs 1 – 9 are photos taken on 9th August 2007.

Sources of Contamination & Related Health Risk to Students

1. Hand washing is not convenient since the taps are broken near to the toilet, therefore many students don't bother to wash their hands after using the toilet. This is a major factor in the spread of faecal-bourne disease (especially parasites, of which there is a very high incidence amongst the students).
2. The overflowing septic tank and lack of drainage field/soakaway poses a major health risk. The students run up and down the bank next to the septic tank in order to play on the field during recess, often passing through the accumulated effluent on the playing field, or picking up a stray football that got kicked into it. In addition, the ubiquitous dogs and chickens that roam the school freely (including one dog that lives with the family in the school comedor), can often be seen near the tank and/or in the aforementioned effluent spill. In this way both children and animals become vectors for disease.
3. Apart from a general lack of cleanliness in the toilets themselves, something that is a potential risk health is the practice adopted by some students of emptying bins full of used toilet paper out onto the ground behind the toilets near the septic tank, at times landing on an exposed (above ground) section of the pipe that joins the pump in the well to the drum in fig 7.

(ii) The well

- The well is hand dug with a total *depth* of 17m, *diameter* 73cm.
- *Water depth*: Measured twice: 1st August – 1.74m, 4th Sep – 1.57m
- *Trends*: The *water table* rises to give a water depth as much as 13-14m in the winter (Nov – April) with the large amounts of rain that fall in this season. In the summer, it falls, usually to the point of drying up in August/September. At such times, water is collected from the Rio Soberano, which flows past the school some 200m walk away. This year due to the mild summer and intermittent rainfall the well has not yet dried up. The *turbidity* of the water increases as the water table falls, with water being clearest in the winter.
- *Level of improvement*: Concrete/brick headstone (fig 4) built up from ground level with a concrete lid (usually in place)
- *Extraction method*: Water extracted using a submersible pump, via a pipe to an open drum behind the comedor.
- *Situation*: The well is situated some 12m from the latrines and 17m from the septic tank.



Fig 4. Headstone with cover.
Visible beyond the well are the cistern and housing for the pump that was used to pump water from the cistern to the water tower.

Sources of Contamination & Related Health Risk to Students

4. Whilst usually in place, there have been occasions when the well was observed without the concrete lid. This is one possible way in which contamination can enter the well.
5. The headstone is made of breeze blocks, the inside being unsealed and with some small holes noticeable that extend from the outside into the interior of the headstone. Cockroaches have also been observed appearing from the holes in the interior of the headstone.
6. As mentioned in 3 above, there are sections of pipe between the pump and the outlet that are above ground. The path of the pipe takes it behind the toilet block, very close to the septic tank, coming above ground very near to it with some leaks visible (“repaired” by a piece of cloth wrapped around them). The potential for contamination entering the water supply in this way is very high.
7. There is concern about the possibility of the well containing high levels of pathogens due to groundwater contamination resulting from the close proximity of the toilets and overflowing septic tank.

(iii) Water tower and cistern

According to Guillermo Aguavil, the school's director, water used to be pumped up from the well into the cistern below ground level, then pumped up to a concrete water tower (fig 7) using an additional pump housed below the tower (fig 8), which is currently unused but said to be functional. This formed the basis of a gravity fed distribution system that supplied water to the block of 6 flush toilets, urinal and the three hand washing taps. The tower was seen to sway from side to side under the weight of the water in the tank, and as such its use was discontinued for fear of it toppling over. This resulted in the current method of extraction of water from the well.

Fig 5. Water tower, pump housing and cistern as viewed from the opposite side as fig 7. The design was considered to be unsafe by Guillermo after it was observed to sway when the open-topped concrete tank was full of water.



Fig 6. Close-up view of the pump housing.

(iv) Drinking, Washing, and Grey water Drainage

There is no running water with which to wash hands after using the toilets, so all hand washing takes place behind the comedor, where there is situated a 200L open plastic drum, serving as the main receptacle for water pumped from the well (fig 7). Dish washing is performed on the table shown in fig 5, with all grey water flowing down the bank to the playing field below (fig 8). The receiving area for this water has a lot of litter on it and is has a muddy, slimy consistency, resulting in very poor drainage into the soil. Drinking water is generally taken directly from this

the outlet into a separate bucket with lid, which sits on the floor next to the comedor (front side) with a communal plastic cup inside.



Fig 7. Drum and outlet pipe from pump behind comedor. The table is used for washing up. Some grey water puddles in the uneven surface below the table.



Fig 8. Grey water draining down from the washing station and accumulating on the ground below.



Fig 9. Student scoops water from the drum for hand washing.

8. Lack of a tap means that the water in the drum quickly becomes sullied as students dip their hands and at times heads into it. This water is then used for cooking, washing of dishes and sometimes even drunk directly.
9. Washing up of all the dishes from the comedor, as well as those of the 'free³' lunch service, take place at a rotting wooden table (fig 7), which is a great source of flies in itself. Underneath the table can be found pools of water and various debris, including food remains and rubbish. These areas are perfect breeding grounds for mosquitoes, with Dengue and Malaria being real risks in the wet season. The water that does escape down the bank from here tends to accumulate in a muddy, slimy area below which too would act as a perfect breeding site for mosquitoes.
10. Whilst some students buy the 10c 500ml bags of water on sale on the shop at the school to drink, many of them choose to drink untreated water that comes directly from the well, either served via a separate bucket near the comedor, or directly from the plastic drum or outlet pipe. The author once observed the aforementioned comedor dog drinking from the students communal drinking water bucket because the lid was left off⁴

³ The school charges the parents approx \$2/month for the purchase of ingredients to provide a cooked meal, prepared by a group of mothers, about three days a week. They use extremely large pans and a mobile gas burner which is stored in one of the classrooms. A typical meal consists of rice, some form of chicken or tuna accompaniment, and a milk-based malt drink.

⁴ It should be noted that in casual discussion one day with some of the younger students before class began, some of them brought up the fact that the author didn't drink "agua cruda," (untreated water) whilst they seemed quite proud of the fact that they did, with seemingly no problems... Health education about the need to boil drinking water has been done in the past in the school with some associated posters remaining in at least one classroom, but clearly more work needs to be done in this regard in the future.

3. Objectives of the Water and Sanitation Investigation and Improvement Project

The main objectives of the project were as follows:

- Perform an analysis of the school's two main water sources - the well and the River Soberano, to determine the level of contamination in each.
- Undertake a project to try to reduce or eliminate the health risks/sources of the contamination listed above and to set up a water supply that provides running, potable water.
- Given the short timeframe of the project, propose ways in which it can be improved.

Each of these objectives will be discussed in turn in the subsequent sections of this report.

4. Water analysis⁵ at EMAPA in Santo Domingo de los Colarados

Objective: Perform an analysis of the school's two main water sources - the well and the River Soberano, to determine the level of contamination in each.

A water analysis was performed by Engineer Narcisa Lopez of EMAPA (Empresa Municipal de Agua Potable y Alcantarillado Santo Domingo) at their water treatment plant on Avenida Quito, Km 7. Full microbiological as well as chemical & physical analysis was requested for samples taken from the well at the school and the nearby Rio Soberano. The following describes the collection method⁶ and summarises the results for each sample.

Collection

Well

Sample codes: AC001, AC002, (full microbiological analysis) AC003 (chemical & physical analysis).

Date: 15/8/07.

Time of collection: 07:20

Collection made by: Nick Bundle with assistance from Guillermo Aguavil.

Method of collection: Water run to waste for 1 minute from the pump outlet before collection in two sterile urine sample bottles purchased from a pharmacy (AC001/2). No contact was made with the inside of the bottles while collecting the sample and the lids were screwed on firmly immediately afterwards. A rinsed empty 4L PET water bottle was then half-filled for AC003.

Transportation: The samples were placed into a sealed plastic container in which they were surrounded by ice cubes (provided by Guillermo). The container held four sample bottles tightly but had to be kept flat for fear of spillage/contamination from the melted ice water all the way into Santo Domingo then out to the EMAPA plant.

Duration between collection and submission at the plant: 1h28min.

Rio Soberano

Sample codes: RS001, RS002, (full microbiological analysis) RS003 (chemical & physical analysis).

Date: 15/8/07.

Time of collection: 07:10

Collection made by: Nick Bundle with assistance from Guillermo Aguavil.

Method of collection: Two sterile urine sample bottles were filled by insertion into the river to a depth of approx 15cm in a free flowing area about 2m from the bank. The depth of the river at that point was about 30cm. No contact was made with the inside of the bottles while collecting the sample and the lids were screwed on firmly immediately afterwards. The A rinsed empty 2L PET water bottle was then filled for RS003.

⁵ Further information about laboratories able to perform water analysis in Quito and Santo Domingo de los Colarados can be found in appendix 2.

⁶ Instructions for collecting the sample were found in "Taking a Water Sample, Technical Note No. RWS.3.P.2." USAID "Water for the World" series of technical briefs available online (and on the Fundacion Yanapuma server). The only difference between the method described above as that in the technical note is the storage of the samples in ice. This was recommended by Eng. Lopez of EMAPA and also Eng. Fierro of CICAN in Quito (see appendix 2).

Transportation: The samples were placed into a sealed plastic container in which they were surrounded by ice cubes (provided by Guillermo). The container held four sample bottles tightly but had to be kept flat for fear of spillage/contamination from the melted ice water all the way into Santo Domingo then out to the EMAPA plant.

Duration between collection and submission at the plant: 1h38min.

Results

Results were initially made available on 21/08/07, when the author visited the offices of EMAPA at the Santo Domingo municipality building and was able to discuss them in person with Eng. Lopez⁷.

The microbiological analysis showed the following:

Sample	Total Coliform/100ml	Faecal Coliform/100ml	Bacteria/100ml
AC001	>2419.6	31.3	Uncountable
AC002	>2419.6	34.1	Uncountable
RS001	>2419.6	727.0	Uncountable
RS002	>2419.6	648.8	Uncountable

Chemical & physical analysis revealed nothing untoward – please refer to the full copy of the results available from Ms. Azalia Cruz at Fundación Yanapuma.

Clearly the river is much more contaminated than the well, and further investigation is required into the source of this contamination. Any water that is drawn from here during dry periods should be boiled or treated with chlorine before consumption.

It should be noted that due to the presence of above ground, leaking pipes between the pump and the outlet, as well as periods during which the well has been uncovered, there are a number of possible explanations for the levels of faecal coliforms indicated above. However, the level is low enough to suggest that the latrines/septic tank are not adversely affecting the purity of the groundwater. This conclusion was used as grounds to continue using the existing well (rather than consider construction a new one in a different site), and as such proceed with the improvements described in section 5.

⁷ Refer to appendix 2 for an explanation of the error made by EMAPA in the recording of with the results.

5. Summary of Infrastructural changes made in the school, including improvements still outstanding.

Objective: Undertake a project to try to reduce or eliminate the health risks/sources of the contamination listed above and to set up a water supply that provides running, potable water.

Objective: Given the short timeframe of the project, propose ways in which it can be improved.

In this section a description of the improvements made at the school over a number of days shall be given, and cross referenced to the items on the list of health risks/sources of contamination listed in section 2 above.

The “Mingas”

This is a term used to describe a community work day, where various members of the community get together to make lighter work of a sizeable task. Through the existing framework of the ‘Padres de la Familia’ of the school. Guillermo was able to gather together a number of fathers of students, willing and armed with machetes and spades, with certain students also proving very capable. 4 mingas (ranging from half to full days, 25/8, 30/8, 4/9, 6/9) were required to accomplish all of the work described below, with another half day of work (5/9) involving only Guillermo, the author and a couple of students. At all times a participatory approach to decision making was encouraged, with the intent to make the whole process a forum for people’s input and ideas in order for them to take ownership of the project as well as gain a practical understanding of any new concepts involved.

Materials purchased

The following materials were purchased using Yanapuma Foundation funds. The actual purchases were made on 24/8 in Santo Domingo by Guillermo and the author.

Description	Costs (\$US)
Box of nails	2.20
Jubilee clips	1.00
Pipe, taps etc.	44.00
Bleach	6.90
Dropper and syringes	1.57
Rotoplast 1100L water tank	123.10
Measuring jug	0.75
Total	179.52

Additional sundry purchases of totalling about \$10 were made by Guillermo and the author for items such as more jubilee clips, threaded joins for plumbing/pipe reducers etc.

The school purchased 7 bags of cement, taking advantage of the ongoing classroom construction which allowed for free delivery of the bags along with other items used in the construction by CorpEcuador. In addition to this, we were fortunate enough to receive some advice from the

CorpEcuador engineers in terms of how to reinforce the water tower (see below), as well as have use of the cement mixer, gravel, stones and sand.

Work carried out

The basic premise was that the well should be cleaned/the pump maintained, as is routinely done by the community at this time of the year. In addition to this, it was suggested that it then be disinfected with chlorine (as this had never taken place before), and sealed properly to prevent further contamination. In addition a new tank was to be installed, at a height, to form the basis of a gravity fed potable water system, feeding taps to serve the needs of hand washing, drinking and dish washing.

As much as possible it was intended that existing infrastructure be improved/repared, rather than building new things.

For consistency and ease of comparison, items will be treated below in the same order as they were in section 2.

(i) Toilets and septic tank

Health/contamination risk 1

Solution:

Running water has been provided to the hand washing station on the side of the toilet block.

Work done:

The taps in the hand washing station were replaced (fig 11), and one of the existing inlets to the general toilet block plumbing (located directly below the hand washing station) was connected to the new pipe come down from the water tower so as to provide water to the taps. The toilet block is plumbed in a loop with two inputs serving the toilet cisterns and hand washing station. All cisterns were turned off at their taps. This was to avoid:

- a) the use of substantial volumes of drinking water through flushing.
- b) The subsequent further overloading of the septic tank.

In addition it was necessary to block the second inlet for water into the toilet block since water was escaping through this and causing a large reduction in pressure. The simple of method of blockage is shown in fig 12.

The original grey water drain from the hand washing station was plumbed directly to the septic tank. It was decided to direct this away (fig 10) from the septic tank so as not to put any more stress on the already overloaded system, connecting it instead to a soakaway pit. The pit was dug to a depth of 1.2m, with the plan area being 1m x 1.2m, giving a total volume of over 1 cubic metre. The pit was filled with stones at the bottom and gravel at the top (a large group of students enlisted to collect the stones and gravel), then back-filled with excavated earth to protect it from surface water (fig 13,14).

Possible improvements:

- In the future it might be worth considering re-plumbing the second inlet to the main pipe coming off the water tower and observing whether there is better pressure or the system performs better as a result.
- Working with the teachers to ensure someone is responsible for having soap available during school times, in an appropriate soap dish (e.g. a cut off bottle).



Fig 10. Diverted drainage from the hand washing station. Pipe is encased in concrete for protection.



Fig 11. New taps installed, with plastic mesh protecting the plug hole from blockage by debris.



Fig 12. Simple method of blocking the second inlet to the toilet back plumbing to 'close the loop' and stop leakage/pressure loss.



Fig 13. Soakaway pit under construction



Fig 14. Finished soakaway back filled with excavated earth.



Fig 15. Water bottle is used as a reducer to send the septic tank effluent down a length of recycled water pipe, which follows the line of a trench.

Health/contamination risk 2

Temporary Solution:

Guillermo came up with the idea of excavating all of the old pipe that was connected to the pump and reusing it to extend the length of the effluent outlet pipe on the septic tank. As such all of the old pipe was dug up, connected back together and attached to the PVC outlet of the tank using a water bottle as a reducer (fig 15) with plastic mesh to stop any large solids blocking the pipe. A trench was dug along the side of the playing field to contain the pipe, but it wasn't buried due to the imminent arrival of a motor leveller that was due to come and turn over/level the playing field the coming week – it was thought best to wait until after this.

Still outstanding:

The improvement was a very effective way of carrying the effluent away from the current outflow area, with it emerging some 30m away in the trench. As such the previously contaminated area

of the playing field that receives such a high volume of student foot traffic is no longer getting covered in effluent. However the original problem still remains in that it all flows out onto the ground in one area. Once the work on the field as a whole has been completed it would be wise to consider either:

- a) perforating the pipe and turning the trench into a soakaway trench, filled with stones, with the pipe contained in the stones running along the length of the trench.
- b) Burying the pipe with earth along the trench then digging a large soakaway pit at the end of pipe so that the effluent can soak away properly this way.

Health/contamination risk 3

No work was done on the latrines themselves, as this was far beyond the budget of the project and a long term, sustainable solution needs to be considered in terms of sanitation in the school.

The problem of used toilet paper being dumped onto the water pipe exposed behind the toilet block was addressed in two ways:

1. Excavation of the old pipe and rerouting of the new one so that it doesn't pass behind the toilet block any more. The new pipe travels from the water tower in front of the toilet block and round the back of the classrooms to the rear of the comedor. It is buried and only comes above ground where necessary to make a connection to a tap.
2. Installation of a metal drum for burning of toilet paper at the end of each day⁸

(ii) The well

Disinfection:

The well is cleaned off mud at the bottom, deepened slightly, and maintenance performed on the pump every August/September whilst the water table is at its lowest. It had never been disinfected after this however, so this time 33L of 2% chlorine solution was thrown down it once all work was finished⁹. After this water was pumped to waste until it smelt of chlorine, then pumped again every hour for 3 hours before being left over night and then pumped completely to waste.

Note that the tank was also disinfected before use using the same 2% solution and scrubbed with a brush inside. This is a practice that should take place every year.

Problems:

The main problem that occurred due to lack of experience in doing this, was that the addition of chlorine coincided with wiring the pump to the new tank, raised on top of the water tower. As such, pumping the water 'too waste' actually meant filling the tank with quite heavily chlorinated water. Still being in the construction phase at that point meant this wasn't a complete disaster, since the water in the tank was being run out to waste a lot anyway, but it would be far better next time to disconnect the pipe from the tank when disinfecting the well and ensuring that there is no strong smell of Cl in the water being pumped out before reconnecting it the following day.

⁸ Refer to "070912_Solid Waste Management Programme in la Comuna Búa de los Tsachilas" by Kyle Muther & Nick Bundle

⁹ Refer to Appendix 4 for the method of calculating the amount of Cl required.

Health/contamination risk 4,5

Solution:

Improve the well by sealing all holes with cement and sealing the lid in place.

Work done:

This sealing work was, leaving the well in an apparently well improved condition. Guillermo and the fathers decided to have the pump outlet pipe coming up out of the side of the headstone, rather than being buried as it was before (fig 16).

Problems:

On 6th Sep, the work seemed to be completed, but the water was coming out very turbid. Guillermo and Jorge Guzner (school treasurer) identified this as being due to the fact that the pump was situated too low in the well, and as such was sucking up the dirt from the bottom. The lid was reopened to address this problem. At this point, the presence of ants was discovered in the inside of the well. This is apparently fatal for a well since the earth that they displace will fall down into the water, becoming a very serious problem over time. Thinking that they could identify the holes that the ants were using to gain access (oversights in the original sealing job), they decided to meet again soon (in the next week) to seal the ant holes then poison them outside the well.

Still outstanding:

Follow up to ensure that this has been done successfully and that the lid and hole around the pipe outlet has been re-sealed also

Health/contamination risk 6 - See the solution to risk 3 above.

Health/contamination risk 7 – As explained in section 4, this was addressed by the water analysis.



Fig 16. Well with the outlet pipe exiting via a hole in the side of the headstone.

(iii) Water tower and cistern

Utilising the existing water tower as platform for the new plastic tank was the cheapest and most sensible way to gain the necessary height for a successful gravity fed system.

The fears about its instability were discussed with the two CoopEcuador engineers present to oversee the building of the new classrooms, and they advised that the base of the tower be reinforced by digging a 30cm wide trench around it and filling it with stones/concrete (fig 17,18).

This advice was duly taken, but there is still a tendency for it to sway from side to side slightly. People are happy that it is not dangerous however (further assurance from the engineers) and the plastic tank is in place on top of it, with a permanent ladder in position (fig 19) to allow easy access to the tank for treatment of the supply with chlorine.



Fig 17. The trench is dug ready for concrete to reinforce the base



Fig 18. Minga, with assistance from the CoopEcuador labourers and machinery to mix the cement.



Fig 19. Ladder in position providing access to the tank for water treatment.



Fig 20, 21. Photos taken from inside the top of the water tower showing the inflow and outflow connections to the tank.

(iv) Washing and Grey water Drainage

Health/contamination risk 8

Temporary solution:

Installation of a tap mounted on an upright piece of wood (fig 22). This is an improvement on the previous system, since at least water can be taken directly from the tap for washing/drinking. No doubt however that the 200L plastic drum will remain in use there until it is removed, and this is not feasible until funds are gathered to purchase or build a large sink and/or washing up station.

Health/contamination risk 9

Solution:

Improve the drainage and workspace behind the comedor.

Work done:

The rotten table was broken down and removed, and the floor re-done and finished on an incline (for drainage) with channel in place to ensure drainage of rainwater. The channel is in fact an extension of the existing rainwater drainage channel that drains rainwater falling from the roof of the nearby classroom. A soakaway pit similar to that used for the hand washing grey water was dug to serve the grey water generated from dish washing behind the comedor. This pit is located

to one side of the main flow of rainwater drainage from above since the large volumes in winter of this would surely overload the pit's capacity. The pipe for this is in place and set into the corner of the concrete floor above, with a good length left free at the top end for connection to the sink/washing station once purchased/constructed. (figs 23, 24)

A temporary table is in place at the moment for the purpose of washing up.

Still Outstanding:

- Until a suitable sink and work space is purchased and installed or constructed, the benefits of the work done here will not be felt. The soakaway pit is only of use once the sink is plumbed to it – otherwise all grey water will continue to drain down the rainwater channel and accumulate below. This sink MUST have a filter in it to stop food debris blocking the 1" drainage pipe. A piece of plastic mesh as used at the handwashing station would suffice.
- The rainwater channel needs further development to take the water away from the bottom of the bank where it will accumulate. Jorge Guzner who was involved in the improvements here has ideas in this regard, so follow up with him is required along with the arranging, through Guillermo, of another minga to finish the job.
- The area of accumulation below needs to be thoroughly cleaned of litter and debris and kept clean, along with the rainwater channel above.



Fig 22. Temporary standpipe style tap, positioned above the rainwater drain.



Fig 23. Minga. The base is filled in and concreted.



Fig 24. Finished base, on an incline with rainwater drainage channels. Temporary table for washing up in lieu of a sink. The drainage pipe that leads to the soakaway below is visible

Drinking Water

Health/contamination risk 9

Solution:

Chlorination¹⁰ of the water supply in the tank whenever it is re-filled with water from the well. Removal of the bucket mentioned in section 2 such that all drinking water is accessed directly from the taps, where it will come out treated.

¹⁰ Refer to appendix 4 for a guide as to how much chlorine (bleach) is required per volume of tank and suggested method of application.

Still Outstanding:

Unfortunately there was insufficient time when the author was in Búa to oversee this being put into practice, and it is one thing that may required some ongoing coaching to get right.

Fundación Yanapuma must spend some time ensuring that a good practice is in place of filling the tank in the afternoon, estimating the amount of water added and putting in chlorine accordingly so that it can stand for a minimum of 30 mins before consumption (in this way it would stand overnight).

Guillermo and Rosa Aguavil have been explained how much should go in to a full tank and are in possession of syringes to measure the bleach in this way.

It should be noted that even without treatment of the water in the tank, the improvements made to the water supply system discussed above should result in the students accessing water of much higher quality than it was before, since a number of possible sources of contamination have been eliminated.

6. Recommendations for further action and/or possible future projects.

A number of issues which need urgent attention in terms of following up/finishing off the work described in section 5 are listed under the various headings *still outstanding*.

Other projects would be possible in the school in the field of health, water and sanitation pending sufficient funding and expertise. Recommendations include:

1. Further water analysis

It should be remembered that water analysis only gives a snapshot of water quality at a given time/date. Water quality can vary with seasonal changes and differences in water table height.

In addition, it would be interesting to test the quality of the water flowing from the taps to measure quantitatively what effect the improvements have had on it.

Suggested tests conditions are as follows:

- (i) Analysis of untreated water from the taps (i.e. water that has been pumped into the tank but not been treated with Cl).
- (ii) Analysis of tap water that has been treated with Cl as described in this report. This would be a way of discovering the Cl residual concentration (see appendix 4) and/or discovering whether the treatment is working correctly. Presence of faecal coliforms in the treated tap water would either imply insufficient Cl is being added, or point to contamination somewhere between the tank and the tap.
- (iii) As for (i) and (ii) above but in the winter when the water table is much higher.

2. Installation of a sustainable sanitation system to meet the demands of an increasing number of students

The septic tank is far too small for the number of people using it. It was built with probably about 80 students in mind, and the number at the school has since quadrupled (and will continue to rise). It has been full for some time and has never been de-sludged, which is a prerequisite of having such a tank. According to investigations at the municipality and EMAPA, no vehicle exists in Santo Domingo that is equipped with the suction equipment normally used in developed countries to empty and desludge the tanks. The common practice therefore is to simply build a new one when the old one fills up, or to use a simple pump to empty it. A more sustainable system must be considered and installed in the school, along with an increase in the number of latrines available.

Dry toilets are one option, but would have to be accompanied by a big educational and monitoring programme to ensure they were used correctly. It would be worth waiting to see how the three pilot toilets are used that already exist in the community.

Another option could be modification/expansion of the existing system with reed beds or drainage fields to ensure effluent is properly treated.

3. Rainwater harvesting.

There are a number of large tin roofs in the school which would be suitable for rainwater harvesting. See appendix 3 for information regarding rainfall data for the area. This could be a secondary water supply, used for flushing of toilets (depending on the sanitation system chosen) or even watering of the school garden/agriculture project which has been suggested on numerous occasions by Guillermo, and which will hopefully involve use of compost generated at the school.

4. Health Education

There is a real need for more health education in the school, aimed not just at the students but also at the parents, teachers and those involved in catering there. With running water now available this should start with a review of the importance of hand washing, and if the chlorination of the supply is to be successful, people must also be taught why a slight taste of chlorine in the water is a good thing, or else there is the chance that it will be rejected in favour of untreated sources. Ms Cruz is coordinating Dr Osvaldo Avar of the municipality to start up a community health programme in the community, and these topics should also be included in these. It would certainly be beneficial have health education sessions of this kind run by qualified Ecuadorians to whom the people can relate.

Appendix 1 - Extract from "Public Health Report: Los Tsachilas del Bua, May 2007 Survey Results" by Jennifer Ramkissoon.

5.0 Information about Abraham Calazon School

I had a meeting with Senor Guillermo Aguavil, the director of the Abraham Calazon School in Bua on April 26th 2007. There are several classrooms but not all in good condition or with sufficient desks or benches. The director is very passionate about improving the school and was very eager to share information with me. He has a lot of plans but cites that he needs help from members and authorities of the community to make them a reality. The director stated that there are many barriers with the Tsachila authority director which impedes progression in the school.

Health and education are top priorities for Senor Aguavil. There is no formal program for health and hygiene, but health issues are discussed in natural science classes.

Toilets

There are a total of 5 toilets for the entire school population. These toilets are septic systems and are around 10 years old. The director mentioned that they are close to reaching their capacity and new ones need to be constructed. In addition, construction of more toilets would be ideal. The bathrooms are located very close to the classrooms. Both teachers and students share the responsibility of maintaining the toilets on a weekly basis and they use various cleaning products to disinfect and sanitize. The younger students receive toilet paper but students in the senior level are responsible for bringing their own. Used toilet paper is disposed in a bin and then is taken to another location to be buried or burned. There is soap and water available to wash hands but this is obviously up to the student. However in all the classes of the younger students, there is a basin of water and a bar of soap. Each of these students also has their own hand towel. When the students return from the bathroom, upon arriving in class they must wash their hands with the soap and water. This is a recently new idea implemented by the director in hopes of teaching the children at an early age the importance of keeping hands clean.

Water

There is one well on the school property and an elevated tank for storage of water. However this tank is unstable due to age (wear and tear) and is not used because of fear of an accident. There is water available for students to use (consume and wash) and this is taken from the well. However the water is neither purified nor boiled and is consumed directly by the students. The director is aware of the health problems associated with unpurified or non-boiled water and it is a definite concern for him. He stated that they do not boil/purify because (1) there is no one to delegate the task to because everyone is busy (2) there is no tank to store the purified water and (3) he has a fear of putting chlorine in the water because he does not know how much to put and does not want to intoxicate the children. He stated that he does not drink the water from school and instead drinks juices from the cafeteria. The director mentioned that most of the children are thirsty and do not care about the quality of the water, therefore consume water directly. He would like to buy a large tank that is specifically for potable drinking water and will treat the water with chlorine. However he would like to consult with someone to make sure that he has the correct proportions of water and chlorine. **There was a meeting to discuss the purchase of a tank one week after I had the meeting with the director.*

Illnesses

The typical illnesses experienced by the students include stomach problems, parasites, the flu and malaria. However the most pressing problem is parasites. The director stated that most parents do not have an interest in knowing more about healthy practices or just lack knowledge. For example, he stated that most families do not boil their water and this is a major source of gastrointestinal problems. Often he writes notes home to the parents to explain the importance of boiling water, but usually there is no change in practice. Interesting to note the school itself does not treat the water, so the parents are not only to blame. However the director is taking steps to solve this problem.

At the school there is no area to treat students who are sick, and depending on their condition they will go to the shaman, Santo Domingo or Umpe Chico. A lot of students take medicine from the pharmacy but their problems are never really solved and they usually fall sick again. Hospitals and clinics are far away and there is no transport from the school because there is no vehicle on site. There are vaccination days at the school but these are not fixed dates. Each student has a vaccination card but according to the director they lack many important shots which are critical in preventing illnesses.

Appendix 2– Laboratories for water analysis in Quito/Santo Domingo de los Colarados.

During the course of investigations carried out by Ms Azalia Cruz and myself during July and August 2007, the following locations were discovered/recommended as places that will perform water analysis:

1. Universidad Politecnica de Quito

CICAN (civil engineering department), 10 mins walk from Fundación Yanapuma office in Quito. Contact: Engineer Carola Ferrio (Ms Cruz has her phone number) should be contacted when samples have been collected to arrange the desired samples. She recommends use of ice to keep samples cool and that samples should be submitted as soon as possible after collection, with a *maximum* of 24 hours between collection and submission.

Cost: \$6 +12%IVA per analysis.

2. North of Quito, information provided by Chris Canaday (of Omaere reserve near Puno and collaborator on the Baños Secos project in Búa) via email.

“There is a good lab in Quito on Seis de Diciembre, north of the Olympic Stadium, in front of Centro Comercial El Unicornio (?). Edificio Garcia. Cant remember the name of the lab ...Bio something. They do Fecal Coliform the traditional way with dilutions and upsidedown test tubes inside others to catch gas from fermentation. \$10/sample, more or less.”

3. Private laboratory in Santo Domingo, as recommended by Dr Osvaldo Alvear of Santo Domingo municipality

Ms Cruz was the main point of contact in this regard and was unsuccessful in arranging an analysis since the doctor in question was away on holiday for 2 weeks at the time of enquiry. She was informed however that it would cost upwards of \$30 per sample.

4. EMAPA, Santo Domingo

Process: First a 'solicitud' must be written and submitted to the EMAPA office in the municipality building in Santo Domingo. In August Ms Cruz submitted it to Mr. Holger Cárdenas. You will be issued with a 'tramite' which contains a reference number which may be required later. Samples must be taken as soon as possible after collection (recommended that they are taken surrounded by ice) to La Planta de Tratamiento de EMAPA, at KM7.5 Avenida Quito. You should take a local bus to Chihuilpe and ask to be dropped at Hotel Miravalle. It takes 20 - 30 minutes from next to the mini terminal. Eng. Narcisa López (02 377 0089) receives the samples and performs the analysis at the plant. Results are then collected from Eng. Ruth Urdánigo (02 275 3357) in the technical section of the EMAPA office in the municipality building.

Cost: Yanapuma was not charged for the analysis in August after a request by Ms Cruz to Mr Marco Alvarez (09 652 4691) explaining the foundation's charitable status. She believes this would be the case with future analyses but this is yet to be tried in practice.

Note about the results of 21/08/09: When the results were received I was able to discuss with Ms López who explained that the well has a much lower faecal coliform count than the river, with some 31 coliforms/100ml in the well water. Upon review of the paper results after leaving the building, it became clear that they read the opposite to what she had said verbally, i.e. the well was much more polluted than the river (which showed 31 coliforms/100ml). Some days later having finally caught Eng Urdánigo in her office I was sent out to the plant again to speak to Ms

López, who confirmed that it was a recording error due to misreading her handwritten notes taken at the time of analysis, and a revised copy of the results for the microbiological analysis was received. She had conviction that the same mistake hadn't occurred for the chemical & physical analysis. Whilst of course mistakes can be made, care should be taken in future to speak to her when receiving results and confirm that the paper record reflects what she is saying.

Appendix 3 – Rainfall data for Santo Domingo de los Colarados and Comuna Búa de los Tsachilas.

Unsuccessful attempts were made to collect accurate rainfall data for Santo Domingo de los Colarados (assuming an absence of data for Comuna Búa de los Tsachilas) from the following sources in Santo Domingo:

EMAPA, Ministerio de Medio Ambiente, Consejo Provincial de Pichincha, Santo Domingo library.

Each place was able to recommend somewhere else to go to get the data, and options that have not yet been explored are:

1. Universidad de Tecnologia de Ecuador. (UTE), They have a campus in Santo Domingo.
2. INAMI in Quito. This is the Meteorological Office for Ecuador and so in hindsight should have been the obvious first choice to try and get this information.

Internet Generated Data

Latitude: 0.254° Longitude: -78.827° Elevation: 1 152m

Month	Prc. mm/m	Prc. mm/d	Prc. cv %	Wet days	Tmp. mean °C	Tmp. max. °C	Tmp. min. °C	Grnd Frost days	Rel. hum. %	Sun %	Wind (2m) m/s	ETo mm/m	ETo mm/d
Jan	361.1	11.6	38.1	24.8	20.2	24.5	16.0	0.2	89.7	22.7	2.6	80.6	2.6
Feb	363.2	13.0	32.4	22.5	20.4	24.8	16.0	0.2	88.7	22.1	2.7	75.6	2.7
Mar	410.2	13.2	32.6	24.4	20.7	25.2	16.2	0.1	88.8	23.9	2.5	86.8	2.8
Apr	422.5	14.1	31.2	23.8	20.7	25.2	16.2	0.1	88.5	24.5	2.4	84.0	2.8
May	300.6	9.7	47.1	23.1	20.7	25.1	16.3	0.2	87.9	23.7	2.3	80.6	2.6
Jun	181.8	6.1	61.7	18.5	20.3	24.7	16.0	0.2	88.3	22.2	2.2	75.0	2.5
Jul	91.6	3.0	59.8	14.5	20.0	24.7	15.4	0.4	87.1	27.5	2.3	83.7	2.7
Aug	107.5	3.5	55.0	15.5	20.0	24.8	15.2	0.4	86.7	26.0	2.3	86.8	2.8
Sep	148.9	5.0	61.5	18.1	20.1	24.9	15.4	0.3	87.5	22.2	2.2	84.0	2.8
Oct	191.2	6.2	48.5	20.2	20.0	24.3	15.7	0.2	88.7	22.0	2.2	83.7	2.7
Nov	173.9	5.8	54.8	18.1	19.9	24.2	15.7	0.2	88.6	20.9	2.2	78.0	2.6
Dec	244.0	7.9	45.5	21.4	20.0	24.1	15.9	0.2	89.2	21.0	2.5	77.5	2.5
Total	2 996.5											976.3	

The data in the table above was generated in the following manner using resources available on line:

Aquastat - Sistema de Informacion sobre el Uso del Agua en la Agricultura y el Medio Rural de la FAO. <http://www.fao.org/nr/water/aquastat/gis/indexesp3.stm>

Scroll down and click on the following link from the page:

[Instrumento para obtención de información climática](#) (en inglés).

I obtained coordinates for longitude and latitude for Santo Domingo using the programme “Google Earth,” which gives $0^{\circ}15'17.53''\text{S}$ and $79^{\circ}10'25.91''\text{W}$.
(Note these coordinates can be converted into decimal degrees using the following website: <http://www.fcc.gov/fcc-bin/convertDMS>).

Inserting these into the calculator yielded the table of results shown below.

Reliability: It should be noted that their accuracy is in question however since the calculator gave an altitude of 1,152m, whereas Santo Domingo actually lies at about 600m. Using coordinates for a location slightly further west (roughly where Búa lies) gave an elevation of over 2000m which is even more inaccurate (Búa being lower than Santo Domingo). Comparisons could be made by using different sources to obtain coordinates for Santo Domingo, as well as comparing data generated by the programme with available existing data for a given location. The overall pattern of rainfall shown however seems reflects the seasonal variation that exists in Santo Domingo.

Appendix 4 - Method for calculating the amount of chlorine required to (i) disinfect a well, (ii) treat a known volume of water.

(i) To disinfect a well using household bleach (5% Cl solution)¹¹.

A 0.2% Cl solution is a suitable concentration for disinfection of a well after construction or after temporary contamination (in this case cleaning/maintenance of the pump). A 0.2% solution can be easily prepared by mixing 1L bleach with 24L water.

This solution is also useful for scrubbing the inside of water tanks to disinfect them.

On 4/9/07, the depth of water in the well was 1.57m.

- Volume, V, of water in the well: $0.785 \times \text{depth} \times \text{diameter}^2$

$$\begin{aligned}\text{Therefore } V &= 0.785 \times 1.57 \times 0.73^2 \\ V &= 0.66\text{m}^3\end{aligned}$$

- Mass(g) of Cl required to disinfect is $100 \times V(\text{m}^3) = 66\text{g}$ of Cl required.

- Using 5% Cl bleach (1L = 50g Cl), $66\text{g}/50 = 1.32\text{L}$ of bleach is required.

- i.e. 1.3L bleach diluted with $24 \times 1.32 = 32\text{L}$ of water is required to disinfect the well.

(ii) Treat a known volume of water.

It is accepted that a suitable amount of chlorine to treat water successfully is an amount which satisfies not only the chlorine demand of the water (amount required to kill all microbes, when in contact with the water for at least 30mins), but that also leaves a concentration of 0.2 – 0.5 mg/l of residual chlorine¹². In order to measure this residual concentration, a DPD test kit is required as described in Appendix 5.

Being unable to purchase such a kit due to budgetary constraints, a more approximate approach (which is common practice in Ecuador by those who disinfect their water with Cl and suggested on the bottles of Ajax brand bleach) was taken. i.e. One drop of 5% bleach for every 1L of untreated water. This is possibly slightly stronger than is required (other literature suggests 3 drops of 1% solution per litre, which is roughly equivalent to Eng Narcisa López of EMAPA's suggested 1 drop of 5% bleach per 2L of water), but it was thought prudent to be cautious, particularly in view of the increased turbidity of the well water while the water table is low in the summer (high turbidity increases the chlorine demand of water), as well as the margin of error associated with 'before' and 'after' estimations of water volume in the tank.

¹¹ Methods of calculation taken from "Rural Water-Supply, A Review of Technologies," B.Skinner, WEDC Publications

¹² Refer to WELL technical brief # 46 "Chlorination," available on-line and also on the Yanapuma Foundation server.

Therefore, so long as the resulting water doesn't taste so strongly of Cl as to be unacceptable to users, the following calculations will apply. Unfortunately, there was no time to test this so I rely on the foundation to follow this up with Guillermo.

200 drops of bleach was measured using a dropper supplied with vitamin C drops and a 10ml syringe purchased from a pharmacy, and found to produce, on average, 7.5ml of liquid. Applying this to a 1100L tank at 1 drop per litre gives **41ml of 5 % bleach required per full tank**. Fractions of this are applicable depending on the amount of untreated water pumped into the tank from the well. Calculating the difference between the estimated volume of treated water remaining in the well before turning on the pump and the estimated total amount of water in the tank after pumping gives the total amount of water added to be treated.

The water in the tank must be well stirred after the addition of the bleach

It is imperative to leave the Cl in contact with the water for at least 30mins in order for all microbes to be killed. As such it was recommended to Guillermo that someone be in charge of this process, and that the tank be filled and chlorinated at the end of each day, so as to have treated water available at the start of each new day, in sufficient quantity to meet the daily demand.

Appendix 5 – Vendors of testing kits to measure residual chlorine.

In order to accurately measure the amount of chlorine required to safely disinfect the water in the school, I was interested in obtaining a testing kit to measure residual chlorine in a water sample.

Having searched in a number of pharmacies, botiquins and hardware stores it was apparent that such kits are not readily available over the counter. Further investigation/recommendations produced the following options:

1. Merck, Quito.

I contacted Mario Morón at Merck

(Phone: (593)-2-2987293, Fax: (593)-2-2981659, Celular: (593)-094040219, Email: mmoron@merck.com.ec)

and enquired about the following **Analizador de Cloro colorimétrico:**

#114978 (Test Cloro (cloro libre) DPD, 0.1, 0.2, 0.3, 0.4, 0.6, 0.8, 1.0, 2.0 mg/l).

Price: US\$274

2. HBM Equitecnica, Quito

Eng. Narcisa López of EMAPA suggested contact this company and asking for Eng. Mauricio Durango. (tel: 02 464577, 02 454076).

Price: Ms López estimated that it would cost between US\$150 – 200.

3. Vacamena, Santo Domingo, via Quevedo Km 5-6.

Price: Ms López estimated that it would cost between US\$150 – 200.

Purchasing a kit as such somewhat exceeded available budget at the time, as such the more approximate method of chlorination described in Due to budgetary constraints