

Running Head: WATER AND HEALTH IN TZUNUNÁ, GUATEMALA

Water and Health in Tzununá, Guatemala

Catherine E. Herrington

University of Virginia

## Introduction and Background

The focus of this paper is on water and health related issues in the community of Tzununá, a small village in the highlands of Guatemala. This paper will first provide some of the historical context of Guatemala that influences the ongoing work by students at the University of Virginia, along with background information on the demographics, social infrastructure and the health system of both Guatemala as a whole, and the community of Tzununá in particular. The next section defines the problem of water-borne illnesses and offers general information on the magnitude and etiology of this problem including various factors related to the transmission of water-borne illnesses that put the community of Tzununá at risk. Lastly, I will explain the qualitative research study that was actually done by me and my colleague, including the rationale, strategies and the overall objectives of the work. I will end with a summary of significant findings and a brief list of recommendations for future work in the community of Tzununá.

## Historical Context

The country of Guatemala is located in Central America and shares its northern border with Mexico. Guatemala has a long history of human settlement, and is home to many archaeological sites that suggest the presence of hunter-gatherer populations as far back as 12,000 BC. In the 1500s, Guatemala was occupied by Spain until it declared its independence from the colonial power on September 15, 1821, a date that is still celebrated widely in the country today.

The early 20<sup>th</sup> Century in Guatemala was characterized by the emergence of a democratic government in the midst of political and economic struggle over land rights during a time when 70% of land was owned by 2.2% of the population (Schlesinger & Kinzer, 1982). The United Fruit Company, a U.S. owned company, controlled a majority of the land, along with the only major oceanic trade port and all of the railroad lines in the country. It also employed and controlled the wages of the majority of agricultural workers, limited the ability of unions to work towards fair standards of work and pay, and was exempted by the Government from import taxes that would have returned wealth to the country. In 1945, the first freely elected Guatemalan president, Jacobo Arbenz, took power and immediately worked to institute a series of reforms that would end the United Fruit Company monopoly. In 1954, accusing Arbenz of communism, the CIA orchestrated a coup which over-threw the Arbenz government and launched the country into a Civil War between the government and the so-called “guerrillas” – I prefer the Spanish term *companeros* – who were fighting to reclaim their rights to the land and to regain control over their economy and government. In 1996, the Civil War officially ended with the signing of the Peace Accords, which were negotiated with the help of the United Nations. For more on the

complexities of this recent history, *Bitter Fruit*, written by Stephen Schlesinger and Stephen Kinzer, originally published in 1982, gives a thorough account of the history of United Fruit Company and the U.S. involvement in Guatemala.

Although the history presented here is necessarily brief, it gives the flavor of this country's past as an unsettled and somewhat embittered one beginning with a long established indigenous tradition, followed by colonization by the Spanish, subjugation of land by a more powerful Mestizo population, a resurgence by the indigenous Mayan population to reclaim land (and thereby reestablish a way of creating wealth and ending poverty), and the current state of relative peace. This history of Guatemala, and of the indigenous population of the country in particular, is decidedly shaped and influenced by a long history of domination by outside groups and a determined resistance to reclaim their land, their culture and their independence.

#### Demographics and Social Infrastructure

Guatemala has a land area of 108,889 km<sup>2</sup> and is divided into 22 departments, which are further subdivided into 332 municipalities. The total population of Guatemala was estimated to be 13,018,759 in 2006 (PAHO/WHO, 2007). The community of Tzununá is located in the municipality of Santa Cruz la Laguna, which is composed of 5 communities on the north shore of Lago de Atitlan, situated in the department of Sololá. The municipality of Santa Cruz la Laguna has about 4,200 residents according to the 2002 local census, of which about 99% of the people are indigenous Mayan. The overall percentage of indigenous Mayan countrywide is 41% (PAHO/WHO, 2007), so it is clear that there is a higher concentration of indigenous Mayan people in this rural area of Guatemala, which gives this part of the country a distinctly different feel.

The pueblo of Tzununá is located on the north side of Lake Atitlan, and its estimated 1,302 residents, of which 641 are men and 661 are women, live primarily in adobe mud-brick or cinder block homes along the steep mountainsides that rise up over the lake. In terms of community infrastructure, in the village of Tzununá, there are 280 homes, of which 225 have water service, 3 have drainage and 196 have electricity, each provided by the municipality (Viviendas y Servicios de la Poblacion, 2002). According to the 2002 local census, there were 648 individuals under the age of 14 (this is 49% of the population of Tzununá, slightly higher than that country average of 44%). Only 21 individuals were over the age of 65 in Tzununá in 2002, which suggests a close correspondence to the average life expectancy for the country, which is 67.2 years.

Although the official language of Guatemala is Spanish, most of the residents of Tzununá speak K'eqchik'ik'al, which is one of the 22 distinct Mayan languages spoken in the country. In Tzununá, Spanish is generally spoken only by individuals who either work outside of the village or have attended school beyond the primary elementary level. In the municipality, the closest secondary school is a boat ride and then a bus ride away in the city of Sololá, which necessarily limits the number of people in the community who have both the time and the money to pay for transportation to the school. On the 2002 census, only 2 individuals in Tzununá were counted who had attended school beyond primary level. Most likely, these two individuals were men, who were able to leave the community to either work or attend school. According to the Pan American Health Organization (PAHO), a division of the World Health Organization (WHO), in 1998 "illiteracy in the departments with 75% to 100% indigenous population was 52.2% (Health System Profile Guatemala, 2007).

### Health Care System

Health care needs in the country are covered by 4 main types of providers: 1) the government run Ministry of Public Health and Social Welfare, which has 43 hospitals, plus regional health centers, local health posts and health promoters; 2) the Instituto Guatemalteco Salud Social (IGSS, similar to Social Security), which offers health insurance through employers and has its own hospital system; 3) private hospitals and pharmacies; and 4) non-profit, non-governmental organizations (NGO), which help to fill in the gaps, particularly in rural areas (PAHO/WHO, 2007). 70% of the population does not have IGSS or private insurance. Traditional medicine and home remedies are also part of daily life in Guatemala, and according to one Guatemalan, religion plays a role in all aspects of life, including health – “everyone believes in something” (J. O. Gonzalez, personal communication, July 6, 2010). (The specifics of this kind of traditional and local knowledge regarding health are an area of interest that I hope to explore in more detail in the future, but it is worth noting here because a hint of this kind of influence emerged from our research.)

In Tzununá, there is a local health post run by the Ministry of Health which is open only a few days a week in the mornings, and generally focuses on prevention of diseases and maternal/infant care, including child vaccinations. The rest of the health care needs in Tzununá are filled by a local NGO, Mayan Medical Aid, which is based out of Santa Cruz la Laguna. This NGO is run by a husband and wife team (the husband is American and the wife is Guatemalan) and has a Guatemalan nurse and dental student; the remainder of the staff are foreign medical students fulfilling community health clinical rotations. Each week, the NGO holds outreach clinics in the other communities in the municipality – the outreach clinic in Tzununá is generally held in a classroom in one of the school buildings on Tuesday mornings. They provide medication for common illnesses which include skin rashes and diarrhea. More serious

conditions are referred to the hospital in the capital city of the department, Sololá, which is also the location of the secondary school.

In terms of overall health concerns in Guatemala, the following indicators, which are relevant to the community of Tzununá, are generalized for the entire country:

- *Chronic malnutrition* in rural areas the reported prevalence is 55.5%,
- *Child mortality* is greater in rural and indigenous populations (66 and 69 per 1,000 live births respectively),
- *Poverty* is widespread with 76.1% of the indigenous population defined as “poor” by the World Bank and 29% defined as “extremely poor” (PAHO/WHO, 2007).

The Ministry of Public Health and Social Welfare is responsible for monitoring water quality and disposing of liquid and solid wastes, but according to a 2007 report, “no regulatory entity or regulator exists for drinking water services and treatment. Provision of drinking water services and treatment is decentralized and each municipality regulates it in accordance with the Municipal Code” (PAHO/WHO, 2007). Locally, water quality in Tzununá is tested by a local health and environmental inspector who works out of the Ministry of Health office located in San Pablo, another pueblo located on the north side of Lago de Atitlan.

Environmental determinants of health also play a big role in Guatemala in general and in Tzununá in particular. As summarized by the PAHO, “the climatic changes from the dry season to the rainy season, and vice versa, have a direct and significant impact on health, for example, by altering the availability of food and clean water. These conditions along with Guatemala’s topography cause the country to be vulnerable to various natural disasters, including floods, droughts, landslides, earthquakes, and volcanic eruptions” (PAHO/WHO, 2007). The highland

community of Tzununá is particularly challenged geographically as it is surrounded by steep terrain on three sides and, on the forth side, is bordered by the lake. This geography creates a decidedly down- and lake-ward flow of rain water and drainage in Tzununá, and also limits access to the community via roads and vehicles, which both inhibits the inward flow of resources of all kinds and the outward flow of, for instance, community generated waste.

### Water and Health

The literature on water reminds us that an understanding of the connection between water and health goes at least as far back as Hippocrates in B.C. 350 (Feachem, McGarry, & Mara, 1977; Montgomery & Elimelech, 2007). For people living in most developed countries, water access and water quality are parts of life that are simply taken for granted. However, it is estimated that water-related illness is responsible for the deaths of 1.8 million people every year, and it is estimated that 88% of the global burden of disease is attributable to unsafe water supply, sanitation and hygiene, and is mostly concentrated on children in developing countries (World Health Organization, 2004). These statistics are certainly demonstrated in rural Guatemala, particularly in the community of Tzununá. In a paper published by the UVA School of Engineering, which made the case for their water filtration project in Tzununá, the doctor of the local NGO which operates the mobile clinic in Tzununá reported that “most of the medical cases he comes across are related to waterborne illnesses” (Allam, Hashimi, & Houle, 2010, p. 3).

Waterborne illnesses are commonly classified into 4 types: viral, bacterial, protozoal and helminthic (a.k.a. parasitic worm) (Bradley, 1977). When considering ways to improve water



supplies, the major transmission pathways<sup>1</sup> are of primary concern. In particular, transmission of disease is a result of:

1. Ingestion of water (includes fecal–oral pathogens, arsenicosis, fluorosis, and diseases from other toxic chemicals);
2. Lack of water resulting in inadequate personal hygiene (includes diseases such as trachoma and scabies);
3. Poor personal, domestic, or agricultural hygiene (includes person-to-person transmission of fecal–oral pathogens, food-borne transmission of fecal–oral pathogens as a result of poor hygiene, or use of contaminated water for irrigation or cleaning);
4. Contact through bathing or wading with water containing infectious organisms (such as *Schistosoma*);
5. Vectors proliferated in stagnant water (i.e. malaria, caused by mosquitoes that breed in stagnant water) (Prüss, Kay, Fewtrell, & Bartram, 2002).

It is also worth reiterating an important point made by Prüss et al. that the links between water and health should include the role of inadequate water for food production, which impacts the available nutrition in a community. Additionally, it has been argued that “time spent in search of water forces children to miss school and women to forgo potential opportunities to engage in small business endeavors, such as growing and selling vegetables or weaving mats” (Prüss, Kay, Fewtrell, & Bartram, 2002). Certainly, with water being such a major part of everyday life – an idea that is clearly supported by our research in Tzununá – any time spent in the acquisition and

---

<sup>1</sup> These pathways, of course, translate into the common daily activities and routines of individuals and families in most communities, but particularly in Tzununá, where we observed these activities routinely during our time there.

treatment of water would certainly detract from other household chores or from pursuing opportunities to improve health, education and economic status.

Several other major statistics help to highlight areas on which future engineering projects might choose to focus:

- Improved water supply reduces diarrhea morbidity by between 6% and 25%, if severe outcomes are included.
- Improved sanitation reduces diarrhea morbidity by 32%.
- Hygiene interventions including hygiene education and promotion of hand washing can lead to a reduction of diarrheal cases by up to 45%.
- Improvements in drinking-water quality through household water treatment, such as chlorination at point of use, can lead to a reduction of diarrhea episodes by between 35% and 39% (World Health Organization, 2004).

These statistics are supported by a meta-analysis of the impact of various interventions which concluded that increasing water quantity reduced the occurrence of diarrheal diseases by 25%, whereas point-of-use (POU) household water treatment and improved sanitation led to reductions in diarrheal diseases of 35% and 32%, respectively (Fewtrell, Kaufmann, Kay, Enanoria, Haller, & Colford Jr., 2005). The authors suggest that, interestingly, a combination of multiple interventions do not necessarily convey improved benefit by decreasing water related illnesses.

### Water in Tzununá: the Big Picture

In the fall of 2009, students from the School of Engineering at the University of Virginia initiated a water filtration project in Tzununá. Their plan was to install 20 bio-sand water filters in a pilot project aimed at improving water quality at the point of use (POU), meaning that the

filters would be placed in individual homes and not at the source of the water supply. Participants were selected based on several criteria, and in exchange for a payment of 100 Guatemalan Quetzals (roughly US \$12.50) and participation in an education and training program focusing on basic hygiene and use and maintenance of the bio-sand filter, the participants would receive a bio-sand filter that would have a 10-year life span and would reportedly filter an estimated 99% of waterborne contaminants (Allam, Hashimi, & Houle, 2010).

The work by the engineering students is being done in conjunction with the UVA-Guatemala Initiative (UVA-GI), an interdisciplinary organization with the goal of facilitating the development of long-term, sustainable relationships between the University of Virginia and communities in the highlands of Guatemala. My participation in the project was intended to provide a more well rounded view of the community in Tzununá. My research partner Julian Wiebe-Johnson and I were asked to engage in a project which would help to shed light on general community perspectives on water, with an eye toward assessing whether or not POU filtration systems is the most pressing need for the community. In addition, we hoped that our research would help to situate this project within the “bigger picture” of Tzununá community health needs.

To accomplish this task, we applied for and received Institutional Review Board approval to conduct a Photovoice project. Photovoice (Wang and Burris, 1994) is a qualitative research strategy that encourages participants to capture on film visual representations of a particular concept, and then use the captured images as a means to foster communication on the topic. The topic for our project was the community’s perception of water and its relationship to health. The specific research aims for this project were to identify and codify community perceptions about

water and health, and to provide a qualitative study for use in informing sustainable water development projects in the community.

The actual work that we did in Tzununá ended up taking a different form from the Photovoice project described. The alternative strategies that took shape included a house-to-house survey of 52 households, a focus group discussion involving 33 women who were participating in an NGO sponsored nutrition program, plus conversations with business leaders, NGO leadership, the director of the schools in Tzununá, and also a member of the Tzununá Emergency Committee. All of this was supplemented by hours of visually surveying the physical attributes of the communities including the roads, walking paths, rivers, bridges and selected homes.

Once we arrived “on the ground” in Tzununá, as researchers, we were struck with several realities that caused us to reassess our plan to conduct a Photovoice project. The language barrier, a result of the fact that most residents of Tzununá speak K'eqchikal and not Spanish, made the development of even surface level relationships (such as familiarity with local shop owners) more difficult than anticipated. This language barrier also made it difficult for us to imagine organizing a community meeting about the project on our own, without the help of a contact in the community. Also, surprisingly, the availability of such a community contact was not as easy to come by as we might have thought. As a group, the UVA-GI only had a few contacts, and most of them were already spending a significant amount of their spare time helping with other parts of the filtration project.

We soon realized the cost of developing the roles of film from the disposable cameras (about Q70 or U.S. \$10) was roughly 70% of the cost of one of the bio-sand filters to a participating family; again, this was not a barrier that could not be overcome, but the relative cost

certainly caused us to reassess the value of Photovoice as a good first-time research strategy. We also became concerned that we would need more than 3 weeks to implement a Photovoice project, which we soon realized may very well have involved introducing the *technology* of how to use a camera to study participants for the first time. Whether real or perceived, these barriers led us to reassess our work and consider alternative ways for meeting our research goals.

An alternative plan presented itself quickly in the form of a tip from Scott Schubert, who is UVA-GI's long-term, in-country project coordinator – he is a volunteer who has been on the lake since July, and plans to stay until spring of 2011. Since his arrival, he has been directing and providing much of the physical and intellectual labor for the filter installations in each participating home in Tzununá. During one of his filter installations, he observed a woman at one house in particular who turned a valve downstream from her house, which resulted in a sudden abundant supply of water at her house, when before there had been no water flowing from her pipes. It appeared that she had some control over her access to water and water pressure from her pipes.

So, now the relevant question, one that seemed to naturally come before any concern about water quality, was one of water *access*. Is it possible that while the town has a gravity-fed pipe system, some people in the town don't have access to water via these pipes? That possibility seems strange from our western perspective where the existence of infrastructure implies that the infrastructure is operational; but knowing that we could take nothing for granted, this question seemed like a natural place to begin our investigation. What followed was a house-to-house survey of 52 homes (18% of the 280 homes in the village) conducted over 3 days in various sectors of Tzununá. We were prepared with a series of questions focused on water access, and asked the various questions as judged appropriate based on responses (see Appendix for the list

of questions). As essential part of the survey process was utilizing the help of a translator, Cecilia<sup>2</sup>, who was able to help us translate between the Keqchikal, which was spoken by the majority of community residents that we spoke with, and Spanish which Julian and I were using.

Another important aspect of our initial research on the ground in the community was seeking out connections with leaders of another NGO working in Tzununá, Amigos de Santa Cruz, who have a nutrition program for mothers and children. The director of this NGO introduced us to the program director for the nutrition program, Micaela Ujpán, who invited us to participate in an upcoming meeting of the women's group to be held in Tzununá. This was a fortuitous meeting and turned out to offer more than we were expecting! With Micaela's encouragement, she helped to facilitate a focus group discussion where we asked a series of questions to small groups of about 4 – 7 women, adding a few at times when responses seemed to warrant some follow up. Micaela first asked us to go through our questions with her – she wrote each of them down in her own notebook. She also helped us add a few questions about what possible solutions would be to problems mentioned by the women. Then, when we sat with each group of women, Micaela had us ask the questions first in Spanish, and then she translated them into Keqchikal. We ended up receiving feedback from 33 women in total. A transcript of the audio-recorded conversations conducted in both Spanish and Keqchikal is forthcoming.

---

<sup>2</sup> Cecilia is a 16 year old girl who lives in Santa Cruz la Laguna. By the time we worked with her, she had experience helping to translate from Spanish to Keqchikal while working with other students from the University of Virginia who were conducting a community needs assessment in Santa Cruz. Cecilia impressed me with her willingness to boldly walk into the homes of individuals in Tzununá and obtain their consent to answer questions from *extranjeros* (foreigners). Again and again, I had the impression that she was a good advocate for us and also had a good memory, which allowed for more accurate written records of our conversations with the residents. She also provided valuable insights about the (sometimes surprising to her) differences between Tzununá and Santa Cruz, which were only a 15-minute boat ride away from each other in the same municipality.

Also important to note, during our conversations with the director of the NGO we also learned that this NGO runs their own filter program in the municipality, which uses 2 other types of filters – Ecofiltro, using ceramic filtration technology, and Q-beta filter, which uses candelas. They are also about to begin a pilot project using a new type of microfiber technology. Additionally, they are in the process of starting an eco-latrine program to address sanitation needs in Santa Cruz.

We also conducted an interview with Don Santiago Simon Perez, who is the secretary on the Comité Emergencia (Emergency Committee) in Tzununá. Don Santiago is the committee member with whom Scott Schubert has been working during filter installations; as a way of encouraging sustainability of the project, he is being trained with regard to the bio-sand water filter installation and maintenance along side the participating families. Our questions to Don Santiago were particularly about water issues in Tzununá, including questions about the quality of the water, where people in the community obtain water, and what the needs are in the community regarding water in general. Transcripts of this interview conducted in Spanish are forthcoming.

In addition to these various conversations with residents of Tzununá, we were able to do a thorough survey of the area, and recorded over a dozen videos of water-related sights in the town. These have been posted to a video-sharing website, protected by privacy settings, and they, along with complete captions, will be available to future participants of UVA-GI.<sup>3</sup>

---

<sup>3</sup> Credit for the videos of Tzununá, including their organization, editing, posting, and captions, belong to Julian Wiebe-Johnson. This contribution is probably one of the most important ones to come out of this project.

Although a final summary and detailed recommendations for UVA-GI are not yet complete, for the purposes of this paper, here are a few summarizing concepts and ideas which came out of our research that will likely inform future work of the project:

- Water access in homes is dependent on several factors, including the amount of rainwater, location/elevation of home in the village, time of day, status of the gravity-fed pipe system.
- The source – or *nacimiento* – of the water for the community is located in the mountains above the village. Reportedly, this is a spring that is located near Pajomel, another village in the municipality located about an hour and a half long walk uphill from Tzununá.
- The gravity-fed pipe system was recently damaged during Tropical Storm Agatha, in May of 2010. Repairs by the municipality (specifically by the *fontaneros*, or plumbers, who are employed by the municipality) have not yet been completed, which is affecting water access.
- When water is not available from the pipe system, community residents, including women and children, obtain water from the river or Lago de Atitlan. They also use the river and the lake for washing clothes, bathing, and for recreation.
- Geography (the steep slopes of the mountain sides) and climate (rainy season) create exceptional challenges related to both access and drainage. Large volumes of sometimes fast moving water create landslides, which carry rocks that may damage the pipe-system, or damage homes. Water carries mud, garbage and, likely, unseen contaminants through the town, past the homes, and eventually into the lake.
- Conversations with community residents confirm local census data from 2002, which says that only 3 of 280 households have adequate (or any) drainage.



- There is a lack of adequate sanitation, sewage and trash removal infrastructure.
- Perceptions of water quality within the community vary, and understanding of the concept of “clean” water may not necessarily imply that water is potable and safe to drink.
- Water quality testing is needed to ensure that the filtration technology that is in use (regardless of type) is effective for the particular water containments in Tzununá’s water supply, regardless of source (mountain top spring, river, or lake).
- Well documented epidemiological studies on the types and incidence of water-borne illness in Tzununá are needed to provide for baseline data, and to facilitate comparative studies regarding the effectiveness of POU water filtration systems, or other sanitation and hygiene interventions that may come in the future.
- More research is needed to ascertain whether the community members view a connection between water quality and health, in particular whether they believe that contaminated water can lead to diarrheal illnesses. Anecdotal information from an American doctor practicing in Tzununá suggests that residents believe that diarrheal illnesses are "the result of a person getting too much sun, being exposed to too much wind, or having had a hex put on them" (C. Sinkinson, personal communication, August 9, 2010). Although these explanations do not fit within a Western bio-medical perspective, my strong recommendation is that these concepts must be accounted for when developing an educational campaign from a water/engineering or health/medicine perspective. Indeed, as suggested by a subject matter expert in education, anthropology and global health, “there is often substantial rationale for [these explanations for the causes of illness] (which remains invisible to outsiders to the cultural/social system). At the least these

views must be considered as serious and as having considerable cultural explanatory power as well as influence in everyday practices. Any innovation in the latter must take them into account and accord them the necessary respect” (D. Hoffman, Professor at the Curry School of Education, UVA, personal communication, August 28, 2010).

- Interdisciplinary collaboration will enhance all future projects in this region. Experts in the areas of engineering, development, economics, education, anthropology and cultural studies, medicine and nursing will each make contributions which will lead to well-informed project implementation, and each perspective should be considered as valuable and as necessary as any other.

Sustainability is one of the primary goals of the University of Virginia-Guatemala Initiative. Following this research, specific suggestions are offered with an eye towards promoting sustainability of this initiative. First, UVA-GI should work to further its connections with all existing community groups, including the NGOs Mayan Medical Aid and Amigos de Santa Cruz. Secondly, follow up evaluation of the bio-sand filtration project should be a priority. This evaluation should include not just issues related to day-to-day usage, cost effectiveness, and convenience, but also the effectiveness of the filtration technology to purify and clarify the water in Tzununá, and an evaluation of whether or not the filters are actually reducing water-borne illnesses. An evaluation should be conducted with regard to all households currently using POU filtration technology, regardless of type or provider. Finally, it is imperative that UVA-GI takes action on future projects only after clear communication and collaboration with the community of Tzununá.

## Summary

As has been described, the information provided by this research was gained through observations and conversations with community members. Whether or not our efforts revealed any new information to the leaders of the UVA-GI is a question for which the answer is uncertain. What is certain, however, is that our efforts were comprehensive enough that through our *experience* of working in this community over the course of about 2 and a half weeks, we uncovered and touched upon many of the major issues currently being discussed in the literature with regard to water and its relationship to health, particularly in developing countries. Among these major issues is the availability of water (water access), water quality, sanitation, drainage, and trash removal services. Research suggests that POU water filtration alone, as in the program currently being implemented by UVA-GI, can significantly contribute to a decrease in the rates of water-borne illnesses, especially when accompanied by the kind of hygiene education program being offered to the mothers participating in this project. What remains to be seen is whether or not this project, and others which are currently in progress or forthcoming, will provide sustainable levels of improved health and quality of life in ways that are both culturally appropriate and desirable to the community of Tzununá.

## References

- Allam, M. M., Hashimi, H., & Houle, E. S. (2010, April). *A Culture-Centric & Sustainable Systems Engineering Approach: Water Filtration in Guatemala's Tzununá*. Retrieved July 2010, from IEEE Systems and Information Engineering Design Symposium: <http://www.sys.virginia.edu/sieds10/bestpapers2010.html>.
- Bradley, D. J. (1977). Health Aspects of Water Supplies in Tropical Countries. In R. Feachem, M. McGarry, & D. Mara (Eds.), *Water, Wastes and Health in Hot Climates* (pp. 3 - 17). London: John Wiley & Sons.
- Fewtrell, L., Kaufmann, R. B., Kay, D., Enanoria, W., Haller, L., & Colford Jr., J. M. (2005). Water, sanitation, and hygiene interventions to reduce diarrhoea in less developed countries: a systematic review and meta-analysis. *Lancet Infectious Disease*, 5, 42 - 52.
- Montgomery, M. A., & Elimelech, M. (2007, January 1). Water and Sanitation in Developing Countries: Including Health in the Equation. *Environmental Science & Technology*, 17 - 24.
- Municipality of Santa Cruz La Laguna, Sololá. (2002). Poblacion Demografico Santa Cruz La Laguna, Solola. *Population Demographics*.
- Municipality of Santa Cruz La Laguna, Sololá. (2002). Viviendas y Servicios de la Poblacion. *Census of Household and Services*.
- PAHO/WHO. (2007). *Health System Profile Guatemala*. Pan American Health Organization/World Health Organization (PAHO/WHO), Health Policies and Systems Unit, Health Systems Strengthening Area (HSS/HP), Washington DC.

Pan American Health Organization: Regional Office of the World Health Organization. (n.d.).

*Regional Core Health Data System - Country Profile: Guatemala*. Retrieved August 29, 2010, from <http://www.paho.org/english/sha/prflgut.htm>.

Prüss, A., Kay, D., Fewtrell, L., & Bartram, J. (2002). Estimating the Burden of Disease from Water, Sanitation, and Hygiene at a Global Level. *Environmental Health Perspectives*, 110 (5), 537 - 542.

Schlesinger, S., & Kinzer, S. (1982). *Bitter Fruit: The Story of the American Coup in Guatemala*. Garden City, NY: Doubleday & Company, Inc.

Wang, C., & Burris, M.A. (1994). Empowerment through photo novella: portraits of participation. *Health Education Quarterly*, 21(2), 171 - 186.

World Health Organization. (2004, Nov.). *Water Sanitation and Health*. Retrieved August 30, 2010, from Water related disease: Publications:  
[http://www.who.int/water\\_sanitation\\_health/publications/facts2004/en/index.html](http://www.who.int/water_sanitation_health/publications/facts2004/en/index.html)

## Appendix

## House-to-House Survey Questions

Spanish – As used in the surveyEnglish Translation

¿Hay agua aquí en su casa?

Is there water here at your house?

¿Para qué usan agua?

How do you use water?

¿Que hace usted con el agua?

What do you do with water?

¿Tienes presión del agua?

Do you have water pressure?

¿De dónde viene el agua?

Where does the water come from?

¿(Cuando no hay agua), dónde obtienen el agua?

When there is no water, where to you obtain  
water?¿Cuantos minutos u horas cada dia tienes agua  
del tuvos?How many hours or minutes each day do  
you have water in your pipes?

¿Cómo miran el agua? Sucia o limpia?

How do you see the water? Clean or dirty?

¿Tienen drenaje?

Do you have drainage?

¿Porque no tienen drenaje?

Why don't you have drainage?