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An Evaluation of the Use of Composting Latrines and the Perceptions of Excrement in Ngäbe Communities in Panama

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An Evaluation of the Use of Composting Latrines and the Perceptions of Excrement

in Ngäbe Communities in Panama

by

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DEDICATION

To Brad Akers, I dedicate this work to you. You bring joy and laughter to my everyday life. Over the past four years, your support has made all of my accomplishments possible. From Madagascar to Panama, you bridged the gap. Thank you for always understanding me, even when my words do not make sense. Here's to never having to start sentences with "I should've…" Most importantly, here's to our future together.

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ABSTRACT

Engineers are exploring a new paradigm in wastewater treatment; focus is shifting to the recovery and reuse of energy, water, and nutrients. Ecological sanitation (EcoSan) technologies, which allow for this recovery and reuse, are an environmentally sound option for the future of sanitation. While the technology to achieve this goal of recovery and reuse exists, a limiting factor is user attitudes and perceptions. Social sciences, especially anthropology, can and should inform engineering projects to ensure socio-cultural sustainability.

Since 2003, rural indigenous Ngäbe communities in Panama have been implementing ecological sanitation projects, mainly double vault urine diverting (DVUD) latrines known as composting latrines. With the help of governmental agencies and the Peace Corps, over 200 of these latrines have been built across the province of Bocas del Toro and the Ñö Kribu region of the Comarca Ngäbe-Buglé. To this point, little monitoring and evaluation has taken place in these communities.

Interviews and observations in 23 communities throughout this coastal region revealed that 70.6% of composting latrines constructed (n = 201) were completed and 71.8 % of the completed composting latrines (n = 142) are still in use. Based on observations, 65% of the latrines in use were determined to be used properly, which translates to the proper use of 45.8% of the completed latrines. To promote composting latrine adoption, social marketing and pilot latrine projects can be employed, and to improve the percentage of properly used composting latrines, education campaigns can be deployed as follow up.

Utilizing suggestions made in recent literature as guidelines for the proper application of compost, analysis showed that new training messages have not reached the communities with older composting latrines. Informal interviews in 18 communities identified compost production, the lack of mosquitoes and flies, and the lack of odor as the most frequently mentioned advantages. With respect to the disadvantages, the inability to use water for anal cleansing was the most frequently mentioned disadvantage.

In three communities, informal interviews and 124 surveys were used to characterize the perceptions of Ngäbes regarding feces and their use of composted human excrement as a soil amendment in agriculture. In general, the responses reflected perceptions that show no strong barrier to the operation and maintenance of composting latrines. Utilizing the Fisher's exact test and Kruskal-Wallis test, the community, sanitation classification, gender, primary occupation, and age all showed some level of association with the perceptions expressed in the survey responses.

Filo Verde was more likely to respond with perceptions accepting of composting latrine use, while San San Puente was more likely to respond with "don't know" or with perceptions objecting to composting latrine use. At times, up to 37.9% of the respondents responded with negative perceptions; thus, evaluations of perceptions prior to the implementation stage are still beneficial. One discrepancy existed between the overall majority and the composting latrine user majority; 56.5% of the 124 respondents perceived the handling of human excrement as a great health risk, whereas 59.1% of the 22 composting latrine users did not. As expected, the composting latrine users responses represent the positive perceptions of feces and their reuse, but pit latrine owners were most likely to respond with perceptions contrary to those indicative of proper composting latrine behavior. Overall, males were more likely to agree with the perceptions related to composting latrine use. Regarding primary occupations, farmers consistently replied with more favorable perceptions of feces and their use as a soil amendment, while banana company workers showed more dissidence. Additionally, older participants gave responses reflecting favorable perceptions of composting latrines more than younger participants. Finally, education and household size do not have any statistically significant associations with the perceptions reflected in the survey responses.

CHAPTER 1: INTRODUCTION

Designed to reduce poverty worldwide, the Millennium Development Goals list the access to improved sanitation as a key target. Despite efforts to increase access, 2.5 billion people still lack access to improved sanitation facilities (WHO/UNICEF JMP, 2013). And while improving the access to sanitation, considerations must be made for sustainability, namely the environmental, economic, and social components of proposed projects and technologies.

With respect to environmental sustainability, engineers are exploring a new paradigm in wastewater treatment with a focus on the conservation, recovery, and reuse of energy, water, and nutrients (Mihelcic et al., 2011). Related to this new paradigm, the new and/or reinvented sanitation technologies, which collect excreta, sanitize it, and reuse the nutrients from excreta for beneficial purposes, are dubbed ecological sanitation (EcoSan). While the technology to achieve this goal of resource conservation, recovery, and reuse exists, a decisive factor in its success is user attitudes, including perceptions and motivations. For example, the environmental benefits of EcoSan toilets and latrines are known; however, the user attitudes and perceptions regarding the operation and maintenance (i.e. handling composted feces) specific to these sanitation systems may be limiting factors. For example, according to Drangert (2004), a key barrier to more extensive implementation of ecological sanitation is human perception. At the same time, the perceived benefits of free fertilizer from human excreta can serve as an incentive to EcoSan toilet or latrine users. In order to overcome these barriers or better define these incentives, further research is needed to better understand the users' perceptions and their role in sanitation decision-making.

On the national level, 71% of Panamanians have access to improved sanitation, but only 54% of rural Panamanians have access, as defined by the Millennium Development Goals (WHO/UNICEF JMP, 2013). The indigenous areas of Panama, most of which are designated as rural, experience the highest rates of poverty and the lowest levels of sanitation coverage. In indigenous areas, 96% of the indigenous live below the poverty line, and 85% live in extreme poverty (World Bank, 2011). In rural areas outside of designated indigenous lands, 89% of the indigenous live below the poverty line, and 65% live in extreme poverty (World Bank, 2011). The reported 54% sanitation coverage in rural Panama might also be an overestimate. The presence of a latrine at a household does not guarantee that the household is using the latrine. Little research has been conducted to evaluate the usage of latrines in Panama after implementation of a sanitation technology is complete.

In Panama, EcoSan technology typically signifies a double vault urine diversion (DVUD) latrine installed outside of the home, and not necessarily on the family compound. The common terminology for a DVUD latrine in the field and in this research is a "composting latrine." For the purpose of this research, the term "composting toilet" will refer to composting sanitation technologies installed within the household and typically found in the developed world. In Panama the composting latrine has been implemented primarily out of necessity. For example, coastal and fluvial regions have high water tables that make pit latrines disadvantageous because of possible flooding and groundwater contamination. In areas with sandy soil, wet sand's low friction coefficient and angle of repose make pit latrines prone to collapse. In areas with clayey soil, the low permeability of clay makes septic tank systems technically and economically infeasible. The tank effluent is unable to percolate and undergo subterranean treatment, and to build a proper leach field would be cost-prohibitive, as would the future expense of removing sludge from a septic tank. Thus, in regions of Panama such as Bocas del Toro, Comarca Ngäbe-Buglé, Darien, and Comarca Emberá-Wounaan, composting latrines have met the technical constraints for many communities, whose proximity to the ocean or rivers result in high water tables and/or frequent flooding. As a sealed system, the concrete composting latrine design protects the excrement from incoming water, and, in turn, the design prohibits runoff from carrying fecal contamination to local water sources. If maintained to promote aerobic decomposition, the composting latrine can potentially promote pathogen destruction, avoid environmental contamination, and produce a beneficial soil amendment. Presenting the most economically and environmentally sustainable method to meet the sanitation needs in these communities, development workers and governmental agencies have introduced composting latrine projects to indigenous communities in the regions listed above. Citing the benefit of compost production, the residents of these areas express interest in the technology, but Panamanian governmental agencies are now skeptical, especially regarding the efficacy of the pathogen removal.

With respect to social sustainability, the composting latrine requires a higher interface with the user when compared to a pit latrine. For example, sanitation practices are often a very private matter; in turn, traditions, attitudes, and perceptions regarding sanitation and feces are intrinsic to a culture. A successful sanitation project requires behavior change, and operation and maintenance steps unique to a composting latrine necessitate a greater change in behavior. In addition, the composting latrine requires close handling of feces, so perceptions of feces, their use, and their management strongly influence the latrine user's behavior. Furthermore, this study was conducted along the Caribbean coast in the province of Bocas del Toro and the Ñö Kribu region of the Comarca Ngäbe-Buglé with communities of the indigenous group, the Ngäbe. Living on the waterfront or along rivers in the region, the Ngäbe are tied to water, and the constant presence of water enables the traditional practice of open defecation in or over streams, rivers, and beaches.

According to a survey conducted of composting latrines in the Bocas del Toro and Ñö Kribu region of the Comarca Ngäbe-Buglé in 2009 (personal correspondence with Returned Peace Corps Volunteer Whitney Golob), a significant percentage of composting latrine constructions were never finished. These latrines lack small pieces, such as the urine diversion tubes, the small concrete rear-access doors, or the privacy structure. Of the pieces missing, the first two examples correspond typically to the work and materials provided by the development workers and governmental agencies in the area. However, the privacy structure has typically been the responsibility of the latrine owner. Perhaps the families cannot cover the additional costs associated with construction of the privacy shelter, which make the projects economically unsustainable; or perhaps social factors are important determinants of project completion and uptake of this technology.

Consequently, socio-cultural factors are hypothesized to affect the adoption, operation, and maintenance of composting latrines. In indigenous communities in rural Panama, the socio-cultural factors (i.e., attitudes and perceptions) might influence the success of composting latrine projects, but no published research exists that investigates the social factors affecting the sustainability of composting latrines. This study aims to fill the knowledge gap in the literature corresponding to the social factors affecting decision-making related to sanitation, specifically regarding the use of composting latrines.

Therefore, the objectives of this research are to:

1) quantify the usage of 142 completed composting latrines and of the composted waste in the Bocas del Toro province and Ñö Kribu region of the Comarca Ngäbe-Buglé, Panamá, and
2) evaluate how human attitudes and perceptions towards waste product and its reuse may serve as an incentive or as a barrier to the use of composting latrines.

In addressing the first objective, this research quantifies the number of composting latrines that are in use. The research also quantifies the number of composting latrines currently not in use and characterizes them as finished, unfinished and broken separately. Furthermore, this study evaluates the use of the compost. Additionally, the operation and maintenance of the composting latrines are evaluated. This study will quantify the number of composting latrines that are kept up in accordance with the proper techniques outlined in literature. This evaluation of the upkeep will take into consideration the composting latrine structure, its contents, and the use of its composted contents.

To address the second objective, likes and dislikes expressed by composting latrine users are discussed. In addition to the likes and dislikes of composting latrines, the perceptions of feces and the use of composted feces as fertilizer are evaluated with respect to various socio-demographic factors. The incentives and barriers pertaining to attitudes and perceptions are characterized.

The potential benefits from this research start at the grassroots level. Aiming to help improve the promotion and implementation practices of grassroots development workers, this research will provide a better understanding of the current status of composting latrine projects. A better depiction of the attitudes and perceptions of feces, its use as soil amendment, and composting latrines will allow development workers and, consequently, governmental agencies to target sanitation marketing messages appropriately. The social marketing can address disadvantages of the composting latrine technology while emphasizing the perceived advantages. Additionally, development engineers can redesign the composting latrine to incorporate various socio-cultural factors found to be important. Anticipating barriers and utilizing incentives, sanitation implementers can develop methods, such as composting latrine pilot projects, to address negative perceptions and to reinforce positive perceptions.

On a global scale, the acceptance and subsequent implementation of EcoSan technologies – composting latrines in this case – can address critical issues of environmental sustainability. Considering conservation, recovery, and reuse of today's resources is essential to solving sanitation problems in the developed and developing world. If maintained properly, EcoSan technologies can improve water management, promote nutrient recycle for agricultural purposes, and destroy the pathogens needed to improve public health standards.

The remainder of this thesis is detailed as follows. Chapter 2 presents a review of the literature pertinent to this study. This review includes a description of the current status of sanitation, an introduction to Panama, the description of a composting latrine, and an introduction to importance of social sciences in sustainable development engineering. Chapter 3 discusses the methods, broken into three phases, used to collect the data for the thesis. Chapter 4 includes the results pertaining to the objectives listed in this chapter and the discussion of the key findings. Finally, Chapter 5 will re-address the topics covered in this thesis by providing a conclusion with recommendations for future action and research.

CHAPTER 2: LITERATURE REVIEW

Literature pertinent to this study was reviewed, and key findings are presented in this chapter. A discussion of the current status of sanitation identifies a need for increased sanitation coverage, a shift in the sanitation paradigm, and the benefits of ecological sanitation. To construct the socio-cultural context, the literature review covers the general status of Panama and the indigenous group, the Ngäbes. Explaining the technical complexity of the composting latrine, the discussion of composting latrines also addresses the advantages and disadvantages of this specific sanitation technology. Furthermore, the need for social sciences in engineering is impressed upon the reader in order to show the benefits of interdisciplinary work, especially to ensure the success of sanitation projects in international development. The review of literature has revealed a knowledge gap with respect to composting latrines in Panama. No published literature addresses the need for monitoring and evaluation by quantifying the proper use of composing latrines in this region. Based on personal observations during her time as a Peace Corps Volunteer, the author has seen many unfinished and unused composting latrines. The status of these latrines required explanation. As attitudes and perceptions differ among cultural groups and influence sanitation behavior, the social factors affecting composting latrine behavior needed further investigation. At the time of this review, no published literature existed that examines the attitudes and perceptions of Ngäbes regarding composting latrines, feces, and their use as a soil amendment.

2.1 Sanitation

2.1.1 Definition of Improved Sanitation

According to the United Nations (UN), 1.9 billion people have gained access to improved sanitation facilities between 1990 and 2011. Target 7.C of the Millennium Development Goals (MDGs) aims to halve the proportion of the population that lack access to improved drinking water and sanitation. While the water coverage target has been met, another 1 billion people need to gain access to improved sanitation by 2015 to reach the sanitation target. In other words, between 2011 and 2015, 660,000 people would need to gain access to improved sanitation each day to meet the sanitation target. Additionally in 2010, the United Nations General Assembly acknowledged access to safe, clean water and sanitation as essential to the realization of all human rights (UN, 2013a; UN, 2013b).

Improved sanitation technologies include: (1) flush or pour-flush toilets to (a) piped sewer systems, (b) septic tanks, or (c) pit latrines; (2) ventilated improved pit (VIP) latrines, (3) pit latrines with a slab, and (4) composting toilets (WHO/UNICEF JMP, 2013). A composting toilet is a form of ecological sanitation. For the purpose of this research, ecological sanitation (EcoSan) is defined as the sanitation technologies that involve excreta recovery, conversion into compost, and reuse of the nutrients found in the excreta (Mehl et al., 2011, Hurtado, 2005). In short, these technologies "sanitize and recycle" while preventing pollution and aiding food production (Haq & Cambridge, 2012; Werner et al., 2009; Winblad & Simpson-Herbert, 2004). A double vault urine-diverting (DVUD) latrine is a specific example of the EcoSan technology that deposits feces into one chamber at a time in the dual chamber structure and diverts urine either to a separate container or a soak pit. When one chamber fills, the chamber is topped and the feces are left to decompose and inactivate pathogens via desiccation, an increase in pH, an increase in temperature, and/or a sufficient storage time (Mehl et al., 2011). In the field, DVUD are commonly known as composting latrines, and for the purpose of this research, the layman's term, composting latrine, will be used to describe DVUD henceforth.

Other improved sanitation technologies pertinent to this research are pit latrines with a slab and pour-flush toilets that lead to septic tanks. Pit latrines are simply an excavated hole with a protective slab and seat above. Finally, septic systems are pour-flush toilets that lead to a septic tank that allows for settling and the passing of effluent to a leaching field for environmental filtration. The design of all these sanitation technologies are described in greater detail elsewhere (Mihelcic et al, 2009).

2.1.2 Sanitation Paradigms in the Developing and Developed World

Users of improved sanitation follow one of four sanitation models: (1) "flush-and-discharge"; (2) "flush-and-forget"; (3) "drop-and-store"; or (4) "sanitize and reuse" (Nawab et al., 2006; Drangert, 1998). Within water and wastewater management, the leading paradigm is changing to focus on resource recovery at the same time as the required constituent removal (Mihelcic et al., 2011). The recovery, reuse, and conservation of nutrients, water, and energy are key factors in the development of new sustainable sanitation technology both in the developing and developed world. At the same time, the wastewater treatment industry is starting to look at new decentralized approaches to treatment, in lieu of the traditional centralized treatment approach (Libralato et al., 2012). In turn, with this new wastewater management paradigm and its shift toward sustainable practices, interest in composting toilets has increased (Anand & Apul, 2014).

2.1.2.1 Recycling Nutrients

While access to improved sanitation pertains to the MDG Goal 7, improved sanitation technology can also help achieve a variety of MDGs, especially Goal 1 Target C, depending upon the technology selected. Goal 1 refers to the need to eradicate extreme poverty and hunger, and Target C specifically relates to hunger and food production as it seeks to halve, between 1995 and 2015, the proportion of people who suffer from hunger. Through the recovery of nutrients found in human excreta, improved sanitation can enable the nutrient reuse and help provide a viable fertilizer to improve agricultural output.

In short, Goal 1 Target C recognizes the need to improve agricultural output to meet the increased needs of the world's growing population. One way to improve agricultural output is to apply fertilizers, a nutrient supplement, to the soil. The need for fertilizer around the world raises two issues: (1) availability of nutrients in the natural environment and (2) economic availability of fertilizer for farmers in the developing world.

For agricultural production, the most important elemental soil nutrients are nitrogen and phosphorus. Potassium is the third most important nutrient. For instance, nitrogen is essential to protein synthesis, so it is in high demand during vigorous growth during the development of leaf and seed proteins (Heinonen-Tanski & van Wijk-Sijbesma, 2005). Furthermore, plant dry matter contains 1-5% nitrogen (Heinonen-Tanski & van Wijk-Sijbesma, 2005). On the other hand, the phosphorus requirement is approximately one tenth of that of nitrogen, which equates to 10-20 kg/ha per yield. This phosphorus requirement can be greater in poor soils, where the phosphorus can be bound to non-soluble salts of aluminum, iron, or calcium (Heinonen-Tanski & van Wijk-Sijbesma, 2005).

While agriculture is demanding more phosphorus, the easily mined phosphorus resources with little or no heavy metals are very limited. The phosphorus rock supplies are estimated to last for less than 100 years (Haq & Cambridge, 2012; Cordell et al., 2009; Heinonen-Tanski & van Wijk-Sijbesma, 2005). The limited phosphorus resources are calling attention to the critical need to close the nutrient cycle loop in sanitation (Mihelcic et al., 2011).

The important nutrients for plant growth, especially nitrogen and phosphorus, are found in human excreta. Of the 3-3.3 million metric tons of phosphorus found in human excreta and graywater, an estimated 0.3-1.5 million metric tons of phosphorus are reused annually (Mihelcic et al., 2011; Cordell et al., 2009; Liu et al., 2008). Mihelcic et al. (2011) observed that if regions with low sanitation coverage implement ecological sanitation technologies (i.e. urine diversion, fecal decomposition, and/or biosolids recovery) that recover and recycle nutrients, these regions will be able to recover significant amounts of phosphorus from human excreta for reuse in fertilizer. On the other hand, to recover and recycle nutrients in regions with high sanitation coverage would require considerable investments in retrofitting existing systems. Table 1 summarizes the literature on the reported mass of phosphorus, potassium, and nitrogen found in human urine and feces. In addition, in one year a person produces 500 L of urine and 50 L of feces, of which 10 kg is dry matter (Anand & Apul, 2014; Drangert, 1998).

Table 1. Amount of nutrients excreted per person per year.

	Phosphorus (kg/person/yr)			Potassium (kg/person/yr)			Nitrogen (kg/person/yr)		
Source	*Urine*	*Feces*	*Total*	*Urine*	*Feces*	*Total*	*Urine*	*Feces*	*Total*
Drangert (1998)[1]	0.4 (67%)	0.2 (33%)	0.6 (100%)	0.9 (71%)	0.3 (29%)	1.2 (100%)	4.0 (88%)	0.5 (12%)	4.5 (100%)
Magid et al. (2006)[1]	0.55 (75%)	0.18 (25%)	0.73 (100%)	0.91 (71%)	0.37 (29%)	1.28 (100%)	4.00 (91%)	0.37 (9%)	4.37 (100%)
Vinnerås et al. (2006)[1,2]	0.36 (67%)	0.18 (33%)	0.54 (100%)	1.00 (73%)	0.37 (27%)	1.37 (100%)	4.00 (88%)	0.55 (12%)	4.55 (100%)

Table 1 (Continued)

Wolgast (1993)[3]	-	-	0.6	-	-	1.2	-	-	5.7
Starkl et al. (2013)[4]	-	-	0.383	-	-	-	-	-	1.4
Karak & Bhattacharyya (2011)[5]	-	-	0.6	-	-	1.2	-	-	5.7
Kvarnström et al. (2006)	-	-	0.58	-	-	1.27	-	-	4.55

1 As cited in Anand and Apul (2014).
2 Percentages had been calculated by Anand and Apul (2014) from Table 6 in Vinnerås et al. (2006)
3 As cited in Heinonen-Tanski & van Wijk-Sijbesma, 2005
4 Based on urine and feces data from Arroyo and Bulnes (2005).
5 As cited in Haq & Cambridge (2012)

Much research has cited the value of urine as a good source of nitrogen (Heinonen-Tanski & van Wijk-Sijbesma, 2005) because urine contains approximately 70–90% of the nitrogen, 50–65% of the phosphorus and 50–80% of the potassium excreted from a person (Heinonen-Tanski & van Wijk-Sijbesma, 2005; Wolgast, 1993). Wolgast (1993) published the higher values listed in the above ranges, while the lower value for nitrogen came from data collected in China by Gao et al. (2002) and the lower values for phosphorus and potassium came from Albold (2002). Urine diversion is a proven technology that could be implemented to recover these nutrients, and composting or biosolids collection can recover the nutrients from feces. With these technologies, sanitation can help sustainably meet nutrient needs. Collecting phosphorus from urine and feces could provide for 22% of the phosphorus demand. As the world population increases, the phosphorus available from human excreta, of which 50% comes from feces, is expected to increase from 3.36 to 4.33 million metric tons by 2050 (Mihelcic et al., 2011). Accordingly, the human excreta produced by one person in one year is equivalent to the quantity of fertilizer needed to produce the 250 kg of cereal a person needs annually (Heinonen-Tanski & van Wijk-Sijbesma, 2005; Wolgast, 1993). Furthermore, human compost could annually supplement 4.9–6.4% of commercial fertilizer in Australia (Salmon et al., 2004; Anand & Apul, 2014).

In addition to the top three nutrients, human feces also contain carbon, which increases the fraction of organic carbon in the soil and, in turn, improves the soil structure. In tropical countries, the increase in organic material and improved soil structure will improve resistance to droughts and erosion after floods and heavy rains (Heinonen-Tanski & van Wijk-Sijbesma, 2005). Furthermore, increases in organic matter in the soil from compost can improve plants' salt tolerance, as demonstrated in apple trees (Engel et al., 2001) and Swiss chard and common beans (Smith et al., 2001).

Other benefits related to closing the nutrient loop in sanitation include the reduction of environmental pollution and the promotion of organic agriculture. By reducing the demand for industrial fertilizers, the use of human urine fertilizer could reduce environmental pollution corresponding to the manufacture and transportation of commercial fertilizer (Karaka & Bhattacharyya, 2011; Pradhan et al., 2007). At the same time, the popularity of organic farming is increasing, and the demand for organic fertilizers will increase as well. By introducing contaminants to the environment, resource-intensive conventional agricultural practices can adversely affect the environment and food chain. On the other hand, organic agricultural practices are more environmentally sustainable (Karaka & Bhattacharyya, 2011).

Use of human excreta in agriculture has sustained historical presence in various cultures in China, Japan, and Vietnam (Heinonen-Tanski & van Wijk-Sijbesma, 2005). The composting sanitation technology is spreading, including peri-urban and urban areas of South America, South Africa, East Africa, and Asia (Katukiza et al., 2012) and rural areas of Central America (Mehl et al., 2011).

2.1.2.2 Water Conservation

Composting toilets or latrines in the developing and developed world are designed to conserve water. For example, the DVUD, typically found in the developing world uses no water. Accordingly, Starkl et al. (2013) calculated that a urine-diverting toilet saves 13 m^3 of water/person/year based on the averages of 5 flushes/day, 7 L/flush (IMTA, 2011) and 1.4 L of excreta/day (Arroyo and Bulnes, 2005). Fry et al. (2008) estimates that waterless sanitation can save 22.5 L/person/day. In the developed world context, experience waterless toilets utilize vertical piping without water for excreta transport, but water may be used to clean the toilet. Micro-flush (0.47 L), vacuum (0.2 L) and foam flush (6 oz = 0.17L) toilets utilize water, but significantly less than the standard flush toilet. Considering water use percentages, toilet flushing accounts for the highest percentage of water use in hotels (33%), schools (60%), offices (51%), and residential buildings (27%) (Anand & Apul, 2014). But, with respect to LEED certification, new constructions and major renovations can gain credits for water use reduction and innovative wastewater technology in the water efficiency category with the implementation of composting toilets (Anand & Apul, 2014; LEED, 2005). As sanitation coverage increases, sanitation's water demands factor into water scarcity. Depending upon the sanitation technology chosen, tens of millions of people will suffer from water scarcity, ranging from moderate to severe water stress (Fry et al., 2008).

2.2 Panama

2.2.1 General Information

Panama is a Central American country bordered by Costa Rica to the west and Colombia to the east. Characterized as a "High Human Development" country, Panama ranks 59 on the

Human Development Index (HDI) with a value of 0.780. According to the United Nations Development Programme, in 2011 Panama had a GDP per capita of $13,766 (2005 PPP $), and neighboring Costa Rica had a GDP per capita of $10,732 (2005 PPP $) (UNDP, 2013). Despite Panama's higher GDP per capita, Costa Rica ranked higher in percentage of the population with access to improved sanitation facilities. In 2011, 94% of the Costa Rican population had access to improved sanitation facilities, while only 71% of the Panamanian population had access. Additionally, the disparity between the urban and rural populations is significant. In Panama, 77% of the urban population has access to improved sanitation facilities, while only 54% of the rural population has access (WHO/UNICEF, 2013).

2.2.2 Disparity between Indigenous and Non-Indigenous

Panama is divided into nine provinces, three indigenous *comarcas* with provincial status, and two *comarcas* with the equivalent of a county status. The three provincial *comarcas* include the Comarca Kuna Yala, Comarca Emberá-Wounaan, and Comaraca Ngäbe-Buglé, while the two county *comarcas* include the Comarca Kuna de Madungandí and the Comarca Kuna de Wargandí (shown in Figure 1). The provincial comarcas have autonomous leaders and recognize traditional leaders. These comarcas correspond to the major groups of indigenous people in Panama. The eight indigenous groups of Panama are the Ngäbe, Buglé, Kuna, Emberá, Wounaan, Bokota, Naso/Teribe, and Bri Bri. Indigenous groups represent approximately 12.3% of the total Panamanian population of 3.5 million people (Instituto Nacional de Estadística y Censo (INEC), 2011). The Comarca Ngäbe-Buglé was created in 1997 for the two indigenous groups, which were originally collectively called the Guaymí. But, many Ngäbe communities exist outside the Comarca boundaries in the provinces of Bocas del Toro, Chiriquí, and Veraguas.

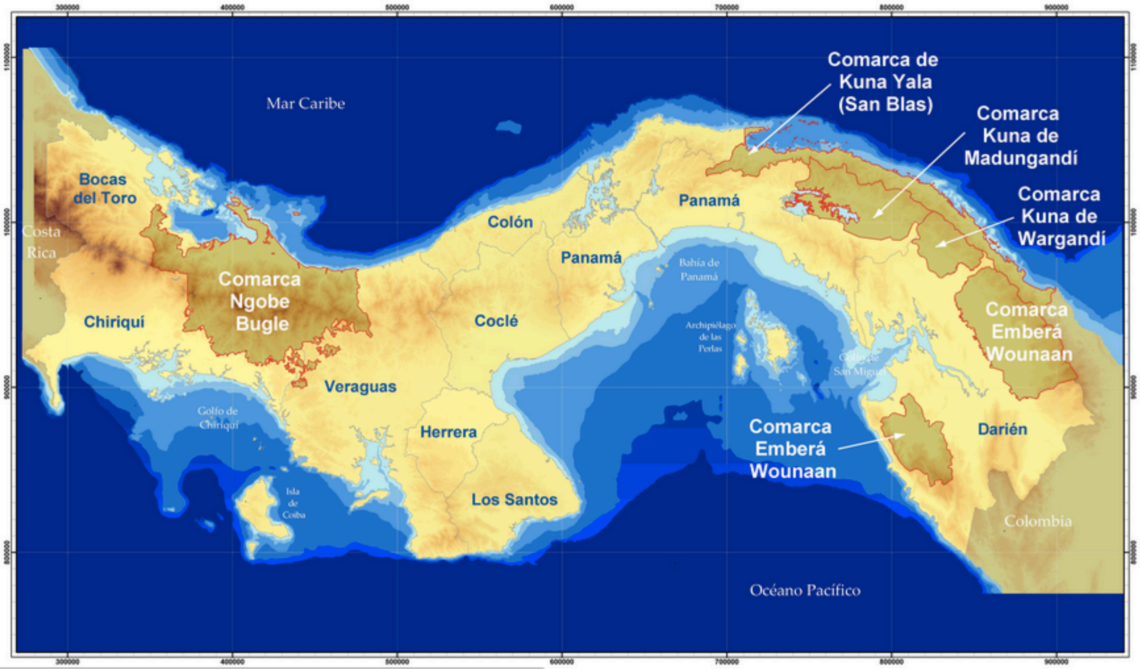

Figure 1. Map of Panama with three provincial and two county *comarcas* outlined (permission pending from EoN Systems, SA, 2000).

This disparity between indigenous and non-indigenous populations is significant in Panama, and Table 2 shows how the Human Development Index (HDI) differs between the province of Panama, which incorporates Panama City and other urban populations, and the province of Bocas del Toro and the Comarca Ngäbe-Buglé, where this study was conducted. While the province of Panama has an HDI of 0.828, Bocas del Toro has an HDI of 0.668 and the Comarca Ngäbe-Buglé of 0.499 (as shown in Table 2). With these HDIs, the province of Panama would be classified as "very high development," Bocas del Toro would be categorized as "medium human development," and the Comarca Ngäbe-Buglé would be considered as "low human development" (UNDP, 2014). With respect to sanitation facilities, less than half of the population in indigenous areas has access to improved sanitation (ANAM, 2010).

Figure 2 shows the availability of improved water sources (percentage of households without access) and improved sanitation facilities (percentage of households without a sanitation facility). Figure 3 also shows the infant mortality rate caused by diarrhea and other gastro-

Table 2. Summary of Human Development Indices (HDI) in study-related regions of Panama in 2013 (UNDP, 2014).

Province	Literacy (%)	Average Years of Schooling	HDI	Life Expectancy at Birth
Comarca Ngäbe-Buglé	70.3	4.5	0.499	69.7
Bocas del Toro	90.0	8.0	0.668	72.7
Panama Province	98.5	11.1	0.828	79.2

intestinal diseases. Together, the statistics shown in Figures 2 and 3 demonstrate the severe disparity between the Comarcas and other provinces, or the indigenous and non-indigenous, respectively. A review of Figure 2 illustrates that the Bocas del Toro and the Comarca Ngäbe-Buglé have high percentages of households without improved sanitation facilities. These regions with a lack of sanitation and higher percentages of households without access to improved water sources correspond to the districts with higher infant mortality rates due to diarrhea and other gastrointestinal diseases (shown in Figure 3). Furthermore, Figure 3 highlights the regions with the highest mortality rates due to diarrhea and gastro-intestinal disease, which correspond with predominantly Ngäbe districts in Bocas del Toro and with the Ñö Kribu region of the Comarca Ngäbe-Buglé, where the research for this thesis was conducted.

2.2.1 Ngäbes and Water, Sanitation, and Health

Very limited research has been conducted about the Ngäbe indigenous group, especially with respect to the group's perceptions and understandings of water, sanitation, and health. Basic ethnographical research on the Ngäbe people primarily focused on work done in Chiriquí (Young, 1970). Since Spanish contact, the Ngäbes have been known for their dispersed and isolated communities along the continental divide in what is now the Comarca Ngäbe-Buglé but previously the provinces of Chiriquí and Veraguas. However, since 1830, the Ngäbes have begun to live on the northwestern coast of Panama (Bletzer, 1991), which pertain to the province of

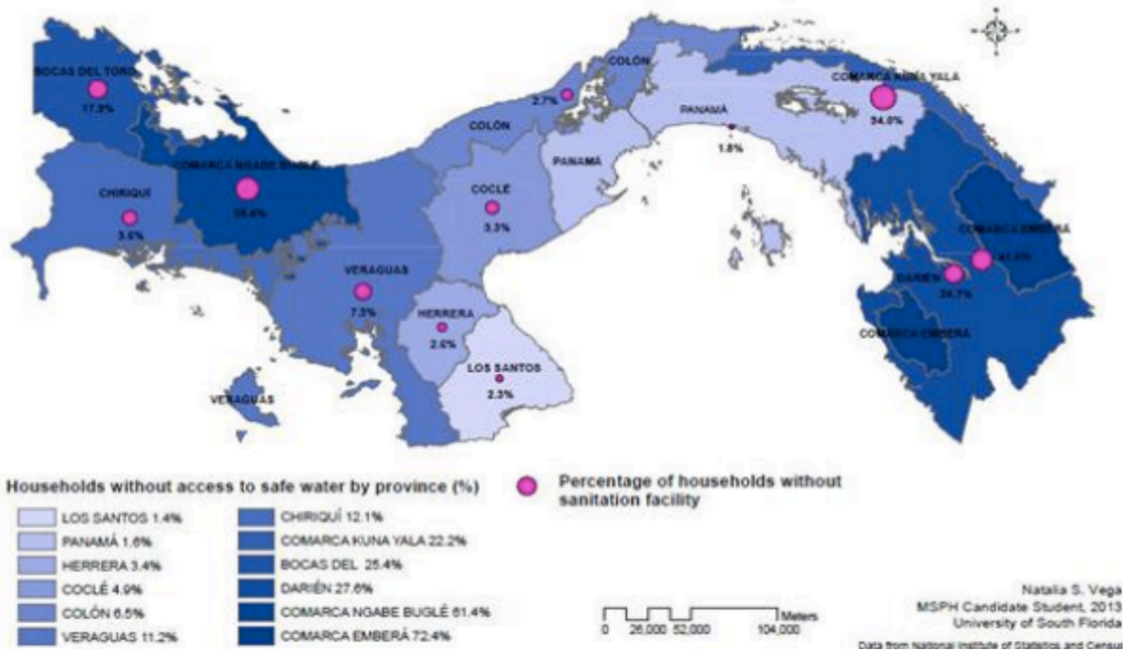

Figure 2. Availability of improved water and sanitation facilities in the Republic of Panama by province for 2010 (reproduced with permission from Vega, 2013).

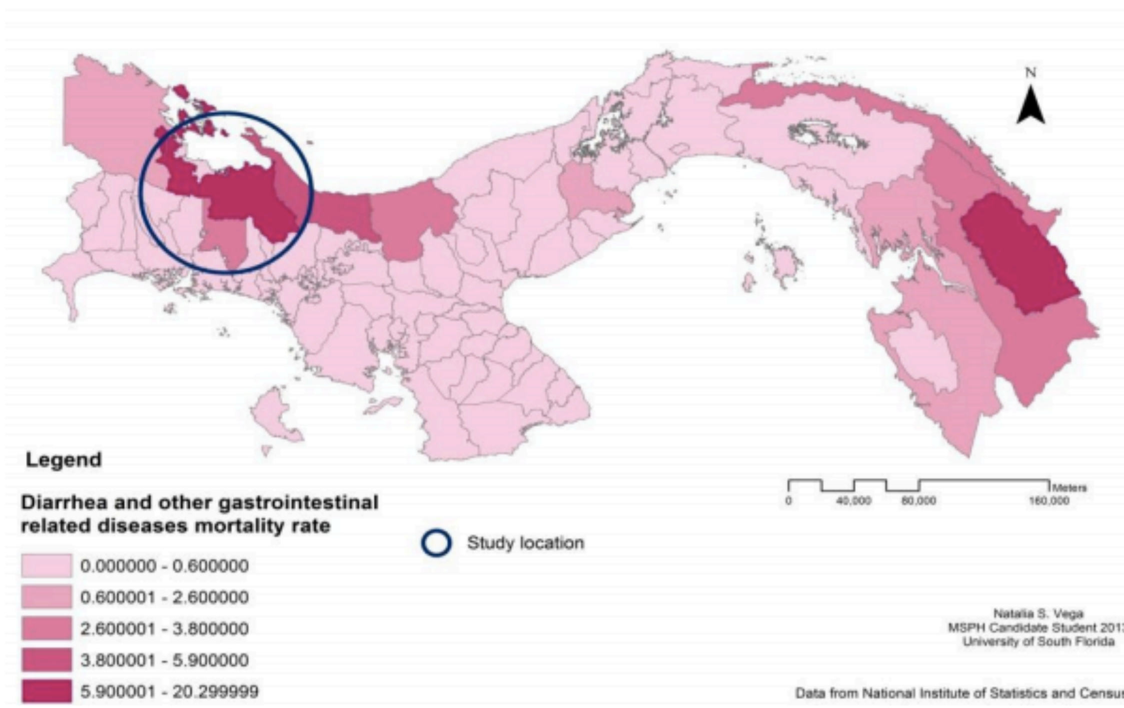

Figure 3. Infant mortality rate caused by diarrhea and other gastrointestinal related diseases in the Republic of Panama at district level, 2010 (reproduced with permission from Vega, 2013).

Bocas del Toro and the Ñö Kribu region of the Comarca Ngäbe-Buglé. The Chiriqui-based research agreed with Bletzer's (1991) assessment of Ngäbe communities along the Bocas del Toro and Ñö Kribu coasts, citing mutual assistance and reciprocity as the basis of the indigenous group's society. Ngäbes will seek aid from close relatives before asking for help from relatives by marriage or other Ngäbes. The term for a close relative, *ha mroko*, comes from one of the words for food (*mro*) and refers to the sharing of food with relatives, especially between households working shared familial lands. The term also reflects this common sense of reciprocity and mutual assistance to provide transportation, subsistence, or health care (Bletzer, 1991).

Within Hispanic cultures, health is often viewed with an attitude that "everything is in the hands of God" (Cavillo & Flaskerud, 1991; Calatrello, 1980) and good health is a gift from God (Purnell, 1999; Cavillo & Flaskerud, 1991). Despite many differences culturally between Hispanic (or Latino) communities and Ngäbe communities, this attitude is present within Ngäbe communities as well and is demonstrated with the following common phrases: "si Dios quiere (if God desires)" and "solo Dios sabe (only God knows)" (personal experience of the author).

Medical anthropology field research conducted by an undergraduate researcher in the Bocas del Toro province and the ÑöKribu region of the Comarca Ngäbe-Buglé in 2013 found a version of medical pluralism among the Ngäbe people. The term, pluralism, infers a recognition and acceptance of multiple views and practices, so medical pluralism is defined as the "co-existence in a society of differing medical traditions, grounded in different principles or based on different world views" (Gabe et al., 2004). The Ngäbe's medical pluralism combines traditional and western medicine (Personal communication with Kelsey Paradise, 2014). Traditional healers, called *curanderos*, use native medicinal plants for treatments of various ailments, including stomachaches, high blood pressure, and headaches. These medicinal traditions and knowledge have been passed down orally from generation to generation (Personal communication with Kelsey Paradise, 2014; Winkelman & Peek, 2004).

While traditional healers still play a role in provisional health care, biomedicine is playing an increasingly important role for Ngäbe communities. The role of biomedicine and the active search for biomedical treatments depends upon the severity of the problem, the cost of access to this modern medicine, and the increasing presence of outside biomedical influences (personal observation of the author).

Integral to the indigenous cultures in Costa Rica and Panama, the water culture has adapted to influences of the Spanish and mestizo cultures (Vega, 2013; Montoya et al., 2012). Montoya et al. (2012) recounted myths and legends of the Ngäbe people based in water. While these myths and legends are being lost as the assimilation of Ngäbes increases, the importance of water to the Ngäbe society is undeniable (personal observation of the author, 2011-2013). For example, surface water is a place of social interaction. Women wash clothes, families bathe, and children play in these communal areas. Additionally, women typically stock up water for consumption (drinking and cooking) from certain streams or tributaries. Meanwhile, other activities, specifically defecation, are reserved for downstream on the main river (Vega, 2013; Montoya et al., 2012). For Ngäbes along the coast, water is essential to their livelihoods, as fishing is a significant source of food and income.

Regarding the consumption of water, Vega (2013) found that women had some knowledge about safe drinking water, because 78% of the respondents reported knowing what potable water is. *Agua potable*, or potable water, is the common terminology used by health promoters when promoting safe drinking water behavior. While the health promoters intend for potable water to mean safe drinking water, the women's responses reflect a different understanding of the word, potable. Of the 78% reporting knowledge of potable water, 20 of the 41 respondents said that potable water is water that comes from the tap or pipe. This water coming from a rural gravity-fed water system is not potable; it still requires treatment. Furthermore, only 8 respondents noted potable water as water that had been boiled, chlorinated, or filtered, which are treatment processes needed to make the tap water potable in many rural villages in Panama (Vega, 2013). Through personal observations, the author of this thesis observed this knowledge-action gap in the Ngäbe community during her Peace Corps service when community members prepared coffee, hot chocolate, or any heated drink. Using untreated, cold water from the tap of a gravity-fed aqueduct system, the community member prepared cold drinks. If the drink involved dissolving an element in the water, the community member boiled the coffee, cacao, or other flavoring. After dissolving the flavoring, and consequently disinfecting the drink, the community member would proceed to add untreated, cold water from the tap to cool the drink. Related to water consumption, personal observations and correspondence with the Floating Doctors, a non-profit group working in the region to provide medical services, revealed dehydration and other medical conditions related to chronic dehydration as some of the most common medical issues for Ngäbe communities.

With respect to sanitation facilities, Ngäbes throughout the Bocas del Toro province and the ÑöKribu region of the Comarca Ngäbe-Buglé have practiced open defecation in the streams and rivers running through the community or on the beach in coastal communities. Defecating in water systems has allowed the Ngäbes to easily continue their customary anal cleansing practice of washing with water after defecation. When interviewing female Ngäbes from the mountainous part of the Comarca Ngäbe-Buglé, Vega (2013) found that 84.6% of the respondents had a sanitation facility inside or close to the home, but 48.0% of the 52 respondents did not feel safe going and using the sanitation facility during the night. Many factors may affect this lack of perceived safety, so this question could be an area of further research in order to better understand sanitation preferences related to of socio-cultural perceptions.

Six factors influence an individual's health behavior. The six factors include perceived susceptibility, perceived severity, perceived barriers, perceived benefits, and cues to action (Lee & Kolter, 2011). The Health Belief Model is directly applicable to the situation of the Ngäbes and will be discussed in more detail in Section 2.4 During her interviews, Vega (2013) found that women list food as the most likely cause of diarrhea in their children, and the majority of women (53.8%) did not attribute water as the cause of diarrhea and other gastrointestinal illnesses. Instead, almost all of the respondents (90.4%) believed their water to be good for consumption (Vega, 2013). Thus, among these Ngäbe women the perceived susceptibility to water-borne illness is low. The perceived susceptibility to and severity of diarrheal cases among children under 5 years old was also reported to be low because 65% of the women responded that their under-five children never had diarrhea or had it only 1-2 times per year. Expecting more women to express higher frequencies of diarrhea, Vega (2013) noted that the women appeared to comprehend what diarrhea was, but recall bias could account for the small number of cases reported (Vega, 2013). Despite the low number of diarrhea incidences reported during the study, diarrhea is still a major health problem in this region. In response to this major health issue, much work still needs to be done in order to alleviate this disease burden through interdisciplinary water and sanitation projects with social, environmental, and economical sustainability in mind. A holistic approach involving the social sciences, public health, and engineering will prove beneficial.

2.3 Composting Latrines

In Panama, especially in the Bocas del Toro province and the Ñö Kribu region of the Comarca Ngäbe-Buglé, the least expensive environmentally sustainable option for sanitation has been the composting latrine. The technical aspects of a composting latrine are described in the following sections to exemplify the higher level of user knowledge and interest required to properly operate and maintain a composting latrine. These technical aspects related to operation and maintenance influence the social acceptability of this sanitation facility.

2.3.1 Design

Many designs for composting latrines exist. For example, a composting toilet can be self-contained or central, single or multi-chambered, electric or manual, water-based or waterless, urine-diverting or mixed, and designed for single or multi-story buildings (Anand and Apul, 2014). These designs are applicable in both the developed and developing world. In India in the 1940s, Appasaheb Patwardhan invented a double-vault composting toilet (Anand & Apul, 2014; Del Porto & Steinfeld, 1998), from which he collected, composted, and applied the human waste for agricultural purposes. In Vietnam in the 1960s, dual chamber toilets were used with aeration chimneys (Anand & Apul, 2014; Del Porto & Steinfeld, 1998). The design of the DVUD latrine utilized in Panama is concisely described as a concrete block structure with two chambers, urine-diverting toilet seats, removable concrete doors at the bottom of each chamber, and a privacy structure with a corrugated tin roof above the concrete structure. More details of the latrine's design and construction can be found in Hurtado (2005) and Appendix A.

Published literature defines functionality, safety, economy, social and environmental affordability, and even aesthetics as the principles of an appropriate composting toilet design (Anand & Apul, 2014; Zavala & Funamizu, 2006). Technical design considerations include ventilation mechanisms, chamber sizing with access doors, carbon supply, and drainage. Ventilation allows aeration to promote aerobic decomposition while reducing the odor. Adequately sized chambers will hold the excreta and carbonaceous material from the household for the desired composting period. The carbon supply adds sufficient carbon in order to reach the appropriate carbon to nitrogen ratio, and drainage systems allow excess liquids to exit the composting chamber (Anand & Apul, 2014; Zavala & Funamizu, 2006).

Two methods exist to determine the appropriate size of a composting chamber. The first method utilizes the following equation (Equation 1) from Anand & Apul, (2014):

$$V = N \times P \times R \qquad (1)$$

where V is the volume of the composting chamber (m^3), N is the emptying interval (years), P is the average number of users (persons), and R is the solids produced per person per year (m^3/yr/person).

In turn, the recommended solids generation rate (R) is assumed to be 0.05 m^3/yr/person (Anand & Apul, 2014). With respect to the composting latrines found in Panama, Mehl et al. (2011) notes that for a family of 8-12 each 0.75 m^3 chamber should fill in 6 months.

In contrast, another method to size the chamber considers the water loading in a mixed-source composting toilet to be the dominant sizing factor, more so than the organic matter loading (feces and carbonaceous material). The method takes into consideration a drying surface area (643 m^3/person), which maintains the compost's 60% moisture content. The volume of the compost generated is 34 L/person/year. Consequently, the height of the compost chamber must be 63 cm in order to account for the mixing mechanism and free space for air circulation (Anand & Apul, 2014; Zavala & Funamizu, 2006). As a result, the 34 L of compost per person fit into a chamber with a surface area of 643 m^3/person and a depth of 63 cm.

2.3.2 Mechanisms of Pathogen Destruction

Composting toilets and latrines can achieve pathogen destruction through the change in four factors: (1) moisture content, (2) temperature, (3) pH, and (4) storage time (Katukiza et al., 2012; Mehl et al., 2011; WHO, 2006). Composing latrines in the developing world have two difficult and often conflicting goals, to manage excreta disposal and management such as to prohibit the spread of fecal-oral diseases (i.e. pathogen destruction) and to provide viable compost for agricultural use (i.e. composting) (Mehl et al., 2011). In controlled environments in the developed world, composting, which is the aerobic decomposition of organic matter, simultaneously destroys pathogens. Under aerobic conditions, microorganisms oxidize organic compounds. Bacteria, actinomycetes, and fungi are the primary microorganisms responsible for the decomposition process (Anand & Apul, 2014). Consequently, the following microbial processes aid in pathogen destruction: thermal destruction; microbial competition; natural die-off; nutrient depletion; fungi's production of antibiotics; and production of toxic byproducts (i.e. gaseous ammonia) (Anand & Apul, 2014; Wichuk and McCartney, 2007). According to WHO (2006) guidelines, the concentration of Ascaris eggs should be < 1 viable egg/g dry compost to be used for agricultural purposes. But, research has shown that maintaining the ideal conditions for aerobic decomposition (and, in turn, pathogen destruction) may be difficult to achieve in the developing world.

With respect to moisture content, the ideal moisture level for thermophilic aerobic decomposition is reported to be 40-60% (Mehl et al., 2011; Cairncross & Feachem 1993) or 50-60% (Anand & Apul, 2004; Zavala and Funamizu, 2006; Jenkins, 1999). The dry conditions of a low moisture level (< 40%) inhibit and slow down the decomposition of the material, necessitating the addition of water, and an initial lag with a lower microbial activity rate is observed at moisture levels around 30–40% at all temperatures (Anand & Apul, 2014). Furthermore, a moisture level of 65% is the upper critical limit for proper composting (Zavala & Funamizu, 2006). For the purpose of pathogen destruction, the human excreta can be desiccated when the moisture content is less than 25% (Mehl et al., 2011; WHO 2006).

Regarding temperature, mesophilic organisms start the composting process at the temperatures 19–45°C (Anand & Apul, 2014). As the organic matter is degraded, the process generates heat and increases the temperature to above 45°C, the thermophilic stage (Anand & Apul, 2014; Zavala and Funamizu, 2006; Jenkins, 1999). In this thermophilic stage the rate of biodegradation increases (Anand & Apul, 2014; Zavala et al., 2004), and maximum degradation and pathogen destruction is achieved between 50–65°C (Anand & Apul, 2014; Bernal et al., 2009).

Studies on the optimum temperature, or temperature range, for composting report different findings: 60°C (Anand & Apul, 2014; Zavala and Funamizu, 2006) and 40–65 °C (Anand & Apul, 2014; de Bertoldi et al., 1983). To destroy pathogens, especially the persistent *Ascaris lumbricoides* (roundworm) eggs, the compost much reach 62°C (Anand & Apul, 2014; Feachem et al., 1983) for one hour, 50°C (Anand & Apul, 2014; Mehl et al., 2011; Feachem et al., 1983) for one day, 45°C (Mehl et al., 2011) or 44°C (Anand & Apul, 2014) for one month, or 42°C (Mehl et al., 2011) or 43°C (Anand & Apul, 2014) for one year (as shown in Figure 4). Most importantly, literature cites 6 months or greater as the recommended storage time (Mehl et al., 2011; Mackie Jensen et al., 2008; WHO, 2006), however, pathogen destruction requires temperatures greater than 42°C for a 6-month storage duration.

Practical suggestions to increase the temperature of the compost pile are to turn the pile, which aerates the pile, and to add food waste, which increases the C/N ratio and the availability of easily digestible compounds that promote microbial activity. Turning the pile on a regular basis has been found to increase the temperature from 40°C to 65°C (Anand & Apul, 2014; Vinnerås et al., 2003). Additionally, turning and mixing can create a more uniform temperature profile, otherwise the highest temperatures remain concentrated in the center of the pile (Anand & Apul, 2014). The compost user can also add food waste to the feces to provide carbohydrates (i.e. sugar) and lipids (i.e. fat), because these compounds serve as an energy source for the growth of thermophilic microorganisms during aerobic decomposition (Steger et al., 2005). Germer et al. (2010) noted sufficiently high temperatures when food waste, including vegetable remains, rice leftovers, and the peels of plantains, pineapple, and yams, were added to the pile.

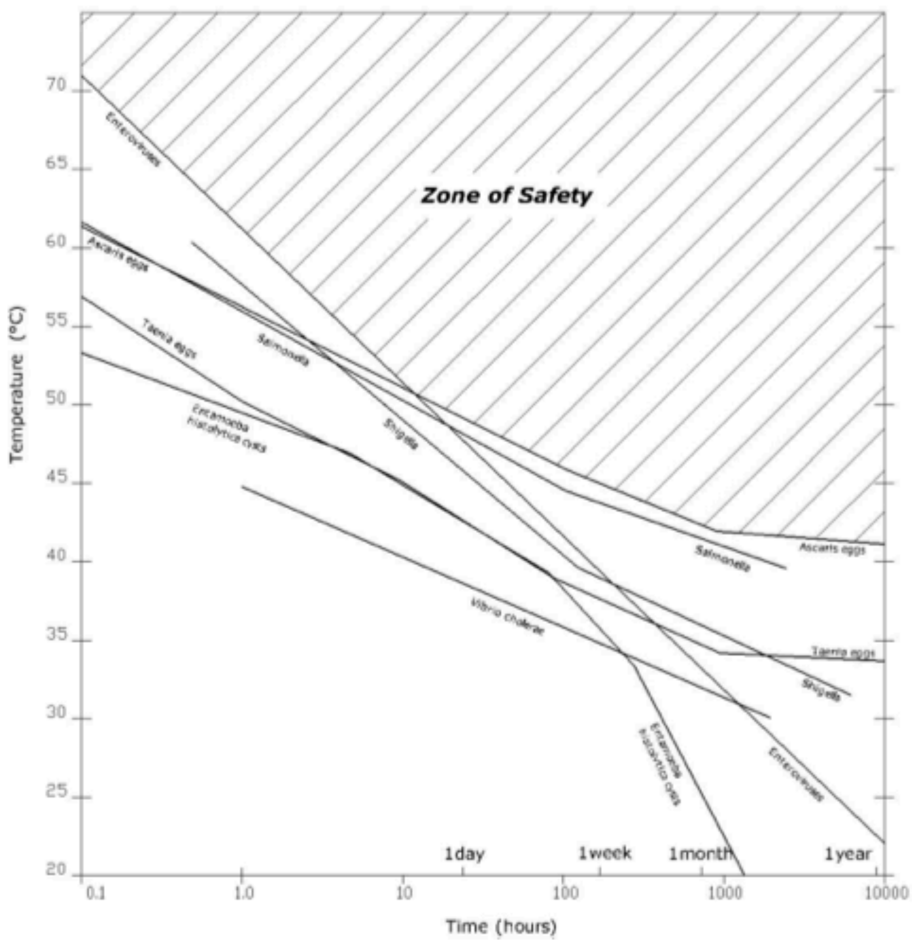

Figure 4. Relationship of temperature and contact time necessary for fecal pathogen destruction (reproduced with permission from Cairncross & Feachem, 1993).

With respect to the carbon to nitrogen ratio (C/N), the optimal ratio for composting should range from 20–35 (Mehl et al., 2011; Mihelcic et al., 2009) or 25–35 (Anand & Apul, 2014; de Bertoldi et al., 1983). The C/N ratio of untreated feces is 5–10, sawdust is 200–500, and wood ash is 25 (Mehl et al., 2011; Mihelcic et al., 2009). Therefore, in order to increase the C/N of untreated feces, sufficient amounts of carbon rich sawdust or ash must be added. For instance, in order to achieve a C/N ratio of 30, a family of 8, excreting 135 g of feces per person per day, would need to add 1.42 m^3 of sawdust each year (Mehl et al., 2011).

With respect to the pH of the compost, the ideal pH range for aerobic decomposition is reported to be pH 7.5–8.5 (Mehl et al., 2011; Jenkins, 1994) or 5.5–8.0 (Anand & Apul, 2014; de Bertoldi et al., 1983). That being said, the ideal pH for pathogen destruction is pH ≥ 9 (Mehl et al., 2011; WHO, 2006). However, a pH greater than 9 also hinders the microbial activity responsible for aerobic decomposition.

Besides the principal four factors affecting aerobic decomposition, particle size and porosity of the composting pile affect the composting process. The particle size determines the surface area available for microbial growth and maintains the desired porosity. For example, large particles are inaccessible on the interior to microbes, making decomposition more difficult. On the other hand, small particles may reduce porosity as the particles pack together with less free space in between. Porosity allows for aeration, so a porosity of 35–50% is ideal for aerobic decomposition (Anand & Apul, 2014; Bernal et al., 2009).

Overall, studies conducted in China, El Salvador, Guatemala, Mexico, Panama, South Africa, and Vietnam have demonstrated the difficulty in achieve pathogen destruction, because the majority of composting latrines in developing do not reach sufficiently high temperatures to completely destroy pathogens in the compost. Consequently, the literature suggests that the primary method of pathogen destruction may be desiccation at a high pH. As mentioned previously, low moisture levels and a high pH inhibit the microbial activity necessary for aerobic decomposition, the key biochemical process that converts the human excrement into viable fertilizer (Mehl et al., 2011). Recent research has looked into the viability of urine as a tool in pathogen destruction. Lacking field testing, McKinley et al. (2012) have shown that using a combination of urine (store of fresh) with wood ash can achieve *Ascaris* egg inactivation. In the future, field tests could determine feasibility, quantity of urine needed, and other pertinent factors in successful pathogen inactivation.

2.3.3 Proper Operation and Maintenance

While no comprehensive manual exists for the proper operation and maintenance of DVUD latrines, recommendations from recent literature can be summarized as follows (Mehl et al., 2011).

1) Start with thick layer of cut grass or other dry organic material on base of latrine compartment.
2) Use only one side for one year.
3) Be sure to urinate in the urinal section of the toilet seat.
4) Deposit anal cleansing materials (i.e. toilet paper) in the latrine compartment.
5) After defecating, add two handfuls (approximately 500 ml) of desiccant to completely cover the excrement with dry, organic material each time. Be careful to not clog the urine tube with the desiccant.
6) Cover the toilet seat.
7) Aerate the latrine compartment's contents by mixing once or twice a week.
8) Keep latrine door closed and/or locked so that animals cannot enter.

9) With a damp cloth, wash the toilet seat weekly.

10) When the first compartment is filled after one year, switch sides and cover the full side's toilet seat with a plastic or wooden covering so as to leave it to decompose.

11) Collect aged compost during the dry season, or less rainy season, and solar-dry for one week (i.e. ≤ 10 cm layer on sheet metal).

12) For non-agricultural use, bury solar-dried or non-solar-dried compost under 10 cm of soil and 300 m from surface water and food sources in an area not easily accessible by children and animals.

13) For agricultural use, bury solar-dried compost under 10 cm of soil around plants that grow over the ground (i.e. banana, peach palm, coconut, or papaya trees) or around crops that are eaten cooked (i.e. corn or wheat). Do not use the compost around fruit and vegetable plants that grow over or under the ground and are eaten raw (i.e. lettuce, berries, or carrots)[1].

Item 5 in the instructions listed above deals with the use of desiccant, or the dry carbonaceous material added to the excrement deposited in a composting latrine. According to Mehl et al. (2011), the user has two options for compost management:

1) To achieve pathogen destruction, the latrine user should add additional dry, high pH, desiccants (i.e. wood ash (Anand & Apul, 2014; Vinnerås et al., 2003) or lime) to the latrine. The pH needs to be increased above 9 and the moisture content needs to decrease below 25% (Mehl et al., 2011).

2) To promote aerobic decomposition and the production of viable fertilizer, the latrine user should add a wider variety of high carbon desiccants (i.e. grass and/or leaves) to increase

[1] The author of this thesis would like to amend the use recommendations found in Mehl et al. (2011). The compost may be used on root vegetables and tubers (i.e. yucca, potatoes, and tarot) that grow under the ground but are cooked before eating.

the C/N ratio. The latrine user must also turn the pile sufficiently in order to aerate the pile and promote the degradation of organic carbon by thermophilic aerobic organisms. In turn, this process will raise the pile's temperature to above 40°C and will thermally destroy pathogens (Mehl et al., 2011).

2.3.4 Advantages

In the developing world, composting latrines have several advantages in comparison to other sanitation technologies, such as the traditional pit latrine. These advantages, sourced from Peace Corps Panama (2013) and verified by the author's observations, include:

1) No bad smell,
2) No breeding ground for insects,
3) Fertilizer production,
4) Buildable in areas with high water tables and any soil type, and
5) Reusable structure.

In the developed world, advantages of composting infrastructure include nutrient recycling, decreased transportation of waste and fertilizer, pollution prevention (in the cases where discharges do not meet wastewater discharge standards), production of a soil amendment free from urban and industrial contaminants, water conservation (Cordova & Knuth, 2005a; Van der Ryn, 1995), and subsequently energy and monetary conservation from the lower usage of potable water and lower production, hence less treatment, of wastewater (Cordova & Knuth, 2005a; Van der Ryn, 1995).

Cost savings may be the overarching benefit of the implementation of composting sanitation technologies for some users. For example, if water usage is metered, reduced water usage will lead to lower water bills for the composting toilet user (Haq & Cambridge, 2012;

Langergraber & Muellegger, 2005). While not discussed extensively in literature, which often focuses on composting toilets in the developed world, the lack of smell and insects may be important to the user in the developing world. The importance to the user will be discussed further in Chapter 4. Not only does the dry carbonaceous material increase the C/N ratio and pH, the addition of this desiccant also reduces odor (Katukiza et al., 2012; Kvarnström et al., 2006). By covering and drying the excreta, the desiccant also decreases the breeding grounds of mosquitoes and flies.

As the paradigm in sanitation, nutrient recycling is gaining importance as not only an advantage, but a necessity of sanitation technologies. Nutrient recycling refers to a closed loop sanitation cycle in which humans consume and excrete nitrogen, phosphorus, and other nutrients and sanitation technologies recover these nutrients to form a fertilizer that will return the nutrients to the soil and plants for future consumption. As Haq & Cambridge (2012) noted, closing the nutrient loop by recycling the nutrients from urine and feces can increase food security while improving soil fertility and reducing water use. Some European cities recycle half of the human waste generated, but, in general, approximately 20% of urban human waste and 70% of rural human waste is reutilized for agriculture (Haq & Cambridge, 2012; Liu et al., 2008; Farmer, 2001). However, in China the percentages increase as 30% of urban human waste and 94% of rural human waste is reutilized for agriculture (Haq & Cambridge, 2012; Barles, 2010; Chen, 2002; Pan et al., 1995). Katukiza et al. (2012) recognize land availability and marketability of the compost as factors affecting the potential for nutrient recycling with UDDTs in urban slums. Furthermore, composting the human excreta increases the possible agricultural benefits from the nutrients in the excrement. Documented in various Asian countries, the use of composted material as a soil amendment improved the agricultural production by 10-25%, in comparison to the use of raw human excrement (Phuc et al., 2006).

With respect to location, a composting latrine can be constructed essentially anywhere. Utilizing locally available materials, these latrines are ideal in areas of high water tables with soil of any type. When a pit latrine is built in a high water table zone, the pit fills quickly with water, may give off odors, and may provide a breeding ground for mosquitoes and flies. While high water tables are problematic for pit latrines, certain soil types also cause problems the pit latrine structure. For example, the pit latrine may collapse in sandy soils and digging the pit in rocky soils can be very labor intensive. While heavy rains can cause flooding in pit latrines, composting latrines are built of concrete with a sand-cement coating, which provides a waterproof chamber for excrement containment. In flood prone areas, this concrete chamber prevents environmental contamination and the corresponding public health problems by avoiding the escape of excrement (Katukiza et al., 2012).

Another advantage of the composting latrine is the reusability of the structure. In rural Panama, pit emptying is rarely practiced, so pit latrines fill up and the household must dig another hole. Ideally, the concrete slab is movable from the first pit to the next pit, but in time, space for digging pits becomes a concern, especially as the communities become more densely populated. Thus, a composting latrine, which provides reusable chambers and occupies approximately 2.5 m^2, may allow for a growing community to have sustainable sanitation structures in close quarters.

With respect to water conservation in the developing world, rural communities without reliable year-round improved water sources could benefit from the dry toilet. For major cities in the developed and developing world with advanced water treatment facilities, composting toilets would separate the toilet from the water supply and wastewater streams (Anand & Apul, 2014). This technology has been implemented chiefly in rural and/or water scarce areas (Anand & Apul, 2014; Fittschen & Niemczynowicz, 1997). However, as the funding for water and wastewater infrastructure maintenance and improvement falls short, the use of composting technologies could reduce the burden on the aging infrastructure in the United States (Anand & Apul, 2014).

Lacking access to electricity, rural communities in the developing world tend to utilize decentralized sanitation systems, which do not require electricity like wastewater treatment plants. For that reason, the use of composting latrines would not affect the level of energy consumed in the water or wastewater treatment plants. In turn, energy conservation is not seen as an incentive among rural communities in the developing world. However, in areas with access to advanced water and wastewater treatment systems, piped water is treated to drinking level standards using energy intensive processes and is promptly used to flush excrement down a toilet. Anand & Apul (2014) note this use of drinking water as poor resource management. For example, 3% of the total electricity consumption in the United States goes to treating water and wastewater (Anand & Apul, 2014). While the initial cost of a composting toilet is higher than that of a flush toilet, the operational costs (i.e. life cycle costs and energy use) and related impacts (i.e. greenhouse gas emissions) are lower than that of a flush toilet (Anand & Apul, 2014; Anand & Apul, 2010).

2.3.5 Disadvantages

The disadvantages of composting toilets are substantial and often affect the socio-cultural and economic sustainability of composting technologies in developing and developed countries. For example, composting infrastructure is viewed as expensive, requires a higher level of maintenance and user knowledge, and may evoke negative user perceptions related to handling composted human excreta. Other issues include a more complicated construction and the need for a regular supply of dry organic material.

As mentioned previously, the capital cost of a composting toilet is higher than that of a flush toilet in the developed world, and the capital cost of a composting latrine is higher than that of a pit latrine in the developing world. That being said, other environmental advantages can outweigh the cost disadvantage. In the developing world context, the capital needed for a composting latrine is often cost prohibitive, especially considering that a pit latrine requires little monetary investment and open defecation requires no monetary investment. While composting latrines require little land, the capital costs depend upon the materials (Katukiza et al., 2012; Kvarnström et al., 2006) and transportation costs. For instance, for a composting latrine in a boat-access community in Bocas del Toro, Panama, the materials and their transportation can cost upwards of $500 (personal experience of the author). In Sub-Saharan Africa, an economic analysis showed that current EcoSan schemes could not increase in scale without extensive outside financial support (Haq & Cambridge, 2012; WSP, 2009).

Requiring high levels of maintenance and user knowledge, the composting latrine is also not the most user-friendly sanitation technology on the market. The latrine requires the manual removal of waste products (Katukiza et al., 2012; Kvarnström et al., 2006), a labor-intensive process if the access doors are sealed with concrete. To ensure safe disposal and reuse, the compost required weekly maintenance activities to promote aerobic decomposition. Removal and safe disposal must be assured for UDDT to be sustainable sanitation options in slums (Katukiza et al., 2012; Kvarnström et al., 2006). Both in developing and developed world contexts, the user needs a knowledge base in the composting process because the systems often do not have monitors to verify the status of the compost.

The potential for negative user perceptions of human excreta is a disadvantage for composting infrastructure. “Fecophobia” refers to the fear of feces (Haq & Cambridge, 2012; Dellström Rosenquist, 2005; Winblad & Simpson-Hébert, 2004), and this user perception can be a barrier to EcoSan technologies. A lack of political will and an opposition from water and sanitation companies have also affected the spread and implementation of EcoSan technologies (Haq & Cambridge, 2012; Abeyuriya et al., 2007; Magid et al., 2006). To counter “fecophobia,” strategies, including participatory learning, informational sessions, and skill capacity building, could alter attitudes, improve awareness, and boost acceptance of these systems. Perceptions related to sanitation technologies and human excreta will be further investigated later in this literature review.

Furthermore, the EcoSan designs do not always consider gender-based preferences or roles. For example, in Panama women typically clean the toilets, but men install the latrine and responsible for removing and using the composted excreta. However, studies in Vietnam show that women are charged with more responsibility, and the women collect the feces and apply the feces to the fields in 57% and 67% of households, respectively. Improvements are also needed to account for gender-based comfort, such as for women during menstruation (Haq & Cambridge, 2012; Kjellén et al., 2011; Hoko et al., 2010).

For users in the developing world, complicated construction and the unavailability of dry carbonaceous material are inhibitive factors. In comparison with a concrete-slab pit latrine, a composting latrine still requires more skilled laborers in order to properly lay block and elevated slabs. Furthermore, the construction schedule for a composting latrine is approximately one week, while a concrete-slab pit latrine can be constructed in 1–2 days. Additionally, the toilet seat for a urine-diverting composting latrine typically utilizes a special mold to provide for urine diversion. While other designs could be jerry-rigged, but aesthetically pleasing toilet seats are more culturally acceptable (personal observation of the author). With respect to the requisite carbonaceous material, sufficient amounts of sawdust are increasingly more difficult to obtain as areas become more deforested and the trees are cut further and further away from the community. For ash, many communities, especially in Panama, are in a transition period as many households move from wood-burning stoves to propane gas stoves. These carbon sources have been the primary materials advertised to composting latrine users, and few know that other dry materials (i.e. rice husks for a pH increase or grass and cacao husks for a C/N increase) may be used.

Other disadvantages were noted during the author's service in Panama. For groups accustomed to washing with water after defecation, keeping the contents of a composting chamber dry is difficult. Attempting to use the urine diversion funnel to collect the water used for anal cleansing, water inevitably enters the composting chamber. Nonetheless, an additional container added to the latrine, similar to a bidet, can serve as an anal cleansing station (Katukiza et al., 2012; Kvarnström et al., 2006). The willingness of a user to bring water to the latrine, which is not required when defecating in the river, would have to be investigated in future research. Another reoccurring issue with composting latrines is the blockage of urine tubes. Foreign particles, such as sawdust and ash, and chemical precipitates, such as struvite ($MgNH_4PO_4$) and phosphates ($Ca_{10}(PO_4)_6(OH)_2$), can block the pipe (Katukiza et al., 2012; Kvarnström et al., 2006). The use of larger diameter pipes and curved, or less sharp, conduits can avoid this obstacle to use (Katukiza et al., 2012). Finally, for low income composting latrine users, cement is expensive, and every year when compost is removed, additional cement is required to reseal the access doors on a traditional concrete DVUD latrine.

2.3.6 Composting Latrines in Bocas del Toro

Rural communities in Panama are at the forefront regarding the implementation of EcoSan technology. Starting in the early 2000s composting latrine projects have been implemented by Peace Corps Volunteers, government agencies, and private individuals. Focusing in the Bocas del Toro region of Panama, rural Ngäbe communities are making the transition from open defecation to urine-diversion dehydration toilets (UDDT), pit latrines, or septic tanks systems.

2.3.6.1 Previous Projects

Completed in 2009, a Peace Corps Volunteer surveyed 197 composting latrines in the Bocas del Toro province and Ñö Kribu region of the Comarca Ngäbe-Buglé (personal communication). According to this volunteer, she found 142 composting latrine completed and 88 of these latrines were used properly[2]. The report noted the benefactor, Peace Corps or a government agency, but since 2009, individuals, both local Ngäbes and expatriates in the region, have constructed composting latrines for themselves or for their workers, respectively.

Table 3. Summary of the communities in Bocas del Toro and Ñö Kribu region of the Comarca Ngäbe-Buglé with composting latrines as of 2009 (Golob, 2009).

Location	Built	Finished	Being used	With dry material[1]
Bahia Azul	6	2	0	0
Barranco Adentra	2	0	0	0
Bisira	3	3	3	2
Cayo Paloma	3	1	1	1
Changuinola Arriba[2]	5	5	0	0
Filo Verde	22	16	16	14
Kusapin	9	6	5	3
La Gloria	12	12	10	15
Milla 03	10	5	5	5
Nance De Risco	8	8	8	7
Norteno	12	8	7	4

[2] The author did not define "proper use." A "successful latrine" was a latrine that had dry material and appeared to be in use.

Table 3 (Continued)

Nudoibidi	11	10	10	6
Oriente de Risco	5	3	3	1
Poman Creek	1	1	1	1
Pueblo Nuevo	3	2	1	1
Punta Pena de Risco	3	0	0	0
Quebrada Pita	4	3	1	1
Quebrada Pluma	3	0	0	0
Quebrada Tula	4	2	2	1
Rio Oeste Arriba	5	2	2	2
San San Puente	11	10	8	7
Santa Marta	6	4	4	3
Silico Creek	10	10	7	7
Soledad de Risco	8	3	2	1
Valle de Risco	23	22	20	16
Valle Junquito	8	4	3	3
Total	197	142	119	91

[1] Dry material present in the composting chamber.
[2] This community has since been flooded by the construction of a hydroelectric dam. The inhabitants were moved to another location.

2.3.6.2 Composting Latrine in Use Percentage

As noted in the previous section, the Peace Corps Volunteer's report (Golob, 2009) showed that 88 of the composting latrines were "used properly." This assessment of proper usage was based upon verbal and visual surveys, but appears to be mainly based upon the presence of desiccant (91 latrines). Her reports suggest that 74% of the 119 latrine users operate and maintain the latrine properly, and 84% of 142 latrine owners with finished latrines use the latrine, whether properly or improperly. Overall, of the 197 composting latrines originally built, only 45% of the latrines are being used properly. Finally, only 54 of the 88 owners of "properly used" latrines have removed compost from the chambers, despite the fact that many of these latrines were constructed 4-6 years before this survey was conducted. That being said, during her data collection, the author noted some errors in the numbers listed above (i.e. number of latrines in the respective community and definition for designating a latrine as "properly used"), but the general trends are noteworthy.

Since the introduction and implementation of composting latrines in Bocas del Toro, there has been limited evaluation of adopters and non-adapters' perceptions of this EcoSan technology. The composting latrine requires a higher level of knowledge and maintenance to ensure the proper usage of the latrine. In the case of a composting latrine, the proper use mandates a higher user-latrine interface. Regardless of the sanitation technology, the socio-cultural background and attitudes of the user play a critical role in the both the latrine's operation and maintenance (McConville & Mihelcic, 2007).

2.4 Social Sciences Aid in the Implementation of Appropriate Sanitation Technologies

Appropriate technology can have many defining characteristics that depend upon the setting of the technology. The Oxford English Dictionary's definition of the two terms, "appropriate" and "technology," is "the application of scientific knowledge for practical purposes so that it is suitable for a particular person, condition, occasion or place" (Oxford English Dictionary, 2007). As this definition suggests, appropriate technology in one place can be inappropriate technology in another place. Thus, the appropriateness varies upon the context and is difficult to define precisely, but criteria, or specific characteristics, can help to outline the working definition of an appropriate technology. In the end, the most concise definition is the implementation of technologies, or solutions, that account for the location's cultural, economic, and social context and suitability (Mihelcic et al., 2009). Building upon that definition, Fuchs and Mihelcic (2011) add environmental and infrastructural suitability in the geographical context. In turn, they define appropriate technology as "solutions that are culturally, economically, and socially suitable to the community as well as environmentally and infrastructurally suitable to the geography in which they are implemented" (Fuchs & Mihelcic, 2011).

Technologies that do not meet the sustainability criteria will face certain failure, and the WHO and UNICEF Joint Monitoring Programme (JMP) (2000) recognized the following challenges as the main barriers to the increase in access to improved sanitation:

1) "Lack of political will.
2) Low prestige and recognition.
3) Poor policy at all levels.
4) Weak institutional framework.
5) Inadequate and poorly used resources.
6) Inappropriate approaches.
7) Failure to recognize defects of current excreta management systems.
8) Neglect of consumer preferences.
9) Ineffective promotion and low public awareness.
10) Women and children last."

Each of these barriers has a social component, but the neglect of consumer preferences, low prestige and recognition, the ineffective promotion and low public awareness, and women and children last are significant social barriers to spreading sanitation access in the developing world. The social context surrounding a sanitation project incorporates all of these barriers and other factors (i.e. drivers for sanitation projects). As noted, cultural and social contexts strongly influence behavior and, in turn, the appropriateness of a sanitation technology. According to Falkenmark (1998), spirituality and ethics drive human behavior, so Nawab et al. (2006) ascertained the need to incorporate cultural values, including religious and spiritual values, in the intervention design and implementation. With respect to water and sanitation, one can find the roots of an individual's values, perceptions, and management in cultural beliefs related to religion and excreta taboos (Nawab et al. 2006). The set of beliefs, values and previous experiences, which are considered the fundamental behavioral mechanisms, and the socio-economic setting will factor into the success or failure with respect to adoption and sustained use of any intervention (Waddington et al., 2009). Vega (2013) pointed out a lack of this behavior-related information for water and sanitation interventions with the Ngäbe indigenous group.

In short, engineers and other development professionals working with water supply and sanitation also need to consider social preferences, traditional beliefs, and experiences. In the end, work from anthropology and other social sciences can shed light on possible repercussions if development workers ignore social preferences and traditional beliefs of a community (Smith et al, 1993; Scrimshaw & Hurtado, 1988), because sanitation involves various scientific disciplines (Dellström Rosenquist, 2005).

Often with the implementation with a new sanitation technology, a certain level of sustained behavior change will be necessary in order to make the project implementation a success in sustainability. Development workers can learn from social science theory, such as the Health Belief Model and the Social Cognitive Theory, to better inform sanitation project plans. Utilizing aspects of the Health Belief Model, designers and implementers of community development projects can increase the success of a project by considering and addressing each of factors the listed in Table 4 (Vega, 2013; Lee & Kotler, 2011). The Social Cognitive Theory acknowledges two factors, related to the Health Belief Model, that affect behavior change: (1) perceived benefits and (2) self-efficacy. Perceived benefit refers to the perception, or the mental impression, of the balance between the cost and benefit of behavior adoption. Self-efficacy refers to the individual's confidence with respect to behavior adoption. The individual gains this confidence through skills learning and social observations. Thus, behavior change occurs with the following steps: exposure, repetition, and reinforcement leading to permanent behavior change (Vega, 2013; Lee & Kotler, 2011).

Table 4. Factors affecting health behavior according to the Health Belief Model.

Factor	Definition	Source
Perceived susceptibility	An individual's perception of vulnerability to a condition	Coreil, 2010
Perceived severity	An individual's perception that the condition causes harsh consequences for oneself	Coreil, 2010
Perceived barriers	An individual's perception that a certain action will decrease the risk of contracting the condition	Coreil, 2010
Perceived benefits	An individual's perception that the resulting advantages outweigh the cost with respect to a specific change in behavior	Coreil, 2010
Cues to action	Internal or external factors or events that trigger an individual to change a behavior	Lee & Kotler, 2011

Many development workers attempt to use the public health argument to invoke the appropriate behavior change, but in the end, the recipient may simply have different priorities. Maslow's theory of the "hierarchy of needs" (Maslow, 1970) and Dellström Rosenquist's (2005) work on the human-sanitation nexus can help to explain the lower-than-expected priority level given to sanitation by many individuals in the developing world. Humans formulate coping mechanisms to deny certain needs and natural events, such as death and defecation (Dellström Rosenquist, 2005). For example, people avoid conversing about excreta because they overestimate the personal risk associated with sanitation. At the same time, people underestimate the societal risk associated with excessive pollution from open defecation. Because of both overestimation and underestimation of risk, people are able to form an overarching denial in response to sanitation issues (Nawab et al., 2006; Dellström Rosenquist, 2005). In turn, Maslow's theory follows the pyramidal scheme from the most important needs to the less important needs. At the base, (1) physiological needs must be met before other needs, such as (2) safety needs, (3) inter-personal needs, (4) status needs, and (5) self-actualization needs can be met. Thus, the bottom of the pyramid controls the individual's motivation to action, but reversals can occur as well (Nawab et al., 2006; Dellström Rosenquist, 2005; Maslow, 1970).

Dellström Rosenquist (2005) presents four factors to serve as the first step toward realizing the mentality shift toward sustainable sanitation solutions. The first factor acknowledges the importance of incorporating human needs in the development process of sustainable solutions. The second factor addresses the fact that denial surrounds sanitation issues, so no natural demand exists. The third factor recognizes that humans have cognitive needs, and these needs can serve motivators for behavior change. In other words, people seek knowledge and understanding at their own pace while avoiding confusion and disorientation; this motivation for learning can promote certain behaviors. Ultimately, sanitation involves various sciences and needs to incorporate knowledge from each (Dellström Rosenquist, 2005).

Integrating social science theories into sanitation planning requires that project planners include participatory planning, scenario building, social sustainability assessments along with technical feasibility studies including environmental and economic sustainability assessments (Starkl et al., 2013). Unfortunately, as Libralato et al. (2012) noted about small wastewater treatment plants and other decentralized systems, the social repercussions are often overlooked while only environmental and economic repercussions are investigated (Libralato et al., 2012).

2.4.1 Project Failure/Disregard for Public Health Argument

Significant research indicates that public health risks rarely play a defining role in the adoption of water, sanitation, and personal hygiene interventions. Studies in both Vietnam and rural Malawi report that community members do not perceive health risks as a threat worthy of changing behavior. Among the ethnic minority groups in Vietnam, fecal and parasitic contamination is not considered a significant danger (Rheinländer et al., 2010). In rural Malawi, the perception of malaria did not impact the adoption of the recommended behavior; rather social factors play a role in the behavioral change involved in controlling and treating malaria (Launiala & Honkasalo, 2010; Agers, 1992). Rather than medical or biological risk that are considered important in public health settings, social risk is perceived to have the highest importance in reality (Launiala & Honkasalo, 2010; Nichter, 2003). Not directly related to biomedical risk, the ethnic minority groups in Vietnam held strong social and embodied motivations for maintaining domestic and personal hygiene (Rheinländer et al., 2010). For instance, maintaining spatial order and keeping dirt out of the indoor environment are strongly-held social habits of the ethnic minority groups. A male from a lowland village responded that he feels dirty in the house if it has not been swept, so the house is clean when it is neat. A male highland villager stated "I have to wash and clean hands and feet to eat anything more deliciously. Because if it is too dirty, you can't eat deliciously" (Rheinländer et al., 2010). For villagers who are farmers, social norms call for clean appearances outside of the work environment. In the end, eliminating the dirt from the home and body corresponds to keeping order. Because these hygiene motivations are not based on biomedical knowledge or calculated risks, initiatives need to be culturally and socially appropriate solutions in order to achieve sustainability (Rheinländer et al., 2010; Panter-Brick et al., 2006). With respect to the Health Belief Model, individuals may consider his or her susceptibility low or the severity of the disease low. These perceptions would lead an individual to disregard the public health argument for behavior change. At the same time, non-health related social factors could serve as cues to action, creating a precipice for behavior change, and perceived barriers and benefits can include socio-cultural barriers and benefits, not just economic, health, or environmental barriers or benefits.

Many researchers have noted the importance of prestige and other non-health related drives to improved sanitation use. The status of having a household latrine is important, because many low-income urban people are not persuaded by health statistics (Franceys, 1988; UNCHS, 1986). Instead of health statistics, convenience can be a key driver for latrine adoption. For instance, when suffering from diarrheal disease, avoiding a long walk on a dark, rainy night is a persuasive reason to build a household latrine (Cotton et al., 1995). Research in five Nepalese urban centers found similar, supportive results. Surveys regarding why people chose to adopt latrines outside of the government-subsidized program revealed that only 28% listed health as a motivation, but 43% gave a combination of prestige, privacy, and comfort as motivating factors (Cotton et al., 1995; UNCHS, 1986). Overall, results show that sanitation consumers often have motives, which do not incorporate health protection or environmental health. Instead, the key motives result from the socio-cultural considerations, such as the prestige, privacy, and comfort associated with on-plot sanitation systems (Nawab et al., 2006; Jenkins & Curtis, 2005; Cotton et al., 1995; Murthy et al., 1990; Goodhart, 1988; Perrett, 1983).

The argument for incorporating social traditions and traditional beliefs illustrates the difference between public health and environmental engineering and social sciences (i.e. anthropology, psychology, and sociology). Manderson (1998) explains that public health programs try to replace 'false' beliefs with 'accurate' knowledge. Public health programs assume that 'accurate' knowledge will induce behavioral changes. But, social scientists have contributed to disease control by conducting ethnographic interviews or surveys to record the community's knowledge, attitudes, and beliefs. The knowledge, attitudes, and beliefs shape the local context. In turn, social science research supports adaptation of national and international interventions to the local context (Manderson, 1998).

2.4.2 Social Marketing – Drivers and Barriers

One method to increase the access to improved sanitation is to treat the movement like a business. Sanitation is a commodity, which has certain desirable, marketable characteristics. The countless failures (i.e., 40% of the latrines a study in rural Ghana were incomplete or unused (Rodgers et al., 2007)) of the supply-driven approach to sanitation projects have caused development organizations to search for alternative approaches. Alternatives to the supply-driven approach promote, reflect, and meet the demands on the community and household levels. In turn, emerging experimental approaches have developed with the goal of stimulating demand, essentially developing consumers, for sanitation (Jenkins & Cairncross, 2010).

Social marketing assesses the drive for adoption, the barriers to adoption, and methods to increase demand. The drive for adoption encompasses the consumer motives and reasons for changing one's current state. In other words, desires for change arise from dissatisfaction with the difference between a desired state and the state of reality (Jenkins & Curtis, 2005; Bagozzi & Lee, 1999; Engel et al. 1978). Jenkins and Curtis (2005) found that the drives for latrine adoption in rural Benin fell into three categories: prestige-related, well-being, and situational. While many drives exist for communities to adopt latrines, other barriers prohibit the uptake of the sanitation system in many cases. Positive motivation is essential to developing demand for sanitation, but at the same time, positive motivation alone is insufficient to cultivate the demand. Rather, the opportunity and ability to obtain sanitation, such as the appropriate resources and transactions, are necessary (Jenkins & Curtis, 2005). From interviews conducted in Benin, Jenkins (1999) listed thirteen barriers to latrine adoption. The leading barriers included high actual or perceived cost, technical complexity, lack of credit, unsuitable soil, familial problems, and poor latrine performance, with regards to smell and safety. Some of these barriers are simply perceived barriers, so a better understanding of the alterable barriers can aid in the social marketing process of increasing demand for ecological sanitation. Furthermore, while previous social marketing research has focused on pit latrines, composting latrines offer resource recovery, which may prove to be an incentive or a barrier. With respect to composting toilets in an urban setting, Anand and Apul (2014) stated the barriers to use are regulations, public acceptance, and a lack of experience and knowledge. In turn, a better understanding of this extra dimension corresponding to composting latrines will prove beneficial for the social marketing of composting latrines.

With respect to the three categories of drivers, prestige-related drives reflect a desire to avoid social embarrassment, achieve the 'good life,' leave a legacy, and emulate royal practices. Community members want to avoid the social embarrassment of lacking a latrine so that the family can identify themselves with urban elite. Striving to be like the urban elite, the community members show achievement by expressing new experiences and a new lifestyle. By leaving a lasting structure that shows status and achievement, the older community members are assuring ancestral status among descendants. Finally, the rural population of Benin will adopt latrines in order to emulate the Fon royal class (Jenkins & Curtis, 2005). Second, well-being drives include protection from both natural and unnatural dangers, convenience, cleanliness, and privacy. With regards to protecting the well-being, rural Benin inhabitants want to adopt latrines to promote health and safety from commonplace dangers, such as infectious disease, and supernatural dangers, such as theft of one's feces or other items of personal vulnerability for use in witchcraft. Increasing convenience and comfort, such as shortening the walk to the defecation site, drives the inhabitants to adopt latrines in their community. Seeking cleanliness and orderliness has become a drive for latrine adoption as the population density increases. Furthermore, privacy is important to the community in three ways: visual screening, social comforting, and limiting personal information access (Jenkins & Curtis, 2005). In turn, rural communities practice open defecation while hiding near a bush or tree to ensure privacy. For example, Geest (1998) expressed the importance of privacy to the Akan people of Ghana. The Akan people will not acknowledge the presence of someone as they are walking to use a latrine, so no greetings are exchanged, because doing so would cause embarrassment and diminish the sense of privacy. In other words, they put up blinders with the mentality that if they do not see anyone, no one sees them. Third, situational drives are related to restricted mobility and rental income. Building a latrine on the property eases the burden of the restricted movement of the elderly, the ill, and people confined due to voodoo ceremonies. Finally, property value increases with the implementation of a latrine, so landlords will adopt latrines in order to increase rental income (Jenkins & Curtis, 2005).

Noting the consumer's lifestyle is beneficial to increasing the demand for sanitation and other public health initiatives. Considerations of gender, age, occupation, wealth and travel can help to better direct the social marketing. For instance, the route of exposure will depend upon those lifestyle factors, but migration, formal education, and travel are key routes to modern ideas. These routes each increased the drive for adoption with regards to family health, safety, convenience, and comfort (Jenkins & Curtis, 2005). In line with Jenkins and Curtis's conclusions, education can influence a person's awareness of the difference between the ideal and actual state, because Smith et al. (1993) find that mothers in Latin America with higher levels of schooling reported more favorable attitudes towards adopting oral rehydration solutions for diarrheal treatment. Consequently, educational campaigns can increase demand by affiliating prestige with the ideal, or more desirable, state (i.e. owning a latrine) and emphasizing the beneficial differences from the actual state, or reality (i.e. practicing open defecation). This information changes the perception of the actual state. For instance, a person may feel that open defecation is less acceptable. The development workers must present all of this information in terms of the consumers' values and lifestyle goals (Jenkins & Curtis, 2005). Drive arousal models can also include various marketing techniques, creative message development, and an awareness-raising campaign (Jenkins & Curtis, 2005).

Evaluating the factors affecting the rate of latrine adoption in communities in Benin, West Africa, Jenkins and Cairncross (2010) observed that population density, size, infrastructure, and proximity to urban areas played significant roles. A higher population density, a larger overall population, infrastructure development, and closeness to urban areas were factors associated with a higher level of latrine adoption. Agricultural factors related to higher adoption rates included a population that is increasingly non-agricultural and a population with larger agricultural households. Noting trends, Jenkins and Cairncross (2010) found that the increased access to piped water and greater adoption rates in nearby communities positively influenced the latrine adoption rates in Benin.

While many socio-demographic factors influence the adoption of latrines in general, the barriers to dry sanitation exist on three levels. The first level relates to the dry sanitation technology itself, the second level involves the problems related to increasing the scale of dry sanitation programs, and the third level barriers are specific to the urban arena with high population density and higher expectations from the user (Cordova & Knuth, 2005a). Cordova and Knuth (2005a) note key barriers that were observed by the author in Panama. For example, insufficient training for the user, an inability to conveniently access dry material, improper operation and maintenance and the need for continued education to promote behavior change were all noted in this study in Mexico. The perceived low-class status of this type of sanitation also plays a role as a barrier with respect to user acceptance. Some structural barriers, which are also present in Panama (personal observation), include a lack of continuity and funding to see these projects from the beginning to the end. See Cordova and Knuth (2005a) for two extensive tables that discuss the barriers related to increasing the prevalence of dry sanitation.

2.4.3 Perceptions of Latrines/Latrine Selection

As noted previously, perceptions are integral to health practices, especially practices related to sanitation, and the interrelationship between perceptions can be very complicated. In general, people may have differing perceptions about the general adoption of a latrine, disease transmission, and the type of sanitation technology adopted. For instance, the latrines can be thought of as dirty and evil, while gender considerations may require separate latrine for males and females. Furthermore, females may desire more privacy, so the superstructure surrounding the toilet is important as well (McConville, 2003). Or, as in Bangladesh, practitioners of open defecation use a new place each time and believe open defecation to be more natural and better than slab latrines, which smell foul (Molla, 2008).

Other information regarding the perception of disease and its causes can influence the sanitation technology chosen and its sustainability. Community members cited the disgusting smell of pit latrines located close to their homes as a reason for discontinued use. The villagers wished to avoid the smell and the potential for it to enter the domestic area, because the transgressions of dirt and dirty smells from the outside to the inside of the home or body caused social embarrassment and health risks. The perception of the dirty air as harmful in the understanding of hygiene explains the avoidance of the latrines in close proximity to the household (Rheinländer et al., 2010). In order to avoid the smell from reaching their house and its perceived effect on people, Rheinländer et al. (2010) noted the importance of asking which direction the wind typically blows. Consequently, Rheinländer et al. (2010) suggested the implementation of pour flush latrines based on perceptions of risk related to dirty, smelly air and on traditional practices of water to contain fecal odors. This study found that the cheapest model of a composting latrine is still unaffordable to the majority of the community, especially highland residents.

In both the highlands and lowlands, the body is seen as permeable to dirty air and, thus, susceptible to health risks, so according to Rheinländer et al. (2010) pour flush latrines better resemble the social preferences associated with an overhung fishpond latrine. Furthermore, people are troubled by the social stigma of being seen defecating, so development workers should consider more than the perceptions of disease when using studies of stakeholder perceptions and attitudes (Rheinländer et al., 2010; Geest, 2007; Curtis, 2001). In sum, an extensive understanding of the perceptions of hygiene is beneficial to any water and sanitation project.

As Bengali Muslims practice water-based anal cleansing after defecation, a study investigating societal preference of ecological sanitation systems in North West Frontier Province, Pakistan revealed that every household wanted water in the toilet or latrine area for cleansing purposes as well. This preference flows from the ritual purification cleaning prior to prayer. Another design consideration related to water-washing is the style of the seat. The villagers preferred a sanitary slab designed for squatting in lieu of the toilet seat design. The squatting design allows for easier anal cleansing, whereas the urine-diverting seats, or even normal seats, do not easily allow for water-based anal cleansing. Ideally, users of urine-diverting latrines utilize toilet paper or another dry material for anal cleansing. When proposed with the option of a separate water-washing location within the toilet area, the respondents responded negatively. After defecation, they did not want to move before cleansing themselves with water (Nawab et al., 2006). On the other hand, evidence from latrine visits within Ngäbe communities shows that this indigenous group could be very receptive to the idea of a bidet inside the toilet area or an attached shower for cleansing after defecation. With respect to the study in Pakistan, another important consideration to include is the direction in which the latrine user squats, which is north-south in order to carefully avoid facing Mecca (Nawab et al., 2006).

Perceptions play a larger role in adoption and acceptance of composting latrines and toilets because of the larger role that individuals play in the operation and maintenance of a composting latrine. This increased role in operation and maintenance requires a change in current habits and an increase in knowledge and skills. For example, for a composting latrine the user must separate urine and feces and avoid cleaning or flushing with water (Anand & Apul, 2014; Starkl et al., 2013). Focus group discussions in this Mexico City study revealed that the participants claimed to be willing to adopt the responsibility for operation and maintenance of these decentralized systems, but the overall preference still sided with the option of a centralized system (Starkl et al., 2013). In comparison, a Swiss study found high acceptance levels of urine-diverting toilets. The majority of study participants expressed interest in renting or owning residences with the urine-diverting technology. Furthermore, they were interested in the ability to purchase urine-fertilized produce (Mihelcic et al., 2011).

As mentioned earlier, one can hypothesize that the increased user-latrine interface required by a composting latrine only increases the importance of the user's cultural background and attitudes and their effect on the latrine's operation and maintenance and the production and use of compost. In the Pakistani study, Nawab et al. (2006) acknowledges perceptions of increased maintenance requirements and expensive investments. The villagers respond that they are “not ready to sell the freedom they see in flush toilets or open defecation.” These villagers do not want to use what little they have to implement a complicated, urine-diverting latrine (Nawab et al., 2006). Perhaps unfounded in his or her perceptions of odor, the sanitation consumer still may not accept the composting technology due to perceived issues of odor and maintenance. In comparison to the flush and forget approach, the composting approach certainly requires more active participation in sanitation, and many perceive the composting approach to sanitation as lower class, troublesome, and inconvenient (Anand & Apul, 2014; Cordova and Knuth, 2005).

According to Dellström Rosenquist (2005), disgust is a determining emotion that leads people to silence on the issue of sanitation. Thus, cleanliness and comfort are also deciding factors for the design of sanitary facilities (Dellström Rosenquist, 2005). Unfortunately, comfort is not synonymous with environmentally sustainability. Social attitudes and perceptions are the foundations of the search for comfort, cleanliness, and perceived safety. These social complexes are also the foundations of the human need to avoid disgust, mental recognition, and physical contact. These human needs result in denial, which is manifested in the silence that surrounds sanitation issues. In order to increase acceptability of environmentally sustainable technologies in the sanitation sector, attitudes and perceptions would have to change, or the needs (i.e. social comfort, safety, status, and physical demands) of the consumer need to be met (Dellström Rosenquist, 2005; Wirbelauer et al., 2003). In accordance with Dellström Rosenquist’s analysis of the human-sanitation nexus, certain operation and maintenance steps (i.e. handling and recycling of excrement) for the EcoSan technologies conflict with human needs, such as avoidance, status, and perceived safety (Dellström Rosenquist, 2005).

While evaluating long-term composting latrine success in a rural village in the lower highlands of central Mexico, Bates (2008) noted that social factors clearly play a role in user’s actions, or lack of actions, related to the composting latrine operation and maintenance. Some of the social factors actually consider technical components; therefore, odor, insects, fear of waste, and fear of contamination are considered technical-social factors (Bates, 2008). As the most influential attitudes, fear and disgust of handling human waste affect operation and maintenance, especially (1) leveling of waste, (2) maintaining the urine tube that often becomes disconnected or clogged, (3) seeing and smelling waste while adding the dry material, and (4) removing the waste, or composted waste, from the chamber (Bates 2008). In summary, Bates (2008) found that comfort, convenience, cleanliness, and distance, as in proximity to waste and separation from waste, are motivational factors for composting latrine acceptance and success. Additionally, insects, odors, aesthetics, waste handling, and poor use due to insufficient knowledge, training, and experience affected the composting latrine social acceptance or rejection and technical success or failure.

As mentioned previously, the consideration of gender roles has been shown to affect the successful adoption of improved sanitation (Brewster et al., 2006; Poku Sam, 2006). For example, women play a significant role in developing the sanitation and hygiene behaviors of young children (Brewster et al., 2006). In Ghana, the women's concerns about maintaining the VIP latrines opened the door to community-planning discussions, which led to exercises in conflict resolution and finally a consensus (Poku Sam, 2006). Perceptions, based in a society with specific gender roles, will influence the social acceptability of a sanitation technology. For instance, men, women and children defecate, but the women in the family are those responsible for cleaning the latrine or toilet as found in the Pakistani study. Changing to a composting latrine would question the status quo for the gender-based division of labor. If the men do not adopt a larger role in the operation and maintenance of the latrine, women could become increasingly overburdened with domestic work. The necessary behavior change and increased responsibility would change the dynamics of sanitation management for men (Nawab et al., 2006).

Cordova and Knuth (2005b) studied five separate communities to evaluate dry sanitation user acceptance and satisfaction. In sites with well functioning dry sanitation, the levels of satisfaction were high, and satisfaction with dry sanitation is positively associated with user motivation, user choice to adopt dry toilets, and support services for the user. The classifications of motivations for installment and adoption of dry toilets are ideological, awareness, demand, and pragmatic. With the exception of one community, which had no user choice in the adoption of dry sanitation, ideological (i.e. environmental protection and preference for dry sanitation) and awareness (i.e. water conservation and water pollution prevention) motives stood out. Thus, the importance of voluntary, active adoption cannot be underestimated (Cordova & Knuth, 2005b; Fittschen & Niemczynowicz 1997). Many positive dry toilet user experiences exist from around the world (Cordova & Knuth, 2005b; Jenkins, 1999). In San Salvador, Milburn et al. (2002) found high satisfaction rates as more than half other respondents reported a rating of "moderately to very satisfied with the system," a DVUD toilet. When low levels of user acceptance were found in Swedish studies, the reasons included poorly operating toilets, a lack of understanding of toilet operation on the part of the user, and/or users who had not actively chosen dry toilets (Cordova & Knuth, 2005b; Fittschen & Niemczynowicz, 1997). For the Mexican study, technical and programmatic issues are the source of user dissatisfaction. The issues include high malfunctioning rates, lack of proper follow-up and support for users, and faulty toilet designs (Cordova & Knuth, 2005b). Finally, implementing social marketing practices, such as promoting dry toilet as associated with higher social status and spreading an awareness of benefits, could improve user acceptance. Consequently, aesthetically pleasing toilets, extended services (i.e.

maintenance and final product recollection), and higher water costs would incentivize the adoption of dry sanitation.

A fundamental problem exists with the inconsistency of Peace Corps and government agency implemented sanitation programs. Neither of these entities in guaranteed to be consistently present with funding available for composting latrines (which is problematic because very few cases exist where an individual household can pay for a composting latrine without subsidy). Instead, these organizations work similarly to a situation described in the city of León, Mexico (Cordova & Knuth, 2005), where the availability of this innovation, the composting latrine, was not continuous. Besides perceptions of disease, perceptions and expectations of aid from the government can influence a community's attitude toward a sanitation project. For example, Rheinländer et al. (2010) encountered a sense of marginalization among the ethnic minority groups of rural Vietnam caused by harsh living conditions. This sense of marginalization affected the ethnic minority groups' perceptions and responses to the government sanitation projects. Perceiving that the community was too poor to invest in sanitation, the ethnic minority groups held high expectations for authorities to provide latrines. In response to this marginalization, Rheinländer et al. (2010) found that a closer match between government hygiene policies and community priorities in Vietnam will improve the success and sustainability of the water, sanitation, or public health project. For instance, Rheinländer et al. (2010) suggests that policies allow for a greater diversity of low-cost sanitation solutions rather than limiting the options that may not meet the socio-cultural traditions or the community's needs, as in the case of the traditional overhung fishpond latrines. Previously, ethnic minority groups used overhung fishpond latrines to control smell in rural Vietnam, but these latrines were recently banned because of fears of transmitting parasite infections between fish and humans

(Rheinländer et al., 2010). Reinforcing the need to verify the consistency of a project with regional development priorities and plans, the Vietnamese study emphasizes that inconsistencies between sanitation policies and communities' living conditions, perceptions, and dependencies will result in failure (Rheinländer et al., 2010).

Depending upon the culture and the history with sanitation, perceptions can differ greatly regarding the EcoSan technologies, especially urine-diverting latrines. For example, villagers in the North West Frontier Province of Pakistan view these latrines as similar to old dry latrines from which night soil was previously removed manually. In turn, these locals equate the urine-diverting toilet with low status, poverty, and underdevelopment. Associating the storage of feces and urine near the home with the traditional dry latrine evokes a sense of backwardness in the villagers, who desire an improved standard of living.

In order to overcome any negative perceptions of composting latrines or toilets (i.e. perceived lower social status), WASH workers need to make EcoSan desirable. In other words, the 2.4 billion people without access to improved sanitation should see similar trends toward EcoSan acceptance in wealthier societies; these societies evoke desires to follow, to emulate (Nawab et al., 2006). Similarly, rural communities will tend to follow the lead of urban sanitation users. Once EcoSan gains ground in urban settings, the rural arena will be more willing to accept EcoSan as well (Cordova & Knuth, 2005a). The social status of EcoSan technology also needs to improve in order to increase the popularity of these sustainable sanitation solutions (Cordova & Knuth, 2005a; Cordova & Knuth, 2005b).

2.4.4 Perceptions of Human Excreta and its Use as Fertilizer

An important benefit of ecological sanitation, such as the composting latrine, is the reuse of the human excrement as agricultural fertilizer. However, perceptions towards the use of human excreta may determine the latrine user's behavior, because this sanitation technology requires advanced operational knowledge and an increased interface with human excrement. Mariwah and Drangert (2011) explored the local knowledge, attitudes, and perceptions regarding human excreta. Using questionnaires and focus group discussions, the researchers surveyed 154 randomly selected households in peri-urban Ghana. The results describing the local knowledge, attitudes, and perceptions are compiled in Tables 5 and 6. In general, the results provided in Table 5 and 6 reveal a negative attitude to fresh excreta and the handling of it. Furthermore, the respondents accept excreta as a fertilizer but are unwilling to use the sanitized excreta on their personal crops or to consume excreta-fertilized crops. Based on the results, Mariwah and Drangert (2011) suggest using open community discussions so that the local cultural and religious context is reconciled with the scientific knowledge of the sanitation technology. In the end, many reports conclude that latrine construction is easier to implement than latrine use (Cotton et al., 1995; Burgers et al., 1988), so education, designed with cultural factors in mind, must be a component of the capacity building for any sanitation intervention, especially for ecological sanitation interventions.

Table 5. Knowledge regarding human excreta as fertilizer (reproduced with permission from Mariwah and Drangert, 2011).

Statements (N = 154)	Agree (%)	Don't Know (%)	Disagree (%)
Human excreta are a resource for the soil	60.4	24.0	15.5
Sanitized human excreta can be used as fertilizer	57.1	29.2	13.6
I will use human excreta on my crops if sanitized	36.3	9.7	53.9
Taste of vegetables will change when fertilized with urine	25.3	28.6	46.1
Smell of vegetables will change when fertilized with urine	25.9	27.9	46.1
Crops can be killed when fertilized with urine	40.9	37.0	22.1

Table 5 (Continued)

Crops fertilized with human excreta are good for consumptions	42. 2	14.9	42.9
I will never consume crops fertilized with human excreta	61.6	6.5	27.9
Animal manure can be used as fertilizer	93.5	2.6	3.9
Ever used animal manure as fertilizer	60.4	0.0	39.6

Table 6. Factors preventing the use of human excreta as fertilizer (Source: Mariwah and Drangert, 2011).

Factor (N = 154)	Feces (%)	Urine (%)
Smell	17.5	51.9
Health risk	39.0	20.9
Appearance	18.2	6.5
Patronage will be poor	10.4	9.7
People will mock me	0.6	0.6
Religious belief	0.6	0.6
None	13.6	9.7

Research performed in Africa and Asia has shown mixed opinions of excreta and its use as a fertilizer on crops. For example, in a community in the North West Frontier Province of Pakistan, the villagers hold strong psychological and religious concerns about the impurity of feces and urine, and these concerns override their knowledge of the fertilizer value of composted human waste. A study conducted in peri-urban Ghana found that the most important factor to deter a person from using sanitized feces on crops is the health risk associated with handling the excreta (Mariwah & Drangert, 2011). While 36% of the respondents were willing to use sanitized excreta on their crops, 42% viewed crops fertilized with sanitized excreta as good for consumption. But, only 28% of the respondents are willing to consume crops grown in human-fertilized soil (Mariwah & Drangert, 2011). These statistics illustrate the importance of fear of excreta handling as a factor in sanitized excreta usage. Additionally, these numbers imply that the respondents are knowledgeable regarding sanitized excreta as fertilizer, but that their socio-cultural beliefs regarding excreta persist and play a role in behavioral choices. A study of rural

Indonesia revealed that more than 80% of the respondents were willing to use human excreta compost as fertilizer, but only 40% of the farmers would inform the consumer regarding the fertilizer. Additionally, 80% said they would be willing to consume products using the human excreta fertilizer. Unfortunately, only 50% of the study participants were willing to handle the excrement to produce the compost themselves. Furthermore, anal cleansing with water, an Indonesian sanitation behavior, posed a barrier to proper use of a composting latrine, so only 40% considered maintaining the latrine hole dry by not washing directly above the toilet (WSP, 2009). In short, one must understand the sanitation beneficiaries' attitudes and behavior, including the gender roles and division of labor based on age, in order to develop appropriate environmental practices and technologies with feasible sensitization and motivational strategies (Nawab et al., 2006).

Robinson's (2005) study looked at rural households at least 30 kilometers from the nearest large town, Kisumu, in the Nyanza Province of western Kenya. The data regarding community perception of the reuse of urine and feces showed that 29% of the 26 surveyed households reported issues with respect to the neighbor's or larger community's perception of them. Individual respondents mentioned social pressure because of fears of danger, health issues, and primitive nature associated with reusing the urine and feces. Acceptance of the implemented ecological sanitation technology (referred to as the Skyloo), depends upon a variety of key factors: (1) operation and maintenance factors related to the recycling of urine and feces, (2) factors associated with the agricultural product, (3) external factors, (4) structural characteristics of the toilet system, (5) personal considerations and situational factors, and (6) financial factors.

Mugure and Mutua (2009) found that 70% of respondents in peri-urban Kenya are willing to adopt ecological sanitation, 15% are not willing to adopt, and 15% are undecided.

With the responsibility of operation and maintenance in mind, 62% would use urine-diverting toilet while 38% would not use the urine-diverting toilet. The principal barrier to the operation and maintenance is based in socio-cultural norms. Many study participants were unwilling to handle human excreta, so participants did not want to comply with the step of removing the full bucket from the chamber in the study's version of a composting latrine. The aversion to handling feces is also evident in the caveat included when asking if participants would eat crops grown from treated urine and feces. Sixty-seven percent (67%) of the respondents would be willing to eat the produce fertilized with treated urine and feces, if someone else grew the crops.

In the Ghanaian district of Manya Krobo, no composting technologies were identified; however, public toilets and septic tanks provide fecal sludge that is used for agricultural purposes. An investigation of the farmers' perceptions showed that farmers, both users and non-users of excreta as fertilizer, show similar trends by agreeing and disagreeing with the same perceptions of excreta. However, the degree to which they agree or disagree typically differs. For example, users and non-users agree that excrement is beneficial for the soil structure and an important nutrient source, but users agree more strongly. And, the farmers disagree with the statement that "excreta causes food contamination," but the users disagree more strongly. Additionally, on average the two groups perceive that "excreta poses health risks," but no farmer complained of any health risk. Farmers with more years of experience, a larger farm size, and a greater perceived agronomic benefit are more likely to use excreta in their fields. While gaining years of experience, farmers were exposed to excreta usage as fertilizer. Larger farms are more difficult to cover with inorganic fertilizer, because the inorganic fertilizer is expensive. If the farmer thought his fields could have higher crop yields, and in turn higher earnings, from the excreta-improved soil, the farmer was more likely to use the excreta in the fields. Furthermore, years of schooling, access to the road, and excreta availability also factor in positively to promote the use of excreta but are not significant with 99% confidence. On the other hand, perceived health risk and an increased per capita income correspond with a lower probability of excreta use. The key barriers to use are the strong odor (30%) and limited availability (21%). In the end, the increased agricultural production results in users earning three times as much as non-users (Cofie et al., 2010).

Sometimes physical surroundings and actions reflect a conflict between reality and a group's perceptions. For instance, in the North West Frontier Province of Pakistan, the villagers' negative attitudes toward human excreta and their religious education in cleanliness from Islamic traditions are in conflict with the physical appearance of the village's streets and defecation areas. Villagers live with the dirt in the streets despite the contradiction it presents against their religious beliefs and cultural taboos (Nawab et al., 2006). Also contradictory to Islamic practices, the women of rural Pakistan share a perception that allows mothers to pray wearing dirtied clothing. Dirtied with the excrement of her baby, this dirt is considered innocent and, therefore, more acceptable (Drangert & Nawab, 2011). Similar dichotomies were observed in Ghana. Despite negative reactions to human excreta, the Ghanaians often came in close contact with their excreta because of poor disposal methods (Geest, 1998). Accounting for this dichotomy, Lima (2004) noted that people become accustomed to a hazard after repeated exposure. Additionally, a change in perceived benefits could contribute to this dichotomy; Drangert and Nawab's study documented a change in perceptions that corresponded with the increased agricultural production, which consequently increased the household's income. Otherwise, the theory of Tragedy of the Commons could also explain this dichotomy. That is, in common spaces, people seek to optimize personal benefit, ignore others' feelings and needs, and expect others will assume responsibility for common areas (Nawab et al., 2006).

With the excreta's change in physical composition, the perceptions of human excreta can change. In Peshawar, Pakistan, two poor individuals were washing dishes in the sewage drains. When asked if they were willing to touch the feces of another person, they became angry. From their viewpoint, sewage water is clean enough for dish washing, but human feces are untouchable. This perception persists despite the health risks associated with touching sewage water and feces. Pakistani farmers share similar sentiments; they show reluctance to use urine and feces but will pay for raw sewage to use for agricultural purposes (Nawab et al., 2006). Sewer water is simply not as disgusting as excreta (Drangert & Nawab, 2011). Still reluctant, the farmers acknowledge that the better crops are located in the open defecation locations. They recognize the excreta's value as fertilizer, but in the case of the open defecation locations, these farmers do not have to play a role in the management of excreta. Instead, the excrement naturally decomposes and is no longer visible (Nawab et al., 2006). Koranic edict dictates the reuse of human excreta is only allowable after the removal of impurities (Nawab et al., 2006; Faruqui et al., 1998), because feces, specifically adult feces, are considered *najas* (impure) (Drangert & Nawab, 2011). The Council of Leading Islamic Scholars in Saudi Arabia decreed that wastewater could be reused for irrigation (Drangert & Nawab, 2011). Consequently, religious beliefs, and the resulting perceptions, regarding excreta can govern sanitation users' preferences and the likelihood of proper operation and maintenance. In the case of sewage water, the appearance changes, as does the acceptance of excreta in the form of wastewater in the fields. Simply put, the wastewater is perceived as less *najas* (Drangert & Nawab, 2011).

With respect to closing the loop and consuming produce fertilized with excreta, the respondents, both farmers and consumers, believe that the plants contain an integral capability to prevent the uptake of harmful chemicals and pathogens past a certain level. Thus, soil acts as a cleaner, just as dry soil can substitute water if necessary in ablution, and the produce from the plant is left uncontaminated (Drangert & Nawab, 2011).

In the Nghean Province of Vietnam, fertilizing crops with human excreta is a well-known practice among farmers, but the human excrement is often inadequately treated. For instance, the Ministry of Health (1999) found that 78% of households used human waste in the production of rice (Phuc et al., 2006; Ministry of Health, 1999). Additionally, for the sake of convenience, 66% of these farmers distribute the waste with their bare hands. These farmers viewed a lack of gloves as more practical and more comfortable. Those with a higher level of education tended to use protective gloves more often than those respondents with a lower level of education. This study suggests another trend related to an increase in income, as a household with an increased income is more likely to adopt a double vault composting latrine, in lieu of a single vault composting latrine. This trend requires further investigation, but the desire for a double vault latrine is promising because two vaults allows for one side to sit unused as it composes. At the time of this research, many households still had single vault latrines, so while almost all houses composted or processed the excreta for some period of time, very few reached the recommended six-month or more wait period. In general, the use of the partially, and sometimes not at all, treated excreta has led to the spread of disease, including *Ascaris* spp and *Trichuris* spp. With respect to the reasons for composting the human excreta, few expressed a concern with disease transmission (16%). On the other hand, the more prevalent responses were to improve soil structure (48%), to easily distribute the excrement (48%), to reduce the smell (40%), and to prevent environmental pollution (32%) (Phuc et al., 2006). The perceived health risk related to the use of raw human excreta as fertilizer appears low.

Again in the Nghean Province of Vietnam, similar habits regarding the use of partially composted excrement for agricultural purposes. Over 90% of the households use excreta as fertilizer, and 94% compost the material prior to use. In order to have fertilizer for each of the three agricultural seasons, most households (74%) allow the excreta to decompose for three to four months, instead of the six-month minimum prescribed by the Vietnamese Ministry of Health. As mentioned previously, the lack of composting time leads to issues with helminthes, such as *Ascaris* eggs. Despite the issues with helminthes, the use of human excreta, especially composted excreta, as fertilizer is seen as very beneficial. Accordingly, 48% of the men and 37% of the women expressed that composting improves the soil structure. Expressing a fear of human feces, respondents said feces could be detrimental to the handler's health because contact with the feces could lead to diarrhea, gastro-intestinal diseases, and lung diseases. Similar to the Rheinländer et al. (2010) study, the foul smell causes concern. Referred to as 'mui hoi,' the bad smell emanating from the latrine waste is considered a health risk when handling the excrement. The informant explained that the smell transmitted bad substances to food, and this food could harm the consumers. Hence, community members thought wet, foul smelling feces to be unsafe or harmful, while odorless feces were thought to be harmless. These perceptions were exemplified by the focus group's assertion that they do not fear applying composted feces by hand. In the end, 68% of the men and 59% of the women believe the composting of excreta could prevent disease (Mackie Jensen et al., 2008). A noteworthy discrepancy in the findings is the response to the household survey regarding the duration of composting. More than half responded with an answer in accordance with the Ministry of Health's guidelines, saying the excreta composted for at least six months. These responses conflict with the known use of excreta as fertilizer for each of the three yearly harvests. Responding in line with the official guidelines, the respondents could have been answering out of personal interest or because of recall bias (Mackie Jensen et al., 2008).

2.5 Summary

In conclusion, the need for sanitation infrastructure is great, but the need for sustainable sanitation infrastructure is even greater. Ecological sanitation exemplifies the ideal characteristics of an environmentally sustainable sanitation technology. It aims to recover and reuse the nutrients found in excreta while also promoting water and energy conservation. Despite the environmental benefits, the social acceptability of ecological sanitation depends on the culture, attitudes, and perceptions of the user. In Panama, composting latrines, a version of ecological sanitation, have been implemented in coastal and fluvial areas, especially in rural indigenous communities. Proper use of these composting latrines requires daily maintenance and yearly removal of composted feces. Limited research has been conducted about composting latrines in Panama, and no published literature quantifies the number of properly used composting latrines. While the social acceptability of composting latrines has been investigated in other countries, the attitudes and perceptions regarding feces and their use as a soil amendment have not been investigated in Panama. Furthermore, the human attitudes and perceptions have not been evaluated in terms of incentives or barriers to composting latrine use.

CHAPTER 3: METHODS

3.1 Composting Latrine Use

This chapter will outline the research steps taken to collect and analyze the data needed to address the objectives of this study. The methods are comprised of three phases: (1) composting latrine use, (2) likes and dislikes of composting latrines, and (3) perceptions of feces and the use of composted human feces as a soil amendment. Phase 1 involves observations and formal interviews and addresses the first objective. Phases 2 and 3 involve informal interviews and surveys, which correspond to the second objective. A brief summary of the three phases of data collection, including sample sizes, is shown in Table 7. With respect to data collection for this study, the observations, formal, and informal interviews were conducted between August 2013 and January 2014, while surveys were conducted during the first quarter of 2014. The author conducted this research in communities with composting latrines in the province of Bocas del Toro and the Ñö Kribu region of the Comarca Ngäbe-Buglé (see Figure 5 and 6). The Ñö Kribu region is the portion of the Comarca that pertained to the Bocas del Toro province prior to the formation of the Comarca Ngäbe-Buglé in 1997. These communities had implemented composting latrine projects with the help of Peace Corps Volunteers starting in June 2003 up through the present.

Table 7. Summary of research phases for data collection.

Research Phase	Methods	# of Communities	Sample Size[1]
1. Composting Latrine Use	Interviews & Observations	23	113
	Interviews Only	23	49[2]
	Observations Only	23	39[3]
2. Likes and Dislikes of Composting Latrines	Informal Interviews	18	18
3. Perceptions of Feces and the Use of Composted Human Feces as a Soil Amendment	Surveys	3	125

[1] Sample sizes were determined by the availability of participants meeting the study inclusion criteria (i.e. household with latrine, etc.) and the limited time dictated by the difficulty of travel.
[2] Only interviews were conducted when the latrine was broken or declared unused.
[3] Only observations were conducted when the latrine owner was not present. Proper use was still determined using observations.

Figure 5. Map of Panama showing the inset area detailed in Figure 6.

Figure 6. Map of inset of Bocas del Toro province and the Ñö Kribu region of the Comarca Ngäbe-Buglé.

3.1.1 Description of Communities

Twenty-three (23) communities were visited to investigate the use of composting latrines. Figure 7 shows the location of all 23 communities visited for the composting latrine use interviews. All of the communities (listed in Table 8) are indigenous Ngäbe communities with relatively small populations between 100 and 2,200. As some communities are on the roadside, the distance by foot or boat to the main David-Changuinola highway, or regular hourly public transport, ranged from 0 to 150 minutes. The traditional home in this location is a wooden structure built on wooden stilts with thatched roofs made from dried palm fronds. Many households have started to use corrugated tin roofs, and a few started to build concrete-block houses. Most communities have a gravity-fed water supply system, but many do not supply sufficient amounts of water for 24-hour service to all households. Some communities rely upon rainwater, and others use unprotected sources, such as hand-dug wells or streams. With respect to sanitation infrastructure, certain households without composting latrines have pit latrines (in a few, select communities) or a pour-flush septic tank system. But, many community members still defecate in the river or streams either at night or in a hanging latrine.

The major source of income for the majority of the communities in the study is subsistence agriculture. Principal crops in the two study regions include cacao, bananas, plantains, tropical fruits (i.e. soursop, papaya, and pineapple), and root vegetables (i.e. yucca, white yams, and taro). Along the coast, fishing and lobstering are major sources of income. Additionally, men often leave their community to find work in the nearby banana company's plantations or in construction in the bigger cities. In the mountains, men may leave yearly to seek work in the coffee fields in Costa Rica or in the neighboring province, Chiriquí. The city of Bocas del Toro on Isla Colon has grown significantly in recent years and has provided jobs in the tourism and hotel industries.

Table 8. List of communities for the composting latrine use interviews and general community.

Community		Dates Surveyed	Second Date	Approximate Population	Total Number of Households	Distance from Regular Public Transport
1	Bahia Azul	27-Aug-13	28-Aug-13	550	70	60
2	Cayo Paloma	20-Nov-13		300	40	150
3	Filo Verde	7-Nov-13	8-Nov-13	375	49	60
4	Kuite	16-Aug-13		100	18	150
5	Kusapin	19-Nov-13		2,200	600	60
6	La Gloria[1]	7-Oct-13		650	80	Regular direct transport
7	Milla 7 1/2	9-Oct-13		250	40	Regular direct transport
8	Nance De Risco	13-Nov-13		800	120	20
9	Nidori	29-Aug-13		70	11	90
10	Norteño	6-Nov-13		1,000	100	20
11	Nudovidi	21-Nov-13		800	50	30
12	Punta Avispa	29-Aug-13		16	100	60

Table 8 (Continued)

13	Punta Sirain	26-Aug-13		600	50	60
14	Quebrada Pastor	29-Oct-13		1,000	105	On the highway
15	Quebrada Pita	26-Oct-13		200	30	40
16	San San Puente	5-Nov-13		600	120	On the highway
17	Santa Marta[1]	22-Nov-13		300	35	15
18	Santa Rosa	30-Oct-13		250	31	Regular direct transport
19	Silico Creek[1]	28-Oct-13	23-Nov-13	550	34	On the highway
20	Soledad de Risco	14-Nov-13		300	Not obtained	20
21	Valle Escondido	15-Jan-14		300	40	30
22	Valle de Risco[1]	26-Oct-13	24-Nov-13	1,500	126	Regular direct transport
23	Valle Junquito	6-Oct-13		400	45	20

[1]Communities' populations and number of houses taken from Mehl (2008) from data collected between September and November 2007.

Figure 7. Locations of sites identified in Table 8 and visited for the composting latrine use interviews. Map is reproduced from GoogleMaps with Google © 2013 information. Data contributors are listed in the figure. The figure was changed only in that markers were placed in each of the community locations.

3.1.2 Interviews

The composting latrine use interviews were conducted in 23 communities, and 201 composting latrines were visited. Outside of these communities approximately four other composting latrines would have been built, in conjunction with Peace Corps Volunteers, during the time of data collection. The community itinerary and expected number of composting latrines to be visited was based upon a survey of composting latrines conducted in 2009 by the Peace Corps Volunteer Whitney Golob. The author conducted unannounced visits to each community. Typically, the closest Peace Corps Volunteer familiar with the community guided the author through the community, but some communities the original leader of the composting latrine project led her through the community. If neither a Peace Corps Volunteer nor a community guide was available, the author visited the first latrine and relied upon the guidance of latrine owners to direct her to the next owner.

At each household with a composting latrine, the author introduced herself, asked to speak with the latrine owner, or caretaker, and used the script for informed consent found in Appendix B. The family selected the respondent, as he or she was most knowledgeable and also willing to answer my questions. Upon receiving verbal consent, the author continued with the questions outlined for Phase 1 in Appendix C. All interviews and discussions were conducted in Spanish. Thus, the criteria for inclusion in the study was (1) the respondent could communicate in Spanish, (2) the respondent was the household leader, or selected by the household leader, and (3) the respondent's family owned a composting latrine.

Questions 1-13, 20, 22-23 in the composting latrine use interview found in Appendix C were derived from the questions posed in "An Analysis of the Use of Desiccant As a Method of Pathogen Removal In Compost Latrines in Rural Panama" (Kaiser, 2006). These questions evaluated the following characteristics for the corresponding reasons as shown in Table 9. Questions 14-19, 21, 24-26 were developed by the author to evaluate the following characteristics shown in Table 10.

Table 9. Characteristics of the composting latrine condition to be evaluated (Kaiser, 2006).

Characteristic Evaluated	Reason for Evaluation
Presence of desiccant sack/container	Determine if desiccant is being used
Quantity of desiccant in latrine box	Determine if proper amount of desiccant is being added for pathogen removal through desiccation
Types of desiccants used	Determine if proper types of desiccants are being used for pathogen removal through desiccation
Method of depositing desiccant	Determine if consistent amounts of desiccant are being deposited
Seat covered properly	Determine if latrine is managed to protect health of user
Odor problems in latrine	Determine if proper quantity and quality of desiccant is being used
Use of compost	Determine if households are using finished compost
Training received on latrine use and maintenance	Determine if latrine user received proper training
Change in frequency of diarrhea	Determine how latrine affects health of households

Table 10. Characteristics of the composting latrine condition to be evaluated as developed by the author.

Characteristic Evaluated	Reason for Evaluation
Latrine maintenance responsibility	Determine gender-based responsibility in latrine maintenance
Location of compost use	Determine if compost use instructions are followed Determine veracity of response to use of compost question
Operation of composting latrine	Determine if users are following prescribed instructions to achieve aerobic decomposition
Cleansing mechanism	Determine how traditional water-washers adapt to composting latrines Determine effect of water-washing tradition on composting latrine use
Training efficacy	Determine if the latrine users remembered the original training

Table 10 (Continued)

Training efficacy	Determine if the latrine users had received updated training based on recent research findings
Origin of composting latrine project	Determine date and background of the project
Rate of disuse	Determine with respect to time the rate of disuse of composting latrines

3.1.3 Observations

The observation steps were detailed in Mehl (2008) and Kaiser (2006). The following steps were followed for the observation portion of the data collection:

1) After interviewing the latrine owner, the author asked for permission to enter the owner's latrine to make observations. With permission, the author passed to the latrine and entered.
2) Upon entering the latrine, the author first noted if the owners had a sack or container with desiccant available in the latrine. If a sack or container existed, the type of desiccant and presence or absence of a scoop was noted.
3) Using a flashlight, the author looked into the box in use of the dual chamber composting latrine. The presence and type of desiccant was observed and noted.
4) Based on the author's visual observations of the material on the top of the pile, the moisture level of the latrine contents was rated on a scale 1 to 5. A rating of 1 signified very dry contents, and a rating of 5 signified very wet contents.
5) The author also recorded if the latrine seats were covered properly.
6) Based on the author's olfactory observations, the odor level of the latrine was rated on a scale 1 to 5. A rating of 1 signified no odor or only odor of the desiccant, such as sawdust, and a rating of 5 signified an odor similar to that of an unmaintained pit latrine or raw sewage.

7) Based on the author's observations, the overall cleanliness of the latrine was rated on a scale 1 to 5. A rating of 1 signified a well-swept floor and a clean latrine seat, and a rating of 5 signified a dirty floor and a dirty seat with cockroaches or fouled by urine and/or excrement.
8) The author also examined the physical status of the latrine. For instance, broken tubes, unsealed rear doors, missing seats, and structural failures were observed and recorded.

3.2 Likes and Dislikes of Composting Latrines

3.2.1 Informal Interviews

In 18 of the 23 communities, the author held an informal interview with a community member about the likes and dislikes of composting latrines. Phase 2 of this study is comprised of these informal interviews, whose questions are listed in Appendix C. By asking about advantages/likes and disadvantages/dislikes, these questions were used to investigate the attitudes of composting latrine owners toward their latrine. The frequency of response was tallied and provided the foundation for the Phase 3 survey. The interviewee was selected after conducting Phase 1, the composting latrine use interviews and observations. Noting a more outgoing, forthcoming, and frank respondent, the author discussed the questions found in Appendix B. The following communities were involved in the informal interview step of the research: Bahia Azul, Filo Verde, Kuite, Kusapin, La Gloria, Nidori, Norteño, Milla 7 ½, Punta Avispa, Punta Sirain, Quebrada Pastor, Quebrada Pita, San San Puente, Santa Marta, Santa Rosa, Silico Creek, Valle de Risco, and Valle Junquito. Thus, the criteria for inclusion in the study was (1) the respondent could communicate in Spanish, (2) the respondent was an outgoing, forthcoming household leader, and (3) the respondent's family owned a composting latrine.

3.3 Perceptions of Feces and the Use of Composted Human Feces as a Soil Amendment

3.3.1 Description of Communities

3.3.1.1 Norteño

The indigenous Ngäbe community of Norteño is located approximately 20 minutes walking from the main David-Changuniola highway. The community consists of approximately 100 houses. Because of its location, the approximately 1,000 residents have regular access to transportation and a larger town, Chiriquí Grande. But, the community lacks cell phone signal and remains relatively isolated for this reason. Within the community, the primary occupation is subsistence agriculture, but some seek jobs outside of the community in construction and banana plantations. Norteño has a grade school and middle school, which means that community members can reach ninth grade without leaving the community for schooling. The middle school serves the surrounding communities located further from the road in the mountains. To complete high school at this moment, a student would need to travel over an hour each way to attend school near Chiriquí Grande. As a larger community, Norteño has a Puesto de Salud, a Health Post, which is staffed with a nurse and community health worker.

The community has access to two separate gravity-fed aqueduct systems, which provide water on an irregular schedule. In the late 1990s, a Peace Corps Volunteer worked with the community to obtain ribbed plastic tubing with diameters of 8 feet for the construction of pit latrines. Because of sandy soil, the pit latrines needed linings in order to prevent collapse. In 2003 with the help of a neighboring Peace Corps Volunteer, community leaders attended training in Changuinola, the regional governmental agency hub, to discuss composting latrines. Within the following year, the community constructed 19 composting latrines. But, the community health worker, native to this community, made the personal observation based on experience and conversations that during the day latrine owners will use the latrine, but if defecating at night, the person will go to the nearby stream. Open defecation is still common in the river or streams that run through and alongside the community.

3.3.1.2 Filo Verde

The indigenous Ngäbe community of Filo Verde is located approximately an hour from Norteño or an hour and 20 minutes walking from the main David-Changuniola highway. The community consists of approximately 49 houses. Because of its location, the 375 residents have limited access to transportation and the larger town, Chiriquí Grande. Furthermore, the community lacks cell phone signal and remains very isolated for this reason. Within the community, the primary occupation is subsistence agriculture, but some seek jobs outside of the community in coffee and banana plantations. Filo Verde has a grade school, which means that community members can reach sixth grade without leaving the community for schooling. To complete middle school, a student would walk for an hour to Norteño. To complete high school at this moment, a student would need to travel over two hours each way to attend school near Chiriquí Grande or reside with extended family outside of the community.

The community has access to one gravity-fed aqueduct system, which reliably provides untreated water. In 2003 with the help of the community's Peace Corps Volunteer, community leaders attended training in Changuinola, the regional governmental agency hub, to discuss composting latrines. Within the following year, the community constructed 20 composting latrines. However, open defecation is still common in the rivers that run alongside the community according to the responses of community members.

3.3.1.3 San San Puente

The indigenous Ngäbe community of San San Puente is located on the main highway 10 minutes driving north of Changuinola. The community consists of approximately 120 houses. Because of its location, the approximately 600 residents have easy access to transportation and a larger town, Changuinola. The community has a cell phone signal and is not isolated in comparison to the previous two communities. Within the community, the primary occupation is day labor in banana plantations. Very few have farmlands of their own, and if a family does have a farm, the farm is located in another community far away. Some community members work in tourism as the River San San is a natural habitat for manatees. San San Puente has a grade school, which means that community members can reach sixth grade without leaving the community for schooling. To complete middle or high school at this moment, a student would need to travel 10 minutes by bus each way to attend school in Changuinola.

The community does not have access to a gravity-fed aqueduct system, so households depend upon rainwater for consumption. With respect to the sanitation infrastructure situation, a Peace Corps Volunteer worked with the community to construct 11 composting latrines in 2004 or 2005. Significant flooding has caused problems even for composting latrines, but a few families have implemented pour-flush septic tank systems. Open defecation is still common in the river that runs alongside the community according to the responses of community members.

3.3.2 Surveys

The surveys regarding the perceptions of excreta and composted excreta used as fertilizer were conducted in three communities. Coordinating with the resident Peace Corps Volunteer, the author conducted announced visits to each community. In each community, the resident

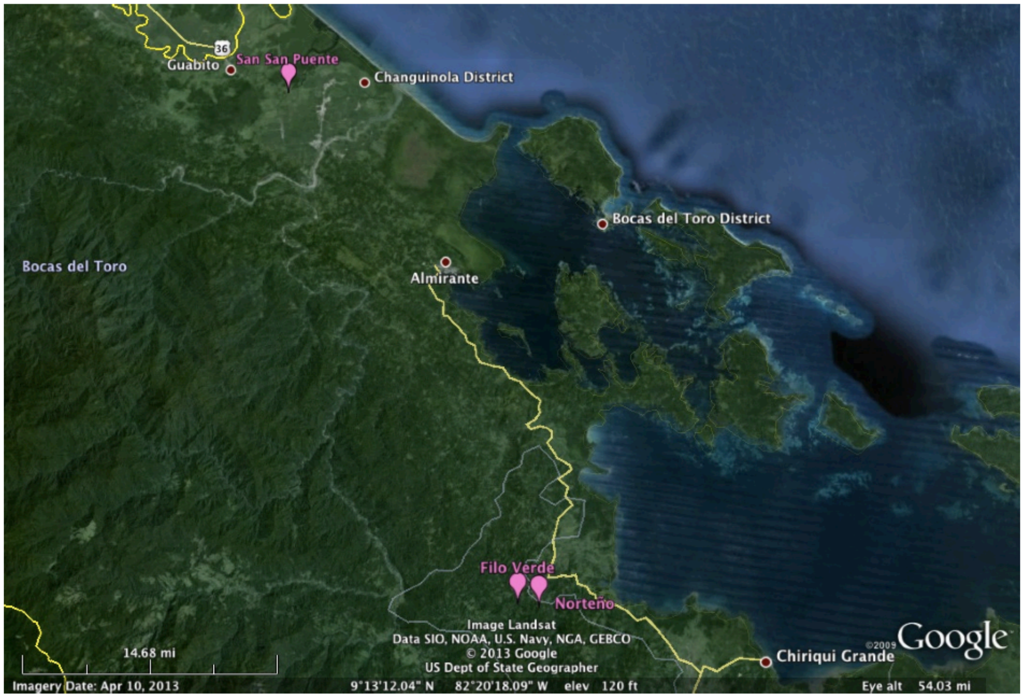

Figure 8. Map of sites visited for the perceptions of excreta and composted excreta survey. Map is reproduced from GoogleMaps with Google © 2013. The figure was changed only in that markers were placed in each of the community locations.

volunteer accompanied and introduced the author to each household. At each household, the author introduced herself, asked to speak with the household leader, and used the script for informed consent found in Appendix A. The family selected the respondent, as he or she was most knowledgeable and also willing to answer my questions. Upon receiving verbal consent, the author continued with the questions outlined for Phase 3 in Appendix B. Many houses were empty, but in an attempt to visit every household in Norteño and Filo Verde, the author revisited previously vacant houses a second time. Due to limited time, the author was only able to visit a portion of the houses in San San Puente. All surveys were conducted in Spanish. Thus, the criteria for inclusion in the study was (1) the respondent could communicate in Spanish, (2) the respondent was the household leader, or selected by the household leader, and (3) the respondent was a resident of one of the three communities. The three communities were selected for the presence of a Peace Corps Volunteer to facilitate logistics and for the diversity in demographic characteristics between the three communities.

Compiling the surveys from Mariwah and Drangert's (2011) work in Ghana, residents' attitudes and perceptions towards human feces and the residents' knowledge on utilization of human excrement as fertilizer were surveyed. Mariwah and Drangert (2011) posed eight statements to assess the residents' attitudes and perceptions regarding human excreta. Utilizing a Likert-type scale ranging from 1 to 3, the study participant then responded to the following statements with agree (1), don't know (2), and disagree (3):

1) Human excreta is a waste and suitable only for disposal
2) Handling excreta is great health risk
3) Human excreta should not be handled in any way
4) Human urine has no benefit to humans
5) It is a taboo to handle urine
6) Human feces have no benefit to humans
7) It is a taboo to touch feces
8) It is a taboo to touch treated feces

Additionally, Mariwah and Drangert (2011) posed ten statements to access the residents' knowledge on utilization of human excreta as fertilizer. Utilizing a Likert-type scale ranging from 1 to 3, the study participant then responded to the following statements with agree (1), don't know (2), and disagree (3):

1) Human excreta are a resource for the soil
2) Sanitized human excreta can be used as fertilizer
3) I will use human excreta on my crops if sanitized

4) Taste of vegetables will change when fertilized with urine
5) Smell of vegetables will change when fertilized with urine
6) Crops can be killed when fertilized with urine
7) Crops fertilized with human excreta are good for consumption
8) I will never consume crops fertilized with human excreta
9) Animal manure can be used as fertilizer
10) Ever used animal manure as fertilizer

After observing that no composting latrine users in the study area collect urine from the composting latrine, the author eliminated the statements 4-6 that related to urine attitudes, perceptions, and knowledge. Additionally, the direct translation of "taboo" and certain technical words, such as "fertilized," are not familiar to this indigenous group. Therefore, the "taboo" statements were changed to say "it is OK to touch excrement with your hands" and "it is OK to touch composted excrement" (see Appendix C). As noted by Vega (2013), a Ngäbe participant is able to speak Spanish, but he or she is not always fluent in this language. The vocabulary is typically basic, so some English vocabulary was broken down into simpler Spanish vocabulary to maintain the contextual meaning.

Mariwah and Drangert (2011) also questioned the participants about the factors that would prevent residents from using sanitized excreta on crops. The frequency of the following factors were analyzed:

1) Smell
2) Health risk
3) Appearance
4) Patronage will be poor

5) People will mock at me

6) Religious belief

7) None

As previously mentioned, some English vocabulary was broken down into simpler Spanish vocabulary to maintain the contextual meaning and to remain understandable for the participants. Incorporating factors discussed during the informal interviews, the author added the following possible factors for the nonuse of composted excreta as fertilizer:

1) COCABO/ organic certification group says it cannot be used

2) Other community members have told me that it was bad

3) The farmland is too far away

4) Other

3.3.3 Socio-demographic Information

After completing the survey with each household leader, the author requested the following socio-demographic information for each respondent:

1) Age

2) Sex

3) Education

4) Household size

5) Religious affiliation

6) Marital status

7) Primary occupation

8) Length of stay (5, 10, 15, 20, 30 years)

3.3.4 Data Analysis

To better understand the perceptions of feces and their reuse, 16 statements were read to the participant, to which he or she responded, "agree," "don't know," or "disagree." Then, statistical analysis tests were run using SPSS to evaluate the relationship between socio-demographic information and the responses to the 16 statements. The three response options were treated as nominal data for each of the statements. These responses were not treated as ordinal data because "don't know" could arguably refer to a third category that lies outside of the scale between "agree" and "disagree." If "don't know" corresponded to a "maybe" in the respondent's mind, the responses would have been deemed ordinal data for the purpose of statistical analysis. Other nominal variables included the community, sex, sanitation classification, and primary occupation. However, the scalar variables included age, education, and household size.

For the scalar variables, the frequencies of the values were plotted in a histogram to determine if the data was normally distributed. The histograms and a more detailed analysis of the distribution can be found in Appendix D. The distributions were determined to be non-normal, so non-parametric statistical tests were used for further analysis. When comparing the scalar demographic data with the responses (i.e. scalar versus categorical), a form of the Mann Whitney test was run, the Kruskal-Wallis test. The Kruskal-Wallis test compares three or more unmatched groups to determine statistical significance ($p < 0.05$).

When comparing the nominal demographic data with the responses (i.e. categorical versus categorical), the chi-squared test was run. However, the chi-squared test assumes that less than 20% of the expected cell counts are less than five. The expected count of each response option (i.e. "agree," "don't know," or "disagree") should be greater than five for each categorical value (i.e. male, female or Filo Verde, Norteño, San San Puente) in the demographic variable. This assumption did not hold for the majority of the chi-squared tests. Thus, the Fisher's exact test was used to determine statistical significance ($p < 0.05$). To know the strength of the association for the statistically significant relationships, Cramer's V was calculated. Finally, the standardized residual, a z-score, was used to identify which categorical value affected the chi-square, or rather, to pinpoint the demographic information that affected the responses.

3.4 Summary

Prior to beginning data collection, the research methods employed were approved by the Institutional Review Board (IRB) at the University of South Florida (see Appendix D for IRB correspondence). Three phases of data collection were carried out in the province of Bocas del Toro and the Ñö Kribu region of the Comarca Ngäbe-Buglé. Formal interviews and observations were used to quantify proper use, and informal interviews and surveys were used to evaluate the attitudes and perceptions of feces and their reuse among the Ngäbe indigenous group. The frequencies of likes and dislikes represented the general attitudes of composting latrine owners toward their latrine. Using the statistical analysis software, SPSS, data analysis showed the association between certain demographic variables and the survey responses.

CHAPTER 4: RESULTS AND DISCUSSION

As discussed in Chapter 1, the objectives of this thesis are to (1) quantify the usage of completed composting latrines and the composted feces and (2) evaluate how human attitude and perceptions of feces and the use of composted feces serve as an incentive or barrier to use of composting latrines in the Bocas del Toro province and Ñö Kribu region of the Comarca Ngäbe-Buglé, Panama. Through interviews and observations, the author quantified the (1) number of composting latrines in use, (2) the number of composting latrines not in use, and (3) the number of unfinished or broken composting latrines. Of the composting latrines in use, the number of latrine owners operating and maintaining the latrine properly was quantified and responses regarding the proper utilization the composted feces was also evaluated. By conducting informal interviews and surveys, the research also evaluated the likes and dislikes of composting latrines and the perceptions of feces and their use as a soil amendment. Finally, the incentives and barriers based in human attitudes and perceptions are characterized.

4.1 Composting Latrine Use

To quantify the use of composting latrines, the visited latrines were divided into the four main categories depicted in Figure 9. "In use" refers to complete composting latrines that are in use, or showed the presence of feces in the latrine compartment. Thus, "not in use" refers to complete composting latrines that were in use at one point but are no longer in use, in accordance with observations and/or the interview with the latrine owner. Italicized headings represent the completed latrines that are not used properly. “Unfinished” represents the composting latrines that are missing pieces of the base (i.e. urine separation tubes, seats, or back doors) or do not have a completed privacy structure. “Broken beyond reasonable repair” represents the composting latrines that have been significantly damaged, such that the latrine owner cannot financially or physically repair the structure. If only minor repairs were necessary, such as sealing doors or reconnecting urine tubes, the latrine was considered “not in use.” Of the completed “in use” composting latrines, the latrines were divided between “proper” and “improper” based on the observed characteristics of the composting latrine. Based on observations, the properly used composting latrine had desiccant present in the compartment, a moisture rating of three or below, and an odor rating of three or below as well. The moisture rating of three or below would correspond to either method of pathogen destruction: aerobic decomposition (ratings 2 or 3) or desiccation (rating 1). An odor rating of three or below allows for the fact that recent use could lead to strong smells if the family opts to add desiccant weekly or biweekly rather than after each defecation.

Table 11 shows that the percentage of completed composting latrine projects is 70.6% (n = 201), but important findings of note are the significant range in completed ranges and the difference between communities. For example, the low percentage of completed latrines in Santa Rosa (22.2%) is partially a result of their relatively recent construction. Depending upon the household’s income, the time required to save sufficient funds to purchase or cut wood for the privacy structure will vary. Some families will cut wood immediately to line the privacy

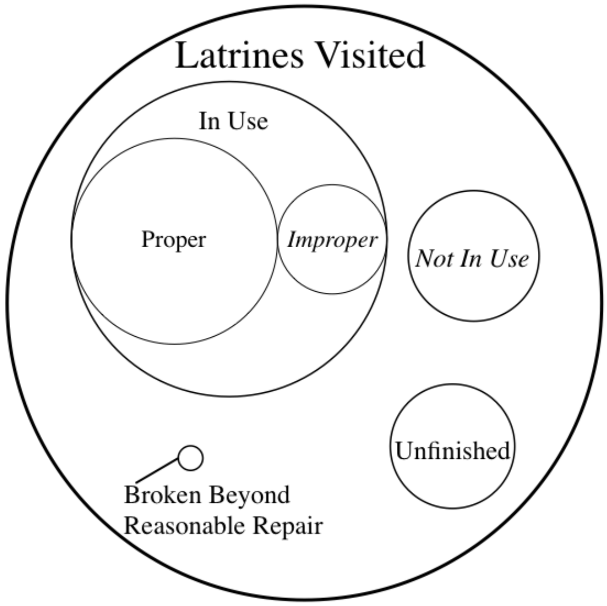

Figure 9. Pictograph describing the use status of composting latrines visited.

structures, while other families may wait over a year to purchase the wood to line the privacy structure. On the other hand, in Valle Junquito the 33.3% completion percentage is still relatively low despite the construction took place over five years ago. In contrast, some communities did achieve 100% completion, such as in Kuite, Milla 7½, Nidori, Punta Avispa, Silico Creek, and Valle de Risco. That being said, the first four communities mentioned only have one latrine in the community, and for Silico Creek and Valle de Risco, the number of visited latrines could possibly not account for all of the unfinished latrines. In larger communities with numerous composting latrines, exact numbers for composting latrines constructed, whether finished or not, are difficult to ascertain from the various answers received from community leaders. No documents within the community or from the donor organization existed to identify the latrine owners with 100% accuracy. Despite this difficulty and other constraints, the best attempt was made to visit all latrines present in a community.

Table 11. Numbers and percentages of composting latrines visited and their respective use status.

Community	Expected Total[1]	Visited	Completed	Completed in Use[2]	Used Properly of Completed In Use[3]	Used Properly of Total Completed[4]	Unfinished or Broken
Bahia Azul	12	12	66.7%	75.0%	83.3%	62.5%	33.3%
Cayo Paloma[5]	1	1	0.0%	N/A	N/A	N/A	100.0%
Filo Verde	22	20	75.0%	80.0%	75.0%	60.0%	25.0%
Kuite	1	1	100.0%	100.0%	100.0%	100.0%	0.0%
Kusapin[6]	8	8	75.0%	66.7%	75.0%	50.0%	25.0%
La Gloria	12	10	90.0%	77.8%	57.1%	44.4%	10.0%
Milla 7 1/2	1	1	100.0%	100.0%	100.0%	100.0%	0.0%
Nance De Risco	10	8	62.5%	80.0%	25.0%	20.0%	37.5%
Nidori[7]	1	1	100.0%	0.0%	N/A	0.0%	0.0%
Norteño	22	19	84.2%	68.8%	63.6%	43.8%	15.8%
Nudovidi	11	10	90.0%	66.7%	50.0%	33.3%	10.0%
Punta Avispa	1	1	100.0%	0.0%	N/A	0.0%	0.0%
Punta Sirain	8	8	50.0%	50.0%	N/A	N/A	50.0%
Quebrada Pastor	12	12	83.3%	90.0%	88.9%	80.0%	16.7%
Quebrada Pita	4	2	50.0%	100.0%	0.0%	0.0%	50.0%
San San Puente	11	11	81.8%	66.7%	33.3%	22.2%	18.2%
Santa Marta	7	7	42.9%	100.0%	33.3%	33.3%	57.1%
Santa Rosa	9	9	22.2%	100.0%	100.0%	100.0%	77.8%
Silico Creek	14	14	100.0%	57.1%	87.5%	50.0%	0.0%
Soledad de Risco	9	8	50.0%	100.0%	25.0%	25.0%	50.0%
Valle Escondido[6]	22	22	50.0%	72.7%	75.0%	54.5%	50.0%
Valle de Risco	33	10	100.0%	50.0%	40.0%	20.0%	0.0%
Valle Junquito[6]	6	6	33.3%	100.0%	100.0%	100.0%	66.7%
Total	**237**	**201**	**70.6%**	**71.8%**	**65.0%**	**45.8%**	**29.4%**

Table 11 (Continued)

[1] The expected total comes from personal communication with RPCV Whitney Golob (2011), her report (2009), personal communication with RPCV Tess de los Rios (2013).
[2] Percentage of completed composting latrine that are in use, according to observation.
[3] Percentage of the in use completed composting latrines that are properly used, according to observation ratings.
[4] Percentage of the completed composting latrines that are properly used, according to observation ratings.
[5] The composting latrine was torn down within the past 5 years to allow for the construction of another building.
[6] One to two of the composting latrines in these communities were used only by the elderly in the family. The remaining family members continued to practice open defecation, but the latrine was deemed "in use."
[7] The composting latrine was built for the use of tourists. No community members use the latrine.

Of the completed composting latrines in the region, Table 11 also shows that 71.8% were determined to be in use (n = 201). In each community with more than 1 latrine, greater than half of completed composting latrines are being used. However, the percentage of completed composting latrines that are used properly as determined by observation was only 65%. Accordingly, 35% of used latrines are not used properly, as reflected by observed high moisture contents, strong odors, and a lack of desiccant in the compartment.

Of the composting latrines visited, 29.4% were broken (8) or unfinished (51). To speak to a technical aspect of latrine operation, 22.5% of the respondents with completed composting latrines mentioned problems with the urine tubes. Accordingly, the technical and durability of the composting latrine design should be further studied. Because of severe flooding, low quality construction materials, or poor placement/backfilling in marshy areas, some latrines could no longer be used. On the other hand, many latrines are either missing small pieces like compartment access doors or do not have a privacy structure to enclose the latrine seating area. With respect to small pieces, such as the access doors, urine tubes, or seats, the financier of the project is typically responsible for funding these components. On the other hand, the privacy structure typically is normally the responsibility of the latrine recipient, or owner. Unfinished latrines, which account for 25.4% of 201 latrines visited, typically reflect a lack of interest from the stakeholder. Each community has residents experienced with the construction of the composting latrine, so despite the departure of a Peace Corps Volunteer or governmental agency, the community had the technical capacity to continue building and finishing composting latrine. Owners of the unfinished composting latrines cited economic barriers, but other community members cited low levels of interest as the reason for latrine incompletion. For this reason, a better understanding of the attitudes and perceptions related to composting latrines and their operation and maintenance (i.e. interaction with feces and their reuse for agricultural purposes) is valuable in assessing levels of interest and priorities. The socio-cultural sustainability of a sanitation project depends upon high levels of stakeholder interest.

Looking at all of the completed composted latrines, Table 11 shows that communities with a high completion levels (≥60%), high proper usage levels (≥60%), and more than one latrine include Bahia Azul, Filo Verde, and Quebrada Pastor. Differing in levels of accessibility, Bahia Azul's latrines were constructed in 2011-2012, Quebrada Pastor's were constructed in 2010, and Filo Verde's were constructed in 2003-2004. Despite the different construction years, a Peace Corps Volunteer from the community led the respective project, and each community had had a Peace Corps Volunteer within the year prior to the interviews and observations. Besides ethnicity, other similar characteristics include populations dependent upon subsistence farming, communities without previous aid for sanitation, and traditionally practiced water washing and open defecation in rivers or streams.

Only the interviews of owners operating the latrine properly were analyzed further. Of the properly operated latrines, 14 were less than 1 year old and thus too new to have the opportunity to remove compost. That being said, most respondents did not know the month in which they would change chambers or remove compost. Rather, the response from 19 owners was that they would change sides (and, in turn, remove compost) when the side in use fills. Only the communities with composting latrines constructed since August 2011 mentioned a one-year storage time, because until recently, all latrine recipients had been instructed to use each side for only six months. Of the 102 composting latrine owners identified as using the latrine properly, 34 claim to have mixed their compost at least once, and 25 of those 34 claim to have mixed within the past three months.

As expected, all families with male and female household leaders described similar divisions of labor. The females perform the daily maintenance by cleaning the latrine, but the males remove the composted excrement. In households run by women, the women either charged the eldest son with the work of removing the composted excrement, or she was responsible for its removal.

When asked, "What do you do when you remove the compost?" only four people mentioned drying the compost additionally in the sun. Only two participants mentioned additional storage time in a sack, while one mentioned mixing it with soil. All other latrine owners, who had removed compost from the latrine, responded that the compost was either not used or applied directly around plants. The training message prior to August 2011 is unclear, but since August 2011 the training message has incorporated solar drying and mixing as methods to limit exposure to pathogens. New latrine owners often expressed the desire to see the resulting product before deciding whether or not they would use the compost on their crops. This desire to test the "experiment," the communities' references to the first round of latrines in a community, supports the need for pilot latrine projects. Without investing significant amounts of time and money in semi-successful composting latrine projects, the level of interest and sustainability can be observed, and key stakeholders can be selected for future sanitation projects.

4.2 Attitudes and Perceptions Related to Composting Latrines

4.2.1 Likes and Dislikes

Informal interviews conducted in 18 different communities, attempted to learn of the likes and dislikes of composting latrine users. When posed with the question, "What do you like about your composting latrine?" the respondents discussed the various advantages (shown in Table 12) they had experienced during the lifetime of their composting latrine. And, in response to the question, "What do you dislike about your composting latrine?" the participants discussed the disadvantages (shown in Table 13). It was noted that respondent provided fewer disadvantages than advantages associated with the composting latrine. The advantages, or "likes," often referred to advantages in comparison to open defecation or to pit latrines. Only one advantage was mentioned that compared composting latrines to pour-flush septic tank systems. On the other hand, the disadvantages, or "dislikes," often referred to the disadvantages in comparison to pour-flush septic tank systems.

Table 12 shows the frequency of items referred to by latrine owners that they liked and Table 13 shows the frequency of items that were disliked. As shown in Table 12, the primary advantage of composting latrines, according to the informal interview participants, was the latrine's resulting product, compost (frequency of 13). The production of compost is an advantage when comparing composting latrines to both open defecation and pit latrines. Other key advantages included a lack of mosquitoes, flies, smell, and contamination. The lack of mosquitoes, flies, and odors was an important reasoning behind a preference for composting latrines, in lieu of pit latrines. Other advantages perceived in relation to pit latrines included statements 8, 16, 17, 20, 21, 22, and 23. As shown in Table 12, these responses related to either the smell, such as in the cases of (16) dryness and a (21) crowded community lacking space, or the technical feasibility/practicality of building a pit latrine in certain terrains. In the literature, convenience, privacy and safety were all key drivers in social marketing (Jenkins & Curtis, 2005; Geest, 1998). Instead of "convenience," six respondents mentioned proximity as a positive attribute. For these respondents, increased proximity signifies increased convenience. While not top on the list of advantages, privacy and safety were mentioned by five and three respondents, respectively. Finally, the lack of running water in one community put pour-flush septic tanks systems at a disadvantage to composting latrine, when typically, the observation of this study's author was that water-based systems are viewed highly by Panamanians in general.

Table 12. Responses to the informal interviews about composting latrine users' likes regarding the sanitation technology (n = 18).

	Likes Regarding Composting Latrines	Frequency
1	Provides compost	13
2	No mosquitoes or flies	11
3	No smell	8
4	No contamination or leaking	7
5	Proximity	6
6	Peace Corps Volunteer recommended	6
7	Privacy	5
8	Built in areas with high water tables and areas prone to flooding	5
9	Can take one's time	4
10	Stop using the stream	3
11	Can be offered to visitors	3
12	Safety	3
13	Avoid illness	3
14	Don't need to bother another person for accompaniment	2
15	Available at the time you want	2
16	Dry	2
17	Doesn't collapse in sandy soils	2
18	Hides poop	1
19	No fish to bite or bother them	1
20	No need to make another hole	1
21	Good for crowded community lacking space	1
22	Buildable in rocky soil	1
23	Not dangerous, like pits, for kids	1
24	Clean if maintained	1
25	No running water needed	1
26	Easy to use	1

As shown in Table 13, the primary disadvantage of composting latrines, according to the informal interview participants, was the need, or lack of provision within the latrine, for water for anal washing after defecation. While the composting latrine needs to remain dry inside the excrement tank to best promote pathogen destruction through desiccation or aerobic biodegradation, open defecation in streams and oceans, pit latrines, and pour-flush septic tank systems all allow for water washing after defecation. While adding water to a pit latrine is undesirable because of odor and the potential for mosquito breeding grounds, pit latrines are included in the list, because anal cleansing with water is still practiced among Ngäbes with pit latrines. Other key disadvantages mentioned in Table 13 included the required daily maintenance and the need for a consistent supply of sawdust or ash. Besides Response 1, responses 6, 8, 10, 11, and 14 communicate negative perceptions and attitudes related to feces and composting latrines. Other responses in Table 13 that relate to the software, or the educational component, of sanitation project include numbers 4, 6, 7, 12. The aforementioned responses to the transfer of knowledge, sustained upkeep, and behavior change. Finally, the remaining responses, 5, 9, 13, 15, 16, 17, and 18 correspond with technical or financial issues related to the latrine and its use. As the author noted in composting latrine use portion of the study (Section 4.1), the urine tubes are the latrine component most prone to failure. The redesign of specific aspects, such as the urine tubes, should be investigated. As an exterior barrier, number 5 in Table 13 presents a noteworthy barrier to composting latrines and the use of the composted feces. According to the certified organic cacao farmers who participated in this sturdy, a Costa Rican organic certification agency has banned the use of composted human feces on the certified organic cacao to be sold at the Multi-service Cacao Co-operative of Bocas del Toro (COCABO). Further study is needed to fully understand the reasoning behind the ban affecting over a dozen of COCABO's cacao-producing communities and to fully understand the ban's causal or non-causal relationship with the use of composting latrines in the area.

Table 13. Responses to the informal interviews about composting latrine user's dislikes regarding the sanitation technology (n = 18).

	Dislikes Regarding Composting Latrines	Frequency
1	Needed water for washing	8
2	Getting sawdust or ash	5
3	Daily maintenance	4
4	Not kid friendly	3
5	Can't use compost for COCABO organic cacao	3
6	Difficult to change behavior	3
7	Requires education	2
8	Compost is disgusting	2
9	Leaky urine tubes	2
10	Not modern	1
11	Worried might bring disease	1
12	Filthy (cockroaches, ants, etc.)	2
13	Cost of toilet paper	1
14	River cleans better	1
15	Breaks (lack of interest to repair)	1
16	Small size of latrine tanks	1
17	No need for compost	1
18	Ruined if water enters	1

4.2.2 Perceptions of Feces and Its Use as a Soil Amendment

As described in Chapter 2, the author surveyed a total of 124 individuals from three different communities. This survey aimed to assess the perceptions of feces and its use, after decomposition, as a soil amendment. Table 14 outlines the socio-economic demographics of the 124 participants in the perceptions survey. On a macro scale, these communities are very similar and share ethnicity, age distributions, average household sizes, and many of the same customs inherent in Ngäbe culture. That being said, on a micro scale the communities have differences evident when looking at each community within the regional context. For example, because of the difficult access to the community, Filo Verde (n = 37 of the 124 respondents) has had fewer opportunities for education (59.5% with no education) or other occupations outside of subsistence farming (83.8% farmers). With easier access to amenities, Norteño (n = 62 of the 124 respondents) has had more opportunities than Filo Verde with respect to education (16.1% with no schooling) and occupations other than farming (66.1% farmers). San San Puente (n = 25 of the 124 respondents) has still easier access to amenities because of its close proximity to Changuinola, so opportunities to continue schooling or to obtain employment from a company are more feasible (52% banana company employees). At the same, because current residents have been moving to San San Puente from rural areas within the past 10-15 years, the number of participants with no schooling (28.0%) is higher. Additionally, the number of those with a high school education (28%) is lower than expected for the same reason. In general, Filo Verde either uses composting latrines (35.1%) or practices open defecation (59.5%). Norteno uses composting (12.9%) and pit (61.3%) latrines or practices open defecation (25.8%). Finally, San San Puente primarily practices open defecation in the nearby river (92%).

Table 14. Socio-economic demographics of respondents to the perceptions survey.

	Filo Verde	Norteño	San San Puente	Overall
	n = 37	n = 62	n = 25	n = 124
Age[1]				
Range	17-72	15-65	15-70	15-72
Average	39.4	32.0	37.3	35.3
Sex				
Male	40.5%	37.1%	32.0%	37.1%
Female	59.5%	62.9%	68.0%	62.9%
Education[1]				
No schooling	59.5%	16.1%	28.0%	31.5%
Grade 1-6	27.0%	40.3%	40.0%	36.3%
Grade 7-12	10.8%	40.3%	28.0%	29.0%
University	2.7%	3.2%	4.0%	3.2%
Average Years of Schooling	2.6	5.8	5.3	4.7
Household Size[1,2]				
1 to 5	21.6%	21.0%	36.0%	24.0%
6 to 10	54.1%	54.8%	48.0%	52.8%
10 to 15	16.2%	21.0%	16.0%	18.4%
16 or more	8.1%	3.2%	0.0%	4.0%

Table 14 (Continued)

Average	8.1	8.4	7.2	8.1
Primary Occupation				
Farmer	83.8%	66.1%	4.0%	58.9%
Banana Company Employee	0.0%	0.0%	52.0%	10.5%
Store Owner	5.4%	8.1%	8.0%	7.3%
None	8.1%	16.1%	16.0%	13.7%
Other	2.7%	9.7%	20.0%	9.7%
Sanitation Classification				
Composting Latrine	35.1%	12.9%	4.0%	17.7%
Pit Latrine	2.7%	61.3%	4.0%	32.3%
Pour-flush Toilet	2.7%	0.0%	0.0%	0.8%
Open Defecation3	59.5%	25.8%	92.0%	49.2%

[1] The distribution description of these scale variables can be found in Appendix E.
[2] The sample size for Norteno's household size is n = 61.
[3] If the participants indicated that they used their sanitation facility sometimes or that the sanitation facility had recently been broken, the response was categorized as "open defecation."

A noteworthy statistic among the demographic data is the average household size. The average household size across the three communities is approximately 8 people, including children. According to Mehl et al. (2011), one side of this double vault composting latrine should fill in 6 months for a family of 8-12. Mehl et al. (2011) also recommends a storage time of one year to ensure pathogen destruction in the feces. In order to ensure pathogen destruction at ambient temperatures in the latrine, the compartments would need to be doubled in size. However, this increase in materials could make the composting latrine a cost prohibitive option for individuals and, perhaps, for governmental agencies and development workers working with donor agencies.

From the perceptions survey data, Table 15 shows the percentage of overall responses, "agree," "don't know," and "disagree," for the 16 statements about feces and their reuse. Defining a high level of consensus as ≥ 75%, the participants showed a high level of consensus in Statements 5, 6, 7, 8, 12, 13, 14, and 15. In general, the participants thought that it is OK to touch treated excrement, but not fresh excrement. While not tabulated in this data set, participants often viewed the excrement of infants and small children differently. When asked if it is OK to touch the excrement of babies with your hand, the participants responded positively. Regarding the use of composted human excreta as a soil amendment, the vast majority viewed the compost as beneficial to the soil (80.6%), a viable fertilizer (91.1%), and not harmful to plants (90.3%). Additionally, high percentages of participants responded favorably to the concept that crops fertilized with human excrement are suitable for consumption (87.9%) and to the idea of consuming these crops themselves (91.1%). Finally, animal manure was viewed as suitable for use as fertilizer (87%).

Responses with percentages ranging from 60-75% reflect moderately high levels of consensus. Consequently, Statements 3 and 9 show moderate agreement in responses. For example, 64.5% believe that human excrement should be handled in some way, and 71% say that they would use composted human excrement on their crops. In turn, the 50-60% range represents low levels of consensus. The low-level consensus statements include 1, 2, 4, 10, 11, and 16. The majority (56.5%) of participants view human excrement as something other than a waste for disposal, but the management and handling of the excrement is still a health risk. At the same time, the majority (54.0%) believes that human excrement can provide something good to humans. Regarding the taste and smell of produce grown using composted human excreta, a slight majority (55.6% and 58.1%, respectively) of participants feel that these sensory components of the produce will not change. Finally, the last statement essentially asks if the participant has used animal manure as fertilizer in the past, but again, only a slight majority (57.3%) indicated that they had previously used animal manure. The only statement with substantial “don’t know responses” was Statement 10 with 17.7%

Table 15. Responses to statements regarding perceptions of excreta and its use as fertilizer (n = 124).

	Agree	Don't Know	Disagree
1. Human excrement is a waste and should be only for disposal (cannot be used for something else).	36.3%	7.3%	56.5%
2. Handling human excrement is a great health risk (bad for one's health).	56.5%	5.6%	37.9%
3. Human excrement should not be handled in any way.	29.8%	5.6%	64.5%
4. Human excrement has no benefit (something good) to humans.	37.9%	8.1%	54.0%
5. It is OK to touch excrement with your hands.[1]	13.7%	1.6%	84.7%
6. It is OK to touch treated excrement.	75.8%	7.3%	16.9%
7. Human excrement is a resource for (gives something good to) the soil.	80.6%	8.9%	10.5%
8. Human excrement from a composting latrine can be used as fertilizer.	91.1%	1.6%	7.3%
9. I would use composted human excrement on my crops.	71.0%	1.6%	27.4%
10. Taste of vegetables will change when fertilized with composted human excrement.	26.6%	17.7%	55.6%
11. Smell of vegetables will change when fertilized with composted human excrement.	33.9%	8.1%	58.1%
12. Crops can be killed when fertilized with composted human excrement.	5.6%	4.0%	90.3%
13. Crops fertilized with human excrement are good for consumption.	87.9%	4.8%	7.3%
14. I will never consume crops fertilized with human excrement.	8.9%	0.0%	91.1%
15. Animal manure can be used as fertilizer	87.1%	4.0%	8.9%
16. I have used animal manure as fertilizer in the past.	57.3%	0.8%	41.9%

[1] If the participant indicated "yes, but with gloves" or "yes, but with a shovel," the response was counted as "disagree."

The percentages reported in Table 15 reflect predominantly positive perceptions of feces and its reuse as a soil amendment. The majorities for each of the 16 statements correspond to the expected response of a composting latrine user (as shown in Table 16), with the exception of Statement 2. According to the responses to Statement 2, the slight majority (56.5%) of respondents believe that handling human excrement is a great health risk, or bad for one's health. The concern for health exhibits an interesting divergence as shown in the responses to the Statements 5 and 6. The responses to Statements 5 and 6 show that the participants view treated excrement as OK to touch, but fresh excrement is not OK to touch. With the transformation, or rather the desiccation or aerobic decomposition, of the feces, the perceived risk and aversion change as well. In this case, the perceived susceptibility and severity related to the handling of human excrement is noteworthy. These perceptions are worthy of further investigation.

Table 16 expresses the expected responses to be in line with the perceptions of composting latrine users. These responses reflect opinions that favor the reuse of composted human excrement for agricultural purposes. Two statements, 5 and 16, could be replied to with "agree" or "disagree" and the study participant could still be responding positively to idea of the reuse of composted human excrement. For example, touching excrement with one's hands is not necessary in the use of a composting latrine. As long as the respondent either (a) views composted human feces differently from fresh excrement or (b) views the use of gloves as an applicable solution, the response to Statement 5 does not serve as an indicator of composting latrine behavior. Additionally, Statement 16 may be affected more by the availability of animal manure and training on the subject, rather than a sense of disgust regarding excrement, whether from humans or animals (personal observations).

For composting latrine users, Table 16 displays the percentages for each categorical response to each statement. The statements were grouped according levels of agreement: high (>75%), moderate (60-75%), and low (<60%). Statements 1, 3, 4, 5, 6, 7, 8, 9, 11, 12, 13, 14, and 15 demonstrate high levels of consensus among composting latrine users. Statement 10 shows a moderate level of agreement, but Statements 2 and 16 show the lowest levels of consensus. As mentioned previously, the responses for Statement 2 from the overall study sample are incongruent with the expected responses indicative of composting latrine use. To that point, 59.1% of composting latrine users do not view the handling of human excrement as a great health risk, while 56.5% of the study sample view the handling of human excrement as a great health risk.

Table 16. Responses from composting latrine users to statements regarding perceptions of excreta and its use as fertilizer (n = 22) and expected responses (marked with X) indicative of perceptions accepting of composting latrines behavior.

Perceptions	Agree	Don't Know	Disagree
1. Human excrement is a waste and should be only for disposal (cannot be used for something else).	9.1%	4.5%	86.4% X
2. Handling human excrement is a great health risk (bad for one’s health).	36.4%	4.5%	59.1% X
3. Human excrement should not be handled in any way.	4.5%	0.0%	95.5% X
4. Human excrement has no benefit (something good) to humans.	13.6%	9.1%	77.3% X
5. It is OK to touch excrement with your hands.	9.1% X	4.5%	86.4% X
6. It is OK to touch treated excrement.	86.4% X	0.0%	13.6%
7. Human excrement is a resource for (gives something good to) the soil.	100.0% X	0.0%	0.0%
8. Human excrement from a composting latrine can be used as fertilizer.	100.0% X	0.0%	0.0%
9. I would use composted human excrement on my crops.	95.5% X	0.0%	4.5%
10. Taste of vegetables will change when fertilized with composted human excrement.	22.7%	9.1%	68.2% X

Table 16 (Continued)

11. Smell of vegetables will change when fertilized with composted human excrement.	13.6%	4.5%	81.8% X
12. Crops can be killed when fertilized with composted human excrement.	0.0%	4.5%	95.5% X
13. Crops fertilized with human excrement are good for consumption.	100.0% X	0.0%	0.0%
14. I will never consume crops fertilized with human excrement.	0.0%	0.0%	100.0% X
15. Animal manure can be used as fertilizer	95.5% X	0.0%	4.5%
16. I have used animal manure as fertilizer in the past.	50.0% X	0.0%	50.0% X

Using non-parametric tests for statistical analysis, the associations between socio-economic demographic data and the responses to the perception-related statements were assessed. For this data set, the null hypothesis is that the demographic factor and the response to the perception statements are not associated. If the p-value is less than 0.050, the null hypothesis is rejected. Thus, p-values less than 0.050 indicate an association between the demographic variable and the statement's responses that are provided in Table 15. Table 17 displays the p-values for the association tests corresponding to each demographic variable and statement. The statistically significant associations are highlighted in bold. Comparing the residual, or difference between the observed count and the expected count (i.e. the count to be anticipated if no association exists) for each value (i.e. community name, type of sanitation, male or female, etc.), the association between the socio-demographic variables and the statement responses was analyzed.

Corresponding to p-values less than 0.05, the respondent's community (Filo Verde, Norteno, or San San Puente) had a statistically significant association with the following Statements 2, 3, 4, 5, 7, 9, and 13. Looking at the expected and observed counts, Filo Verde may

Table 17. Association and significance of the relationship between survey responses and selected demographic indicators from the participants in the perceptions survey (n = 124).

Survey Responses	Community	Sanitation Classification	Gender	Primary Occupation	Age	Education	Household Size
Statement 1							
Association Strength[a]	0.108	0.229	0.048	0.162			
Significance[b,c]	0.571	**0.015**	*0.879*	0.585	0.499	0.556	0.219
Statement 2							
Association Strength	0.302	0.280	0.171	0.218			
Significance	**0.000**[b]	**0.000**	0.188	0.073	0.287	0.743	0.644
Statement 3							
Association Strength	0.204	0.228	0.131	0.344			
Significance	**0.025**	**0.013**	0.383	**0.001**	0.315	0.670	0.888
Statement 4							
Association Strength	0.242	0.243	0.244	0.226			
Significance	**0.012**	**0.009**	***0.027***	0.107	**0.000**	0.050	0.261
Statement 5							
Association Strength	0.206	0.209	0.195	0.144			
Significance	**0.030**	0.094	0.094	0.805	0.747	0.134	0.568
Statement 6							
Association Strength	0.189	0.182	0.170	0.249			
Significance	0.056	0.211	*0.179*	0.198	**0.043**	0.404	0.116
Statement 7							
Association Strength	0.254	0.198	0.135	0.360			
Significance	**0.005**	0.101	0.311	**0.002**	0.124	0.314	0.186
Statement 8							
Association Strength	0.122	0.166	0.050	0.240			
Significance	0.388	0.205	0.871	0.062	**0.029**	0.076	0.578
Statement 9							
Association Strength	0.203	0.212	0.153	0.243			
Significance	**0.015**	**0.023**	0.295	**0.046**	**0.044**	0.728	0.629

Table 17 (Continued)

Statement 10							
Association Strength	0.132	0.177	0.135	0.222			
Significance	*0.373*	0.252	*0.324*	0.119	0.947	0.057	0.806
Statement 11							
Association Strength	0.157	0.206	0.260	0.266			
Significance	0.135	0.067	***0.013***	**0.011**	0.459	0.057	0.960
Statement 12							
Association Strength	0.170	0.142	0.182	0.226			
Significance	0.058	0.384	0.172	0.074	0.642	0.695	0.681
Statement 13							
Association Strength	0.213	0.151	0.103	0.170			
Significance	**0.040**	0.401	0.474	0.305	**0.000**	0.164	0.241
Statement 14							
Association Strength	0.055	0.173	0.049	0.131			
Significance	0.839	0.264	0.746	0.640	**0.004**	0.207	0.521
Statement 15							
Association Strength	0.171	0.121	0.105	0.245			
Significance	0.099	0.719	0.630	0.066	0.507	0.729	0.347
Statement 16							
Association Strength	0.113	0.142	0.076	0.137			
Significance	0.521	0.395	0.908	0.637	0.282	0.084	0.964

[a]Cramer's V was used to determine strength.
[b]Significance values determined by Pearson's Chi-Squared Test are in italics. All other significance values for Community, Sanitation Classification, Sex, and Primary Occupation are determined via Fisher's Exact Test. Significance values for Age, Education, and Household Size are determined via Kruskal-Wallis Test.
[c]Numbers in bold face font are significant at $p < 0.05$.

be more likely to respond in a manner congruent with the expected responses of composting latrine users. For instance, Filo Verde participants were more likely to disagree with the idea that handling human excrement is a great health risk. On the other hand, San San Puente showed the significantly more "don't know" responses than other communities. The sanitation classification (composting latrine, pit latrine, pour-flush toilet, or open defecation) had a statistically significant association with Statements 1, 2, 3, and 4. For example, composting latrine users are more likely to disagree with the statement that human excrement is a waste, but pit latrine users are more likely to say that handling human waste is a great health risk. Also, pit latrine users tend to say that human excrement provides no benefits to humans.

Considering other socio-demographic variables, the gender of the respondent had a statistically significant association with Statements 4 and 11. For example, females tended to agree more with the idea that human excrement did not provide a benefit to humans, while males tended to disagree more. In turn, the primary occupation (farmer, banana company employee, store owner, none, or other) had a statistically significant association with Statements 3, 7, and 11. That is, farmers typically responded in a manner congruent with the responses indicative of perceptions accepting of composting latrine behavior, while respondents falling into the occupation category "none" showed more of an association with the opposite response. The age of the respondent had a statistically significant association with the Statements 4, 6, 8, 9, 13, and 14. For each statement, older respondents were more likely to express perceptions in line with composting latrine acceptance. Statements 10, 12, 15, and 16 showed no association with any demographic variables, and of the demographic variables, education and household size showed no statistical association with the responses to the perceptions survey.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 Major Findings

The objectives of this thesis were to quantify the use of composting latrines and to evaluate the attitudes and perceptions of feces and its reuse as a soil amendment among Ngäbes in the Bocas del Toro province and Ñö Kribu region of the Comarca Ngäbe-Buglé, Panamá. Utilizing observations and formal interviews, the use of composting latrines was quantified across 23 communities. The overall percentage of composting latrines completed with respect to the total number of composting latrines started is 70.6%. Of the 142 completed composting latrines visited in this research, 71.8% of the composting latrines were deemed in use. In turn, 65% of those used latrines are used properly. The results suggest that the current implementation scheme can be improved to increase the percentage of completed composting latrines. The percentage of disuse among completed composting latrine owners also reveals a need for follow up to further educate and promote composting latrine usage. Finally, follow up informational sessions, regarding proper, up-to-date composting latrine operation and maintenance techniques, are needed to improve the percentage of properly used latrines.

When surveyed about the likes and dislikes are of composting latrines, latrine owners responded with a variety of answers. The most frequent responses related to advantages of using a composting latrine, with greater than 40% mentioning the advantage, included compost production, lack of mosquitoes or flies, and lack of smell. With respect to the disadvantages, the only dislike mentioned by over 40% of the participants was the need for water for washing purposes after defecation. Otherwise, obtaining dry material (i.e. sawdust or ash) and practicing daily maintenance were the other most frequently mentioned dislikes. These likes and dislikes reflect positive and negative attitudes that represent drivers and barriers for composting latrine adoption and sustained use, respectively. In addition, producing compost, avoiding mosquitoes and flies, and evading offensive smells are drivers for the adoption and use of composting latrines in lieu of adopting pit latrines or practicing open defecation. That being said, the inability to adequately wash with water in a composting latrine is seen as a barrier to composting latrine adoption and use. Additionally, the need for dry material that is added after each use and daily maintenance (i.e. adding dry material, cleaning the latrine, mixing the compost) serve as barriers to continued and especially proper use. These practices involve significant changes in behavior, because until this point, households practicing open defecation could defecate, leave, and never clean the river or stream after defecation.

Regarding the perceptions of users towards feces and the use of composted feces as a soil amendment, the responses from 124 participants revealed favorable results for the promotion of composting latrines. The expected responses, reflecting anticipated perceptions congruent with the actions of composting latrine users, were compared with the responses of the general public in three communities. The majority of the respondents, ranging from 54.0% to 91.1%, answered the survey in a way that aligned with the responses favorable for composting latrines. In other words, these participants expressed positive perceptions, regarding feces and their reuse as a soil amendment. These positive perceptions suggest that composting latrines would be socially acceptable. Composting latrine users from the survey responded with positive perceptions, as expected. However, the responses to Statement 2 show a discrepancy between the overall group of respondents and the composting latrine users. That is, the majority (56.5%) of respondents (n = 124) perceive the handling of human excrement as a great health risk, but the majority (59.1%) of composting latrine users (n = 22) do not perceive the handling of human excrement as a great health risk. With respect to the other statements, the majority (54.0 – 91.1%) responded in a manner conformant with composting latrine use, but a significant percentage (up to 37.9% for statement responses) responded negatively, such that the perceptions of a community are important and worthy of note. Using the Fisher's exact test and Kruskal-Wallis test, statistical analysis was performed to compare the association between demographic indicators and the responses to the survey. The community, sanitation classification, gender, primary occupation, and age all showed some level of association with the perceptions expressed in the survey responses. For example, Filo Verde was more likely to respond in a manner reflecting perceptions receptive to composting latrine use, while San San Puente was more likely to respond with "don't know" or in a manner contrary to the expected responses of composting latrine users or potential users. With respect to these two communities, Filo Verde had more exposure to composting latrines (i.e. a larger project and an additional year with a Peace Corps Volunteer present to reinforce concepts related to the project). Contrarily, San San Puente had less exposure to composting latrines, more exposure to water-based sanitation technologies, and incidences of flooding, which had destroyed some composting latrines. As expected, composting latrine users replied with answers reflecting the opinion that human excrement is not a waste, should be managed or handled in some way, and should be used on crops as a soil amendment. However, pit latrine owners showed the most dissidence of the non-composting latrine users, such that the pit latrine owners were more likely to respond in a manner contrary to the expected responses that would reflect favorable perceptions in line with composting latrine use. In general, males were more likely to be in agreement with the expected composting latrine use responses, or rather the responses that reflect perceptions that are accepting of composting latrine behavior. Regarding primary occupations, banana company workers showed the most dissident perceptions of feces and their reuse as a soil amendment, or they were associated with the response "don't know." With respect to the age of the respondent, older participants expressed favorable perceptions more. Contrarily, years of schooling and household size did not show any statistically significant associations with the perceptions represented by the survey responses.

A key finding of this research illuminates the missing critical first step, whose absence is detrimental and, therefore, noteworthy for many development projects. The missing critical step was a complete understanding of the customs of project participants. In a sanitation project, the first step in the project cycle should involve the characterization of sanitation customs. How the project participants traditionally defecate should be considered in the design process. For example, designs should address preferences for squatting or sitting commodes, and traditional cleansing behaviors (i.e. washers versus wipers) should be taken into account. Traditional sanitation behavior to be considered are not limited to sitting versus squatting or washing versus wiping, so a complete understanding of the various sanitation customs are essential to developing an appropriate technology.

In the case of composting latrines in the Bocas del Toro province and Ñö Kribu region of the Comarca Ngäbe-Buglé, the designers of these sanitation projects failed to recognize the importance of water for washing purposes among the Ngäbe indigenous group. None of the reviewed literature addressed water washing as a barrier to latrine adoption, operation, or maintenance. Looking at the aspects that Ngäbe composting latrine users disliked, the inability to use water to wash was the most common response. The provision of water for anal cleansing is important to the Ngäbe indigenous group, and the provision of water is important to many populations outside of Western culture.

Whether working on water systems, sanitation infrastructure, or personal hygiene educational programs, development professionals, including engineers, have brought foreign perceptions and ethnocentric ideas to developing countries. Often, development professionals are essentially "outsiders" and fail to consider the "insider" perspective. Hence, many technologies, including sanitation options, are ethnocentric designs that do not incorporate the traditional behaviors of the project area's population.

In order to improve the social acceptability and overall adoption of a sanitation technology, the operation and maintenance of the latrine or toilet should require the least amount of behavior changes. In other words, the proper use of the technology should not require major changes to the traditional behavior associated with defecation and sanitation. In the case of composting latrines in Ngäbe communities, the technology required users to not use water for washing and to buy toilet paper for anal cleansing. The change to toilet paper left users feeling "unclean" and desperate to find expendable funds for toilet paper. The significant changes result in a lower level of latrine adoption and a lower percentage of properly operated and maintained composting latrines.

The divergence between the applied ethnocentric ideas of a development professional and the cultural traditions of the project area's population result in design flaws. In general, a lack of in-depth cultural understanding in the design process of development projects has led to key design flaws that result in the implementation of socially inacceptable sanitation technologies. The composting latrine design that does not allow for water washing after defecation needs to be redesigned to accommodate the traditional behavior of water washing among the Ngäbe indigenous group. Additionally, the existing composting latrines should be retrofitted such that water can be used for anal cleansing. For engineers, this research affirms the need for education in cultural considerations. Coursework in the social sciences can provide a more well-rounded knowledge base from which future engineers will develop more socially acceptable and applicable technologies.

5.2 Recommendations for Action

Based on the major findings of this research, the following recommendations for action fall into three categories: policy, social marketing, and design improvements. The policy-related recommendations cover the implementation of improved educational campaigns and pilot composting latrine projects. Recommendations related to social marketing call for the need to approach sanitation adoption differently. Finally, design improvements reflect the suggestions and requests made by participants in this study for different technical improvements.

Policy reform would require all acting agencies working with sanitation in Panama to improve educational campaigns while utilizing a piloting system for composting latrines. More informed training sessions, incorporating recommendations from recently published peer-reviewed literature, have not reached the majority of the communities. Only a select few communities with recently constructed composting latrines know of the most recent suggestions for improved composting latrine operation and maintenance. An educational campaign should visit all communities with existing composting latrines. Reinforcing personal hygiene behaviors, the campaign should instruct composting latrine users to increase storage time to one year, use ash, and solar dry the composted feces prior to use (as discussed by Mehl et al., 2011). Additionally, this educational campaign would also focus improving the techniques used by famers to apply the composted feces in order to ensure no pathogens are spread via compost use.

Informational sessions should also address common problems encountered by the user, such as broken or clogged urine tubes, water or urine damaged compost, and cockroach infestations. Problem shooting and basic repair techniques should be taught and reinforced through hands-on practice sessions. Proper operation and maintenance are essential to achieving long-term adoption, so funding should be allocated to post-implementation training activities. Additionally, Starkl et al. (2013) argue that infrastructure should be subject to monitoring and evaluation years after completion, so funding should also allow for this follow up in the case of composting latrines as well.

Pilot latrine projects can better gauge interest in a particular sanitation technology, especially technology requiring significant levels of interest to ensure proper use as in the case of a composting latrine. When geographic and hydrogeologic conditions necessitate a composting latrine, a pilot latrine project can help gauge the level of interest while also acclimatizing the population to the idea of a composting latrine. Consequently, Starkl et al. (2013) notes that pilot projects can assist in the transition from current practices to new alternative methods, including resource-oriented methods, in human waste management.

As described in the literature review (Chapter 2), social marketing can increase sanitation coverage by applying business theories to the sanitation sector. In conjunction with the educational campaign, the trainers can aim messages, stressing the composting latrine's advantages, to the latrine owners who have not finished their latrines. During a discussion of advantages, the idea of safely using urine as fertilizer could be presented. Informational sessions including social marketing messages can also address the community members practicing open defecation. As mentioned in the literature review, lower income families will be more likely to adopt sanitation technologies seen as modern, progressive, or of a higher status. Marketing messages should promote the overall status image of EcoSan technologies, especially the composting toilets and latrines, by showing their use in higher income countries. Meanwhile, messages can target farmers with the benefits of composted feces as an effective soil amendment.

Design improvements would necessitate the changes to both technical and aesthetic aspects of the current composting latrine design. As social marketing develops demand for the product, the producer must meet the needs of the consumer. The quality of the product should increase in order to better meet the needs of the consumer. Furthermore, aesthetics, as a status symbol, are important in the Panamanian culture (personal observation of the author), thus aesthetically pleasing composting latrines appeal more to their cultural preferences. Aesthetics should be considered with respect to the finishing touches of the base, the design of the seats (i.e. smoothness and comfort of the seat), and the privacy structure. Regarding other design aspects, wider urine tubes (i.e. 1”-1½” diameter pipes) should be used and 90º bends should be avoided (i.e. use curved pipes) when possible. Additionally, the size of the composting compartments should be increased depending on the size of the family to accommodate for the longer storage time (i.e. doubled for a family of 8), which improves pathogen destruction at the ambient compost pile temperatures we have recorded in other studies (Mehl et al., 2011). Other substitutes for cement doors or cement sealants should be installed, especially in areas not prone to flooding. Other options include wooden doors (only in areas not prone to termite damage), cement doors using clay sealants, cement doors tied flush to the composting compartment, or sheet metal using clay sealants or ties. Resealing the cement doors is a cost that many families find difficult to save for. Otherwise, community organizations could play a role in managing the systems by fundraising to purchase cement or by asking for funding from local politicians. To address the need for water in the latrine for anal cleansing, designs should consider a separate basin, or a bidet, for anal cleansing, or a connected shower connected to a soak pit should be built to allow for bathing after defecation.

5.3 Areas of Future Research

Areas of future research related to this thesis will cover composting latrines and their sustainability in Panama and around the world. The methods of this study can and should be used to expand the geographical scope of these findings. Future investigations should involve other ethnic groups in Panama with composting latrines, including the Kuna, Emberá-Wounaan, and Latino. In addition to other ethnic groups within Panama, future research should look at other Latin American indigenous groups and other water-washing groups. Subsequently, the results found for Ngäbes in the Bocas del Toro province and Ñö Kribu region of the Comarca Ngäbe-Buglé can be compared first to the results of other Panamanians, second to the results of other indigenous groups (both domestic and foreign), and third to the results of other water-washers on the global scale.

Other areas of research that require additional study include appropriate collection and reuse of urine (e.g., see Shaw, 2010) perceptions of urine use, number of latrine repairs, design changes for water-washers, vermicomposting latrines, and solar thermal pathogen destruction. For instance, the investigations could include user perceptions of urine recovery to assess the social acceptability and feasibility of its use as a small-scale fertilizer. To better understand the sustainability of the composting latrine, future research should quantify the number of latrines that have been repaired. Furthermore, the drivers, attitudes, and perceptions of these owners that have repaired their latrines should be assessed. These owners who have repaired their latrine have vested interest in the latrine, inverted money in the project, and shown ownership.

Understanding these owners' motivations can help improve the social marketing tactics that promote this sense of ownership. Regarding design changes for water-washers, future research should look into various methods to accommodate water-washers in situations that require dry sanitation systems and how that might influence the composting process and pathogen destruction. For example, attitudes and perceptions related to various design options (i.e. bidet versus attached shower) should be investigated, and the physical durability of the concrete structure should be evaluated with respect to the water-washing option selected and the structure's exposure to water. A blend of composting technologies, vermicomposting latrine could prove successful among Ngäbes. Many communities are familiar with vermiculture, but the social acceptability and technical feasibility of the vermicomposting latrine requires more investigation. Finally, solar thermal pathogen destruction should be tested in the field. As recommended by Mehl et al. (2011), the latrine users should dry the aged compost in the sun before using it as a soil amendment, but further studies are needed to confirm sufficient pathogen destruction, especially in situations where urine is separate from feces and water is used for washing and perhaps may not be separated from the compost pile.

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APPENDICES

Appendix A. Basic Steps to the Construction of a Composting Latrine

Day 1 – Lay first *plancha*

Day 2 – Lay 2 layers of blocks

Day 3 – Lay top 2 layers of block

Day 4 – Lay top *plancha*

Day 5 – *Repellar* and build back doors and steps

Day 6 – Build form of *casita*, attach seats & urine tubes

Day 7 – Attach back doors and *forrar* the *casita*

The following images illustrate the composting latrine design during the various phases of construction (reproduced from Matthews, 2014 with permissions).

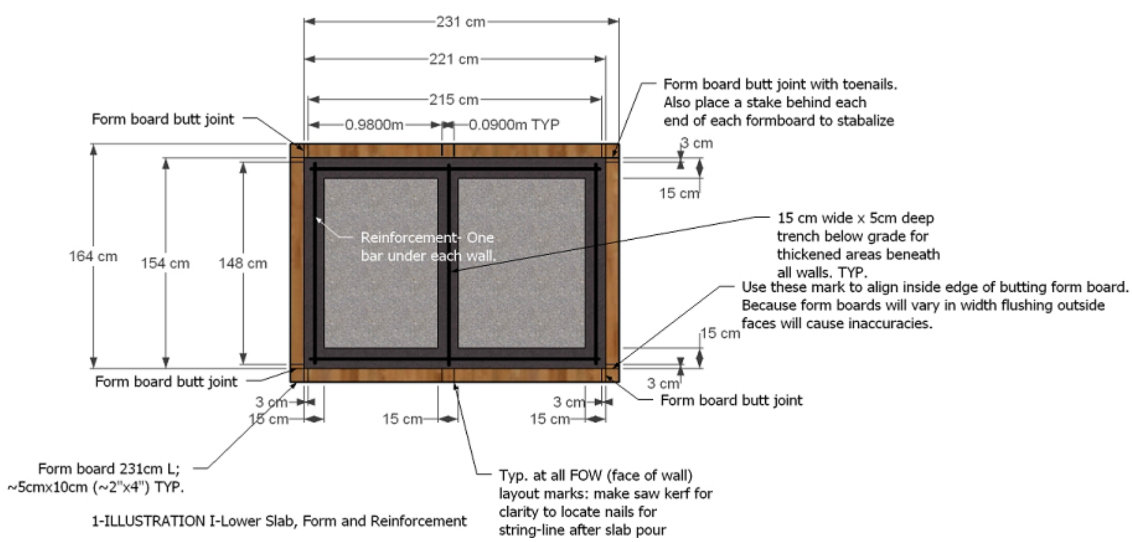
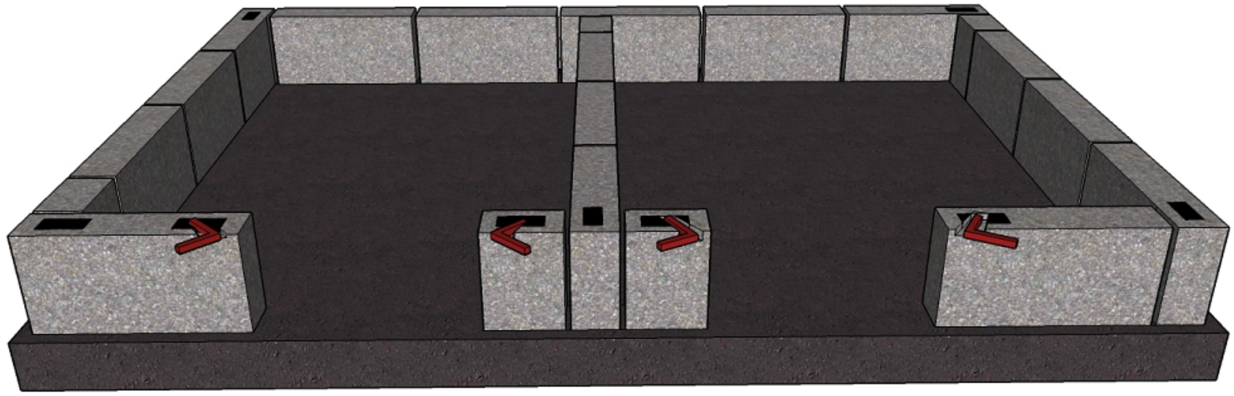


Figure A1. Diagram of the base floor of the composting latrine with dimensions.



5-ILLUSTRATION III.2-First Level ISO with embeds

Figure A2. Diagram of base floor with the first layer of concrete block

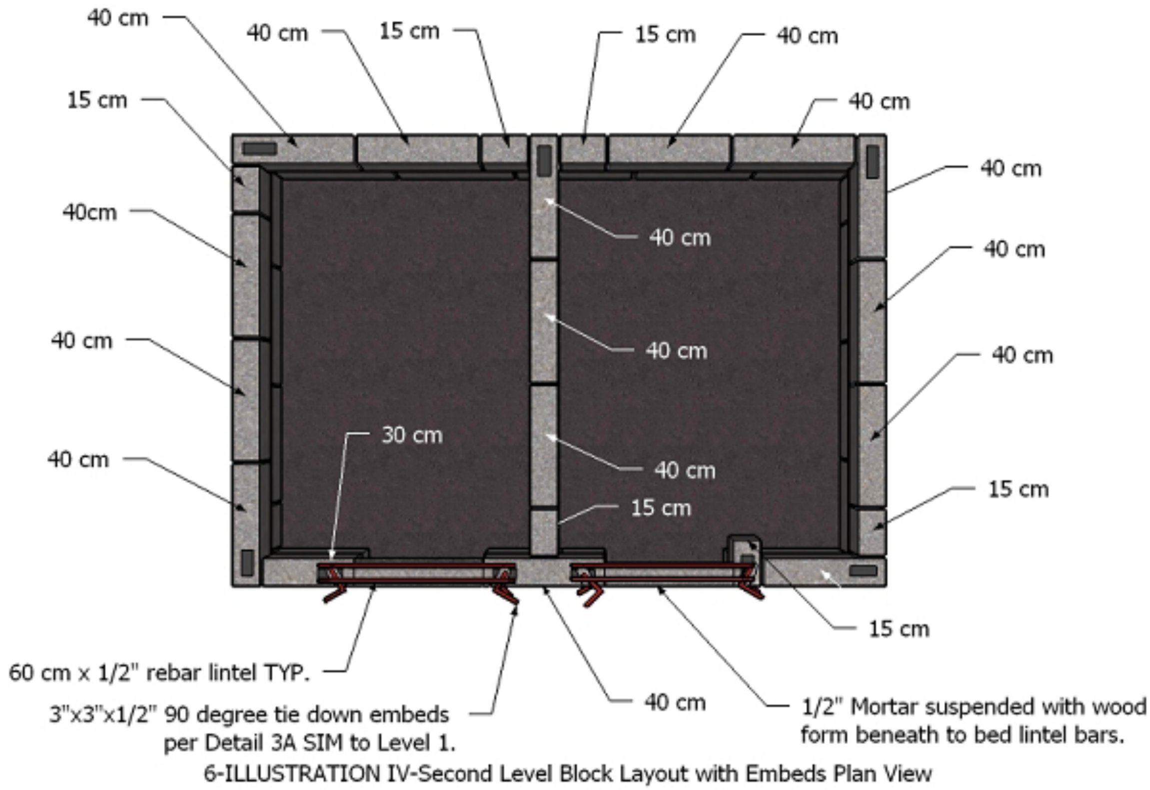


Figure A3. Plan view of diagram of base with two layers of concrete block.

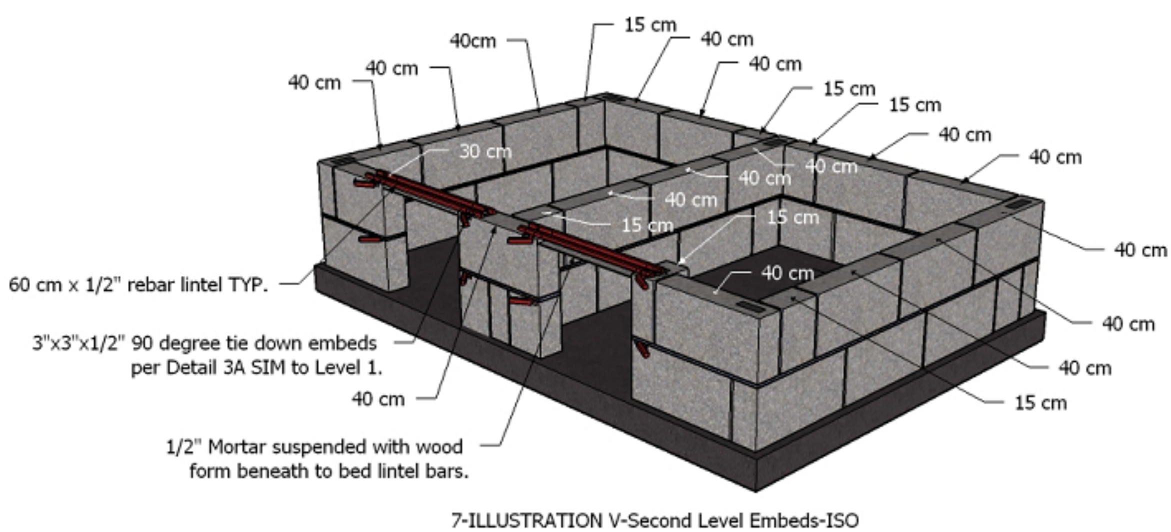


Figure A4. Diagram of base with two layers of concrete block and supportive rebar over back opening.

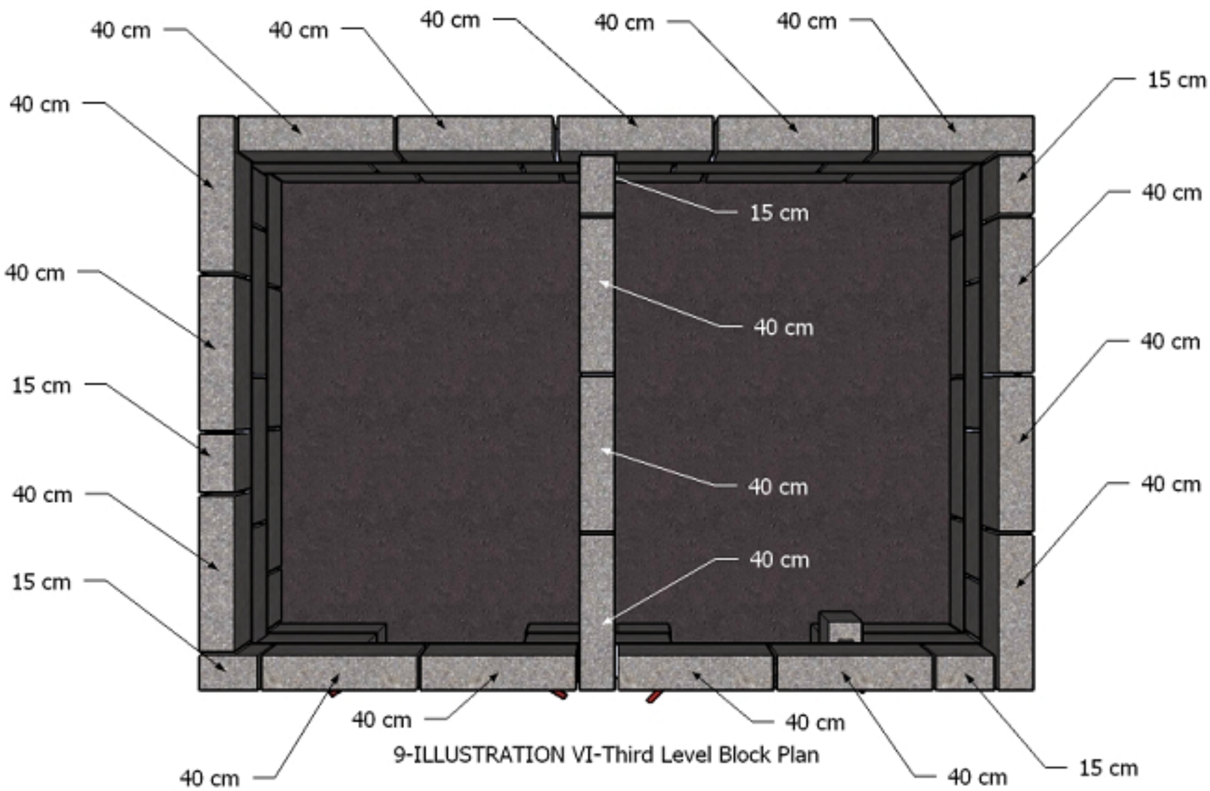


Figure A5. Plan view of diagram of base with three layers of concrete block.

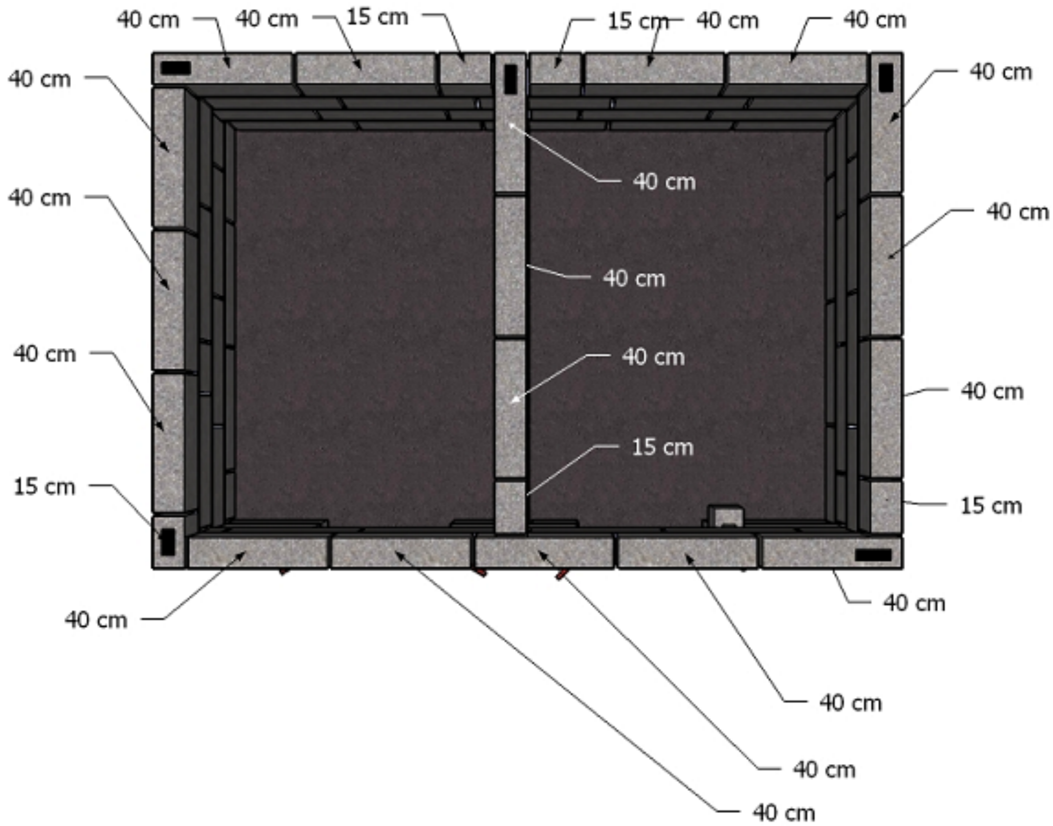


Figure A6. Plan view of diagram of base with four layers of concrete block.

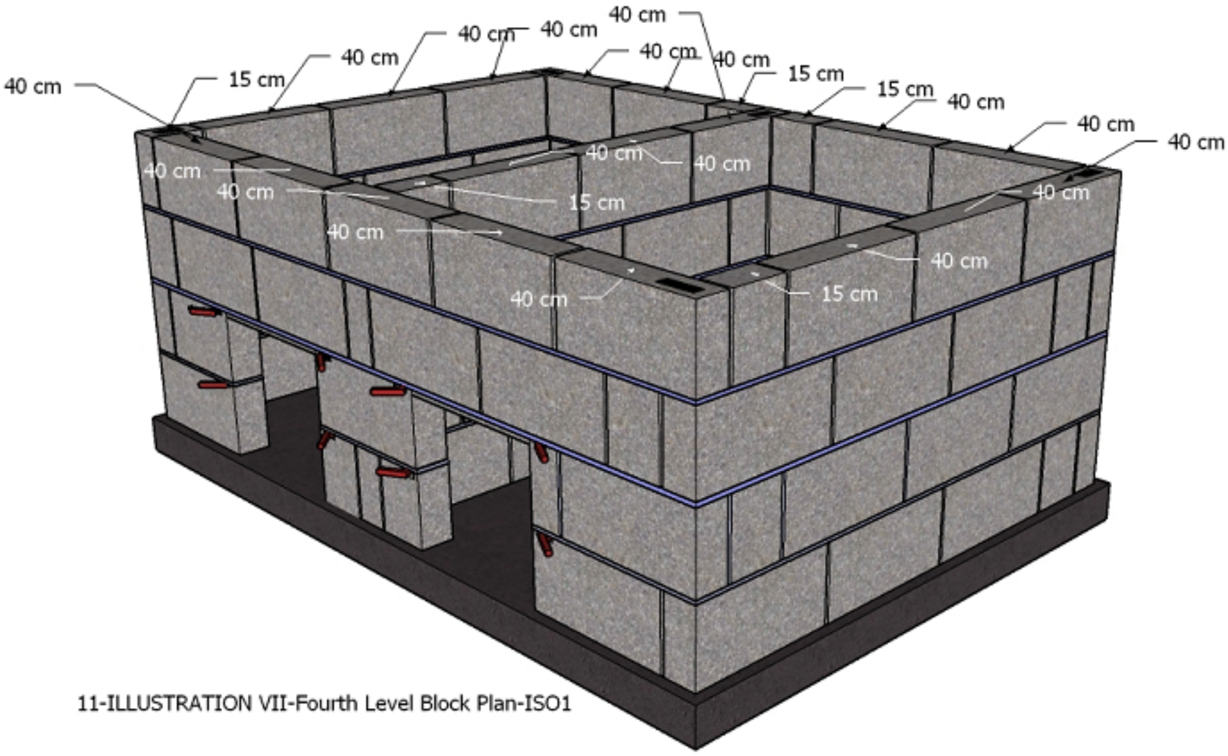


Figure A7. Diagram of base with four levels of concrete block with the back openings.

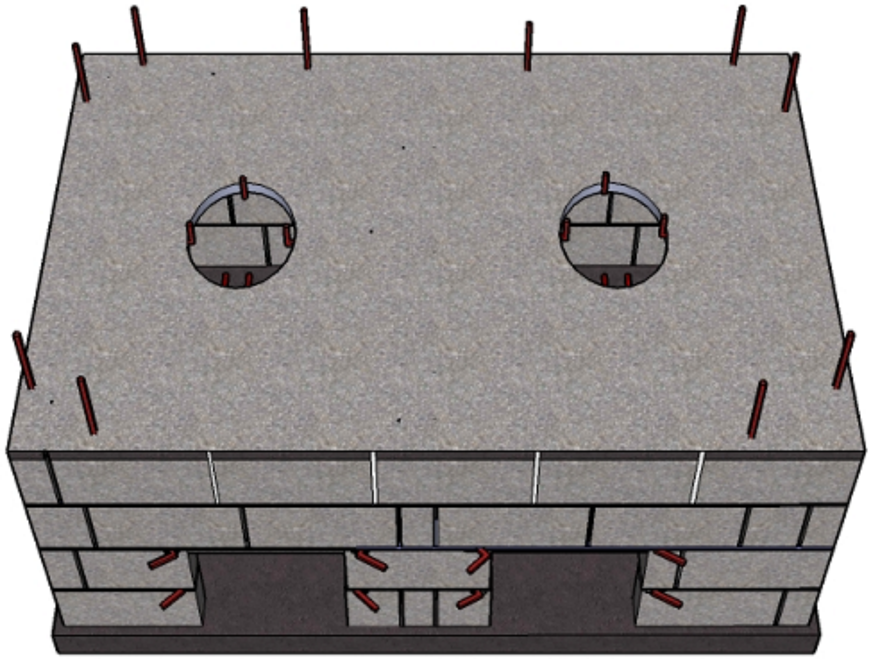


Figure A8. Diagram of completed composting latrine base with top slab and toilet seat openings.

Appendix B. Scripts Used to Obtain Verbal Consent from Study Participants

Corresponding to the Phases 1, 2, and 3, the following scripts will be used to obtain verbal informed consent. Verbal informed consent is necessary because of the low level of literacy in the study communities.

Phase 1. Script for Composting Latrine Use Interviews (23 communities, defined as not human subjects):

I am Patricia Wilbur, and I am a Peace Corps Volunteer in Valle Escondido on Isla San Cristobal. I am also studying for my Master's in the United States, and my research is focused on composting latrines. My goal is to improve the design of the latrine and the training that comes along with a composting latrine project. I have a few questions about your composting latrine and its use. The questions will take about 30 minutes. Then, if it is all right with you, I would like to see your composting latrine. I will write about general ideas and recommendations in my thesis and any reports, so I will not use your name. We do not anticipate any risks or benefits, but I hope that this investigation informs the work of governmental agencies and future Peace Corps Volunteers as it relates to the promotion of sanitation in the community. Your participation in the survey is completely up to you. If at any time you do not want to continue, we can stop. Or, if there is a question you do not want to answer, we can skip it. Do you have any questions? Did I explain myself well? If you have any questions or want to contact me after I leave, my cell phone number is 6525-9000. Or, you can contact the nearest Peace Corps Volunteer.

Phase 2. Script for Informal Interviews about Likes/Dislikes of Composting Latrines

I am Patricia Wilbur, and I am a Peace Corps Volunteer in Valle Escondido on Isla San Cristobal. I am also studying for my Master's in the United States, and my research is focused on composting latrines. My goal is to improve the design of the latrine and the training that comes along with a composting latrine project. I have a few questions about what you like and dislike about your composting latrine. The questions will take about 30 minutes. I will write about general ideas and recommendations in my thesis and any reports, so I will not use your name. We do not anticipate any risks or benefits, but I hope that this investigation informs the work of governmental agencies and future Peace Corps Volunteers as it relates to the promotion of sanitation in the community. Your participation in the survey is completely up to you. If at any time you do not want to continue, we can stop. Or, if there is a question you do not want to answer, we can skip it. Do you have any questions? Did I explain myself well? If you have any questions or want to contact me after I leave, my cell phone number is 6525-9000. Or, you can contact the nearest Peace Corps Volunteer.

Phase 3. Script for Excreta and Composted Excreta Perceptions Surveys (3 communities):

I am Patricia Wilbur, and I am a Peace Corps Volunteer in Valle Escondido on Isla San Cristobal. I am also studying for my Master's in the United States, and my research is focused on composting latrines. My goal is to improve the design of the latrine and the training that comes along with a composting latrine project. First, I have a few questions about yourself and your family. Then, I have some questions about latrines, excrement, and the use of composted excrement. I will write about general ideas and recommendations in my thesis and any reports, so I will not use your name. We do not anticipate any risks or benefits, but I hope that this investigation informs the work of governmental agencies and future Peace Corps Volunteers as it relates to the promotion of sanitation in the community. Your participation in the survey is completely up to you. If at any time you do not want to continue, we can stop. Or, if there is a question you do not want to answer, we can skip it. Do you have any questions? Did I explain myself well? If you have any questions or want to contact me after I leave, my cell phone number is 6525-9000. Or, you can contact the nearest Peace Corps Volunteer.

Appendix C. Questions for Interviews, Observations, and Surveys for Study Phases 1, 2, and 3.

Phase 1. Composting Latrine Use Interviews and Observations Adapted from Mehl (2008) and Kaiser (2006).

Community Surveyed: **Date:**

Surveyed by:

Community Statistics:

1. Population in the community:
2. Total number of houses in the community:
3. Number of houses with a fully constructed composting latrine:
4. Number of houses with a partially constructed composting latrine:
5. Number of houses with another type of latrine/septic system:
6. Type of sanitation technology used at the school:
7. Identified ethnicity:
8. Running water available? (Y/N) Reliability?

Observations:

1. Is there a sack/container of desiccant in the latrine? (Y/N)
    a. If yes, what type of desiccant is it?
2. Is there a scoop present for the desiccant? (Y/N)
3. Is there a presence of desiccant inside the latrine box? (Y/N)
    a. What type of desiccant is present?
4. Do the contents of the latrine appear? (1 dry… 5 very wet)
5. Is the latrine seat covered properly? (Y/N)
6. Is there a bad odor? (1 no odor… 5 bad odor)
7. Is the latrine clean? (1 clean… 5 dirty)
8. Is the latrine in working condition (seats in place, tubes connected, compost doors in place, not major holes, etc.)? (Y/N)
    a. If not, describe the problem below.
9. When was the chamber sealed? How old is the compost?
10. Where does the urine tube lead? Ground? Other container for reuse?

Questions for Latrine Owner/Operator:

Latrine Number: Role of Interviewee in the house:

1. ¿Cuando recibió su letrina? (en cual año) (When did you receive your latrine?)
2. ¿Quién usa la letrina? ¿Los niños también? (Who uses the latrine? Kids too?)
3. ¿Usa material seco? (Do you use desiccant?)
4. ¿Qué tipo de material seco usa? (What type of desiccant do you use?)
5. ¿Cuáles otros materiales secos han usado? (What other types of desiccant have you used?)
6. ¿Cuándo echa el material seco? ¿Todos lo hacen? (When do you add desiccant? Does everyone?)
7. ¿Cómo lo echa? (con su mano o una lata) (How do you add it? With a scoop or by the handful?)
8. ¿Qué cantidad de material seco echa? (cuantos puñados o latas) (How much do you add?)

9. ¿A veces tiene su letrina mal olor? (Does your latrine ever smell bad?)
10. ¿En cuál mes empezó usar el lado en uso? (In what month did you begin to use the latrine side in use?)
11. ¿En cuál mes va a cambiar y usar el otro lado? (In what month are you going to change and use the other side?)
12. ¿Usa el abono? (Do you use the compost?)
13. ¿Cómo lo usa? O sea, ¿qué hizo usted con el abono cuando sacó el abono de la letrina? (How do you use it? Or that is, what did you do when you removed the compost from the latrine?)
14. ¿Dónde lo usa? (Where do you use it?)
15. ¿Quién está en carga de vaciar el compartamento de abono? ¿Y preparar el lado nuevo para uso? (Who is in charge of emptying the compartment of the compost? And, to prepare the new side for use?)
16. ¿Cuándo revuelve el abono? ¿Con qué frecuencia? (When do you stir the compost? How frequently?)
17. ¿Cuándo fue la ultima vez que revolvió el abono? (When was the last time you stirred the compost?)
18. ¿Cómo revuelve el abono? (How do you stir the compost?)
19. ¿Usa papel higiénico? Si no, ¿qué usa para lavarse? (Do you use toilet paper? If not, what do you use to clean yourself?)
20. ¿Recibió capacitación sobre el uso y mantenimiento de la letrina? ¿Quién se la dio? (Did you receive training over the operation and maintenance of the latrine? Who was the trainer?)
21. ¿Qué enseñaron en la capacitación? (What did they teach in the training?)
22. ¿Hay muchos casos de diarrea en la casa? ¿Por cuantos días han tenido diarrea en el mes pasado? ¿Los niños? (Are there many cases of diarrhea in the house? How many days have you had diarrhea in the past month? And the children?)
23. ¿Había más casos de diarrea cuando no tenía su letrina? (Were there more cases of diarrhea before you had your latrine?
24. ¿Quién construyó la letrina? (Who built the latrine?)
25. ¿De dónde vino los fondos para este proyecto de letrinas aboneras? (Where did the money for this composting latrine project come from?)
26. En el caso que no se usa la letrina, ¿Cuándo terminó de usar la letrina? (When did you stop using the latrine?)

Phase 2. Informal Interviews about Likes/Dislikes of Composting Latrines

1. What do you think of your composting latrine?
2. How did a composting latrine project get started here?
3. Why did you want a latrine in the beginning?
4. Why do some people in the community have composting latrines and not others?
5. What are the advantages of your composting latrine? What do you like about your composting latrine?
6. What are the disadvantages of your composting latrine? What do you not like about your composting latrine?
7. Knowing what you know now, would you still get a composting latrine?
8. What do you think about using the compost?

Phase 3. Survey Regarding Perceptions of Excreta and Composted Excreta Used as Fertilizer
Part 1: Socio-demographic Information

1. ¿Usa usted tu letrina abonera? (Do you use your composting latrine?)
    a. No latrine
    b. Sometimes uses
    c. Used it until it filled up and have never taken out the excrement
    d. Took it out but don't use it
    e. Took it out and used it
    f. Used it in the past but have "upgraded"
2. ¿Usa usted el abono de la letrina abonera? (Do you use the compost?)
3. ¿Cuándo recibió usted tu letrina abonera? (When did you receive your latrine?)
4. Edad (Age)
5. Sexo (Sex)
6. Educación (Education)
7. Número de Personas Viviendo en la Casa (Household size)
8. Religión (Religious affiliation)
9. Estado civil (Marital status)
10. Ocupación principal (Primary occupation)
11. Periodo de estadía (Length of stay (5, 10, 15, 20, 30 years))]

Part 2: Agree, Disagree, or Don't Know Survey – wording in parentheses would be used to clarify potentially difficult words or concepts for the participants

1. Excremento humano es un desecho y solo debe ser desechado (no puede ser usado para otra cosa). (Human excrement is a waste and should be only for disposal (cannot be used for something else).)
2. El manejo de excremento humano es un gran riesgo a la salud (es malo para la salud). (Handling human excrement is a great health risk (bad for one's health).)
3. Excremento humano no debe ser manejado en ninguna manera (Human excrement should not be handled in any way.)
4. Excremento humano no da ningun beneficio (algo bueno) a humanos (Human excrement has no benefit (something good) to humans.)
5. Está bien tocar el excremento con la mano. (It is OK to touch excrement with your hands.)
6. Está bien tocar el excremento convertido en abono. (It is OK to touch composted excrement.)
7. Excremento humano es un recurso para (da algo bueno a) la tierra (Human excrement is a resource for (gives something good to) the soil.)
8. Excremento humano de una letrina abonera puede ser usado como abono (Human excrement from a composting latrine can be used as fertilizer)
9. Yo usaría excremento humano convertido en abono en mis cultivos. (I would use composted human excrement on my crops.)
10. El sabor de vegetales va a cambiar cuando se use excremento humano convertido en abono (Taste of vegetables will change when composted human excrement is used.)
11. El olor de vegetales va a cambiar cuando se use excremento humano convertido en abono (Smell of vegetables will change when composted human feces is used.)

12. Los cultivos pueden morir cuando se use excremento humano convertido en abono (Crops can be killed when fertilized with composted human excrement.)
13. Los cultivos usando excremento humano convertido en abono están bien para consumir (Crops fertilized with human excrement are good for consumption.)
14. Yo nunca voy a consumir cultivos que usaron excremento humano convertido en abono (I will never consume crops that used composted human excrement.)
15. El estiércol de animales puede ser usado como abono (Animal manure can be used as fertilizer.)
16. Yo he usado estiércol de animales como abono en el pasado (Ever used animal manure as fertilizer)

Part 3: Factors that prevent residents from using "composted excreta" on their crops.

1. Olor (Smell)
2. Riesgo a salud (Health risk)
3. Apariencia (Appearance)
4. Clientes no van a querer comprar (Clients will not want to buy - Patronage will be poor)
5. COCABO y el grupo de certificación orgánico dicen que no puedo usar el abono (COCABO/ organic certification group says it cannot be used)
6. La gente van a burlarse de mí (People will mock me)
7. Otros miembros de la comunidad me han dicho que el abono sea malo (Other community members have told me that it was bad)
8. Creencia religiosa (Religious belief)
9. La finca está demasiado lejos (The farmland is too far away)
10. Nada (None)
11. Otro (Other)_________

Part 4: Follow Up Questions (for composting latrine owners)

1. ¿Hay otras cosas que no le gusta de su letrina abonera? (Is there anything else that you do not like about your composting latrine?)
2. ¿Hay otras cosas que le gusta de su letrina abonera? (Is there anything else that you do like about your composting latrine?)

Appendix D. Communication with IRB for Study Approval

Gmail by Google

Patricia Wilbur <patricia.a.wilbur@gmail.com>

IRB Questions

Martin, Julie <jtmartin@usf.edu> Fri, May 17, 2013 at 11:10 AM
To: Tricia Wilbur <patricia.a.wilbur@gmail.com>, "Baer, Roberta" <baer@usf.edu>
Cc: "Mihelcic, James" <jm41@usf.edu>

Hi Tricia,

Thank you for your email. Based on the information contained in the document you submitted, it does not appear that this project meets the definition of human subjects research and therefore, submission to the USF IRB for review and approval is not necessary.

As defined by the federal regulations, a human subject is a living individual ***about whom*** an investigator conducting research obtains data through intervention or interaction with the individual or identifiable private information. Research is defined as a systematic investigation, including research development, testing and evaluation, designed to develop or contribute to generalizable knowledge. For a project to include human subjects research which is reviewable by the USF IRB and requires approval per the federal regulations, both of the definitions outlined above must be met.

As your project is not collecting information ***about*** individuals and collects information regarding composting latrines, I do not feel that this meets the definition of human subjects research thereby requiring IRB approval. Should the scope of your project expand, you should contact me to see if the expansion crosses into the definition of human subjects research requiring IRB review and approval. In addition, I would recommend that you keep this email for your files and if you have any questions or concerns, please feel free to contact me.

Julie

Julie T. Martin, M.Ed., RN, CCRP

Assistant Director for Regulatory Affairs

Research Integrity & Compliance

University of South Florida

Phone: 813-974-8360

Email: jtmartin@usf.edu

From: Tricia Wilbur [mailto:patricia.a.wilbur@gmail.com]
Sent: Friday, May 17, 2013 4:07 AM
To: Baer, Roberta
Cc: Martin, Julie; Mihelcic, James
Subject: Re: IRB Questions

USF UNIVERSITY OF SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX(813)974-7091

February 18, 2014

Patricia Wilbur
Civil and Environmental Engineering
Tampa, FL 33612

RE: **Exempt Certification**

IRB#: Pro00016328

Title: Perceptions of Composting Latrines and Composted Human Excreta as Fertilizer in Panama

Study Approval Period: 2/17/2014 to 2/17/2019

Dear Ms. Wilbur:

On 2/17/2014, the Institutional Review Board (IRB) determined that your research meets USF requirements and Federal Exemption criteria as outlined in the federal regulations at 45CFR46.101(b):

(2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless:
(i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, or reputation.

Approved Documents:

IRB Protocol.docx

Script for Informed Consent.docx

As the principal investigator for this study, it is your responsibility to ensure that this research is conducted as outlined in your application and consistent with the ethical principles outlined in the Belmont Report and with USF IRB policies and procedures. Please note that changes to this protocol may disqualify it from exempt status. Please note that you are responsible for notifying the IRB prior to implementing any changes to the currently approved protocol.

The Institutional Review Board will maintain your exemption application for a period of five years from the date of this letter or for three years after a Final Progress Report is received, whichever is longer. If you wish to continue this protocol beyond five years, you will need to submit a new application at least 60 days prior to the end of your exemption approval period. Should you complete this study prior to the end of the five-year period, you must submit a request to close the study.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

[redacted]

John Schinka, Ph.D., Chairperson
USF Institutional Review Board

Appendix E. Distribution Histograms to Test for Normality of Scalar Variables

Each of the following scale variables was plotted in a histogram and determined to show signs of normal distribution. However, further statistical analysis would be necessary in order to adjust the data such that it could be used in parametric tests. Thus, non-parametric tests were run on each of the following variables, and the results are discussed in Chapter 4.

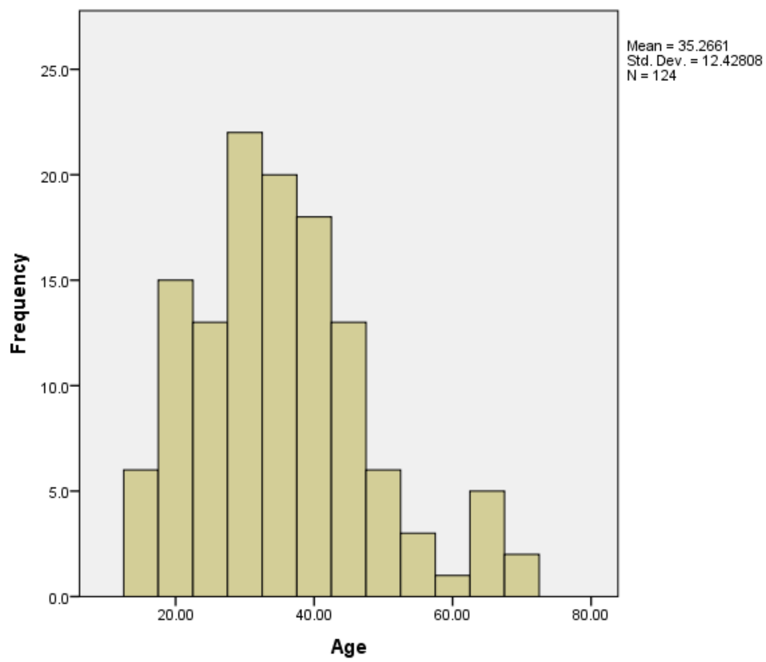


Figure A9. The distribution of age of the participants from the perceptions survey.

Figure A9 shows that the distribution of ages of participants in the final survey is positively skewed. Because of the data's non-normal distribution, non-parametric tests were run. For future analysis, the age variable could be transformed in order to correct for the asymmetry, and parametric test (i.e. the t-test) could be run. Or, the bimodal configuration suggests that two separate t-tests could be run, one for participants under 60 years old and one for participants over 60 years old.

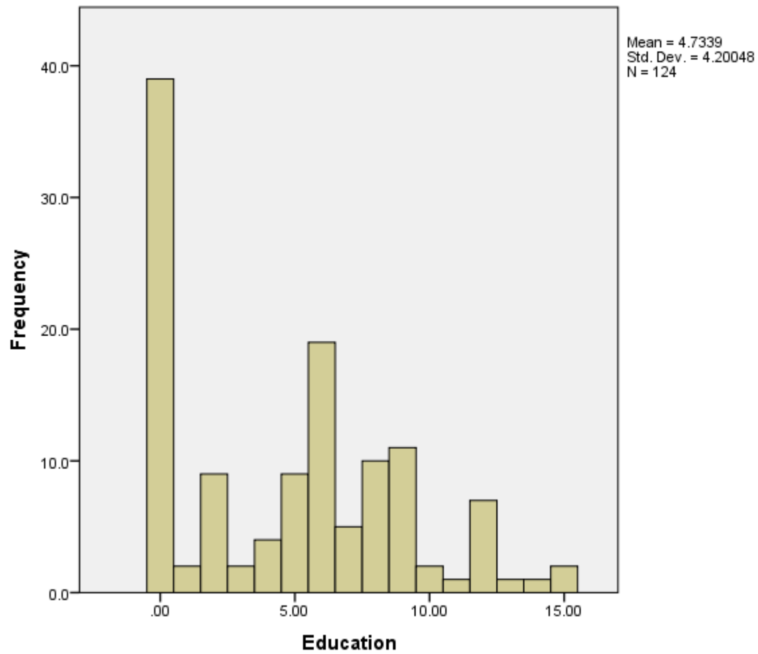


Figure A10. The distribution of years of education obtained by the participants from the perceptions survey.

As shown in Figure A10, a significant number of participants have received no formal education, but those participants who did receive some level of education reflect a normal distribution. Two separate tests could be run on this data. For instance, the association between those without education and those with education could be evaluated with a chi-squared test. Then, a t-test would be used with those who have some level of education and any other categorical variable.

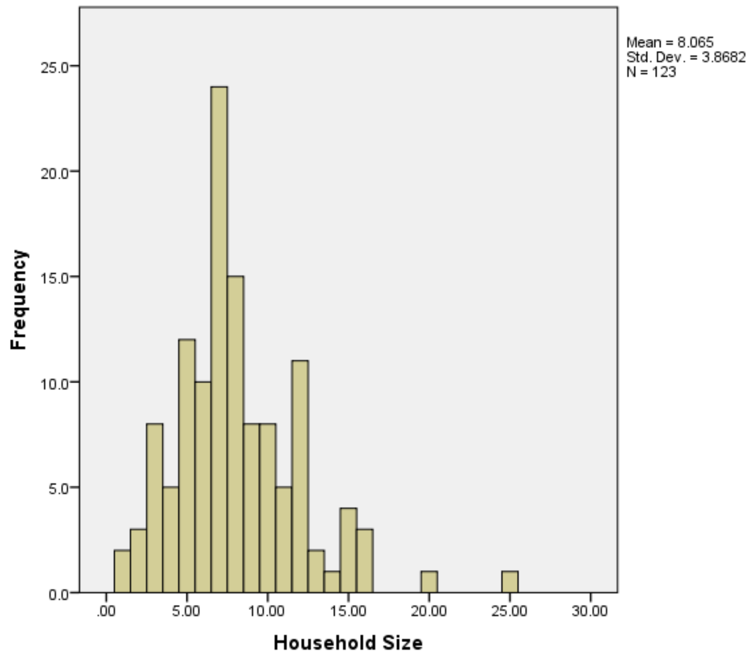


Figure A11. The distribution of household sizes of the participants from the perceptions survey.

The distribution of household size is leptokurtic and positively skewed. The data could be transformed or trimmed such that the outlier cases are truncated and discussed separately. In that case, the data would be evaluated using parametric tests applicable to normal distributions.

Appendix F. Permissions Obtained for the Reproduction of Tables and Figures

Below is the permission for the use of Figures 2 and 3.

Gmail by Google

Patricia Wilbur <patricia.a.wilbur@gmail.com>

Permission Request

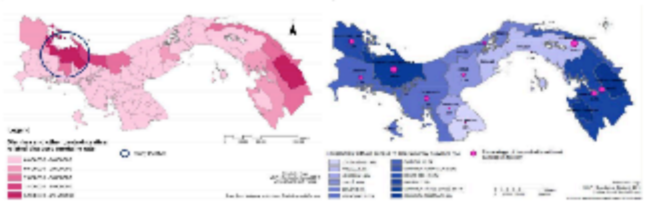
2 messages

Tricia Wilbur <patricia.a.wilbur@gmail.com> Fri, Apr 4, 2014 at 9:27 PM
To: "Vega Patino, Natalia" <nvega1@health.usf.edu>

Natalia,

I am the environmental engineering Master's student at USF who wrote to you about 6 weeks ago regarding your thesis, "Knowledge, Attitudes and Traditions Regarding Water Consumption and Sanitary Practices of the Ngäbe-Buglé Indigenous Women in the Chiriquí Province in Panama." I greatly appreciate your sharing the document with me.

I am writing to you to ask for your permission to reproduce the following two images from your thesis and from the poster presentation entitled "Aplication of the Geographic Information System as a New Approach for the Potable Water and Hygiene Issues in the Republic of Panamá" (http://health.usf.edu/nocms/publichealth/gis/posters/poster6.pdf).



I would like to reproduce these images in my literature review for my thesis devoted to composting latrines in Ngäbe communities. Thank you for your time and I look forward to hearing from you.

Cheers,
Tricia

--
Patricia Wilbur, EIT
Master's Student in Environmental Engineering
University of South Florida
RPCV Panama 2011-2013
(314) 276-8979
patricia.a.wilbur@gmail.com

Vega Patino, Natalia <nvega1@health.usf.edu> Sun, Apr 6, 2014 at 11:31 PM
To: Tricia Wilbur <patricia.a.wilbur@gmail.com>

I have no problem at all if you use it as long is referenced properly.

Im happy that my thesis had been helpful for you!

Regards,

Natalia

On 04/04/2014, at 20:27, "Tricia Wilbur" <patricia.a.wilbur@gmail.com> wrote:

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SAGE

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Author: Simon Mariwah, Jan-Olof Drangert

Publication: Waste Management and Research

Publisher: SAGE Publications

Date: Aug 1, 2011

Logged in as:
Patricia Wilbur
Account #:
3000773914

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Patricia Wilbur <patricia.a.wilbur@gmail.com>

Permission to Use Composting Latrine Manual Images in Thesis

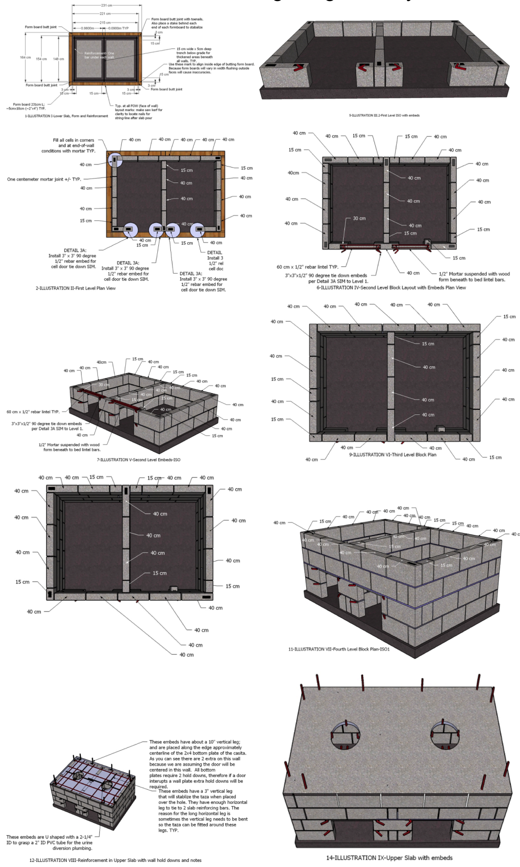
2 messages

Tricia Wilbur <patricia.a.wilbur@gmail.com> Sun, Jul 6, 2014 at 4:04 PM
To: Michael Matthews <miket.matthews1@gmail.com>

Hi Mike,

Hope all is going well with you and your return to the US. I can't believe how quickly the time has passed!

I have quick question about the composting latrine images that you had made for the Peace Corps Manual. I would like to use the following images in my thesis in order to adequately illustrate the construction process.



May I have your permission? You will be appropriately cited in the thesis as the creator of the images.

Thanks,
Tricia

--

Patricia Wilbur, EIT
Master's Student in Environmental Engineering
University of South Florida
RPCV Panama 2011-2013
(314) 276-8979
patricia.a.wilbur@gmail.com

Michael Matthews <miket.matthews1@gmail.com> Sun, Jul 6, 2014 at 4:49 PM
To: Tricia Wilbur <patricia.a.wilbur@gmail.com>

Tricia,
You certainly may, I would be flattered! Glad to contribute.
All the best,
Mike

[Quoted text hidden]