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Assessment of Maintenance and Agricultural Practices among Ecological Sanitation Users in Bolivia

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Assessment of Maintenance and Agricultural Practices among Ecological Sanitation Users in Bolivia

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An abstract of

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ABSTRACT

Background: Worldwide, about 2.5 billion people lack access to improved sanitation which contributes to approximately 10% of the global burden of disease. Bolivia is the only country in Latin America where less than half of the population has access to improved sanitation facilities. Ecological sanitation is a promising solution that increases coverage of sanitation and is sustainable.

Methods: In 2007, a cross-sectional household survey of knowledge, attitudes, and practices was conducted across the three ecological zones of Bolivia. A total of 228 surveys were conducted using convenience sampling methods in 12 communities. Among the 12 communities, nine participated in EcoSan interventions between 2000 and 2007. We examined the demographic characteristics of the study households by type of sanitation facility. Among EcoSan users, maintenance practices were described to determine compliance with recommended EcoSan guidelines. Descriptive statistics and odds ratios were calculated to compare EcoSan users and non-users and to assess the impact of EcoSan toilets on agricultural practices.

Findings: Among the 228 households interviewed, 97 were EcoSan users and 131 were non-users. Of the 97 EcoSan users, 91.8% reported adding drying materials to the storage chamber after each defecation. Ash was the most common drying additive used (68%). The average storage time was 15 months (range 1 to 84 months). EcoSan users were more likely to use the stored human excreta and urine on household gardens and/or crops than non-users. Among non-users, 17.2% reported using urine on gardens and/or crops. Among the 81 EcoSan users with gardens and/or crops, 38.2% reported using urine and 25.9% reported using human feces on gardens and/or crops. EcoSan users with gardens and/or crops were 9.6 (95% CI 3.01, 30.68) times more likely to use urine on gardens and/or crops than feces.

Conclusion: While EcoSan toilets can be a promising approach for safely containing and converting human excreta into valuable agricultural products, less than half of EcoSan users reported utilizing EcoSan fertilizers on gardens and/or crops. Nearly all households reported compliance with recommended WHO maintenance and storage guidelines, however 66% of samples taken from chambers tested positive for *Ascaris*. Because the recycling component is one of the featured benefits of EcoSan toilets, there is a need to understand the barriers to achieving full pathogen inactivation.

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CHAPTER I: LITERATURE REVIEW

Sanitation and Health

The failure to effectively contain and manage human excreta is associated with a wide range of health problems worldwide (1). Poor conditions related to water, sanitation, and hygiene (WASH) are associated with approximately 6.6% of the global burden of disease and disability. Moreover, diseases specific to poor sanitation account for 10% of the global burden of disease (2). In 2007, the readers of the British Medical Journal voted the sanitary revolution as the most important medical milestone since 1840 for its success in reducing fecal-oral disease transmission (3). Although diarrhea is the most common health outcome linked to poor sanitation, it is critical to understand that sanitation is associated with a multitude of long term health problems.

Diarrhea

Globally, 1.5 million people die annually due to diarrhea, and the majority of these deaths occur in children under five (4). Diarrhea occurs when humans are exposed to pathogens, become infected, and experience illness. When access to sanitation is limited, environmental exposure to enteric pathogens is elevated and increases human risk for acquiring diarrheal disease. According to the World Health Organization (WHO), diarrhea accounts for 19% of all deaths in children under five in low-income settings, making it the second leading cause of mortality among this population (5). In Bolivia, diarrhea is the third leading cause of death in children under five, with rates increasing

from 19.2% in 1998 to 31.3% in 2008 (6). Evidence suggests that improving sanitation conditions has the potential to reduce diarrhea significantly (2).

The provision of sanitation facilities is generally part of a larger multi-pronged WASH approach to improve health. This makes it difficult to rigorously disaggregate the health benefits attributable specifically to increased access and use of sanitation facilities (2). Few studies have been able to measure the health benefits associated with the provision of sanitation facilities. Esrey et al. found that access to sanitation reduced rates of diarrhea regardless of type of water supply (7). However, access to an improved water supply had little impact on diarrhea if sanitation remained unimproved. A systematic review of the impact of WASH on health found that sanitation interventions reduced diarrhea, with a pooled relative risk of 0.68 (8). Other systematic reviews and studies of WASH consistently find that sanitation has a significant role in improving health especially when implemented with other WASH interventions (8-10).

Environmental Enteropathy (EE) and Nutrition

Poor sanitation, hygiene, and water are responsible for approximately 50% of the consequences of childhood and maternal underweight, primarily through the synergistic effects between diarrhea and under nutrition (2). Demographic Health Survey data from 140 countries suggests that open defecation, which occurs when sanitation facilities are absent, may be an important determinant of childhood stunting (1). Diarrhea and EE are two important factors associated with rates of childhood stunting in developing countries. Increased access to sanitation facilities is associated with improved growth in children under five (7). Eliminating exposure to fecal pathogens can improve rates of diarrhea and improve the overall nutritional status of individuals, especially children (11).

Recent WASH studies have hypothesized that chronic exposure to fecal bacteria due to poor sanitation and hygiene is a primary cause of EE (12). EE is a newly recognized sub-clinical condition often found in developing countries that causes blunting of the intestinal villi and chronic inflammation of the intestine (13). Even when children are not apparently infected with pathogens or exhibit clinical symptoms, the microbial-laden environment may provide a low level of chronic immune stimulation with catabolic consequences that result in poor growth (12). Although EE is less understood than traditional diseases transmitted through the fecal-oral route, growing evidence suggests that improving sanitation plays a fundamental role in reducing chronic exposures to fecal bacteria and the consequent sub-clinical health conditions that impair growth and development.

Neglected Tropical Diseases (NTDs)

NTDs encompass a diverse group of diseases that primarily affect the poorest populations throughout the globe. Although NTDs are not often fatal, they cause substantial disability-adjusted life years in many developing countries (10). There are many NTDs found throughout the world with soil-transmitted helminth (STH) infections being among the most common worldwide. Estimates predict that over two billion people are infected with STHs, particularly in regions of the world where sanitation is poor (14). STHs refer to a group of parasitic diseases caused by nematode worms that are transmitted to humans by fecal-contaminated soil (14). The primary STHs of major concern include *Ascaris lumbricoides, Trichuris trichiura, Necator americanus* and *Ancylostoma duodenale*. Current control strategies for STHs focus on massive drug

administration to at-risk populations but with reinfection being so pervasive, treatment only provides a temporary solution to a complex problem. Recent systematic reviews of WASH interventions and STH infections underscore the importance of WASH interventions in STH control and prevention (10). Improvements in WASH infrastructure and practices, in collaboration with effective treatment efforts are necessary to ensure long-term control and elimination of STHs.

Global Sanitation Coverage

In 2012, 64% of the global population had access to an improved sanitation facility (15). An improved sanitation facility ensures hygienic separation of human excreta from human contact. The following technologies are considered improved sanitation facilities: flush toilet systems that send waste to a piped sewer system, toilets with septic tanks, pit latrines, ventilated improved pit latrines (VIP) or pit latrines with slabs; and composting toilets (15). Facilities that are shared between two or more households or are not considered improved facilities because of concern that these facilities are not adequately maintained and free of fecal contamination.

Progress to increase sanitation coverage has been greatest in Eastern Asia (15). In contrast, Sub-Saharan Africa lags behind with only 30% of its population having access to improved sanitation facilities. Strong inequalities exist between rural and urban access to sanitation facilities. Of those who do not have access to improved sanitation, 70% live in rural areas (15). Additionally, due to limited sanitation access in rural settings, 9 out of 10 people practicing open defecation live in rural settings (15). As of 2012, 80% of urban areas had access to improved sanitation facilities, whereas only 47% of rural areas had

access to improved sanitation facilities (16). Although urban sanitation coverage is notably higher than rural, strong intra-urban disparities exist, leaving many urban residents without improved sanitation facilities.

Common Approaches to Sanitation

Most conventional approaches to sanitation and wastewater management are categorized as either waterborne or dry systems (17). Sanitation facilities are also categorized as centralized systems —excreta is collected and piped away from the household to a central location or decentralized systems —excreta is stored on-site. In most countries, waterborne, centralized sewage systems provide used access to improved sanitation primarily in urban areas. In Brazil, a citywide sanitation program increased centralized sewage connections from 26% to 80%. According to a before and after study in Brazil evaluating the effectiveness of the sanitation program, the system reduced the prevalence of childhood diarrhea by 21% in the program area demonstrating its impact on health (18). Although centralized systems are conventional approach to increase sanitation coverage and reduce fecal-oral transmitted diseases, they are not always feasible in developing countries. Furthermore, centralized systems are expensive to construct, operate and maintain, and require the use of water and wastewater facilities for safe treatment and disposal. Consequently, many developing countries are not equipped with the resources to effectively maintain these complex systems. As a result, low-income countries rely heavily on decentralized sanitation systems that are managed at the household level and require minimal resources for operations and maintenance.

VIP Latrines

VIP latrines continue to be the primary technology used to increase access to improved sanitation facilities in developing countries (19). VIP latrines were first developed and used in the 1970s to improve public health in resource poor settings. These latrines require the excavation of a deep pit and are similar to simple pit latrines with the exception of their vertical ventilation system that reduces foul odor and flies (Figure 2). These systems can safely remove human excreta from the local environment, but they pose risks of groundwater contamination. After latrine pits are full, households are required to seek sludge removal services or close off pits and move latrines to new locations. Because VIP latrines can fill quickly and need to be reconstructed or pumped frequently, their long-term sustainability and feasibility for densely populated areas has been questioned (20).

EcoSan technologies

EcoSan is a closed-loop system that has become increasingly common to address sanitation challenges in developing countries in both rural and urban settings (19). The term EcoSan encompasses a variety of technologies that can be tailored to meet the social, economic, and environmental needs in developing countries worldwide (17). EcoSan systems aim to close the nutrient loop between sanitation and agriculture by biologically treating human excreta and urine and recycling them as fertilizer for agricultural purposes. Fertilizers derived from treated human excreta and urine can serve as valuable products to generate household income through their application on crops and

gardens, primarily by increasing crop and garden production for household consumption or sales and reducing financial investment in commercial fertilizers (21).

In addition to sanitation benefits, EcoSan addresses food security by boosting agricultural production through the use of treated human excreta and urine as fertilizer. In Uganda, households using EcoSan technologies reported the use of human excreta and urine was an inexpensive way to fertilize gardens. Among EcoSan users, 20.8% reported agriculture as a primary factor for using the toilet (22). Unfortunately, not all EcoSan users have adapted the use of human feces and urine as fertilizer. Reviews from Eastern and Southern Africa programs found that EcoSan fertilizers were not widely embraced by users (23). EcoSan technologies have been more successful when subsidized rather than promoted as an agriculture benefit in Africa (24). This is primarily because the use of human feces to replenish soil nutrients have not be culturally acceptable in many countries. In addition, the small amount of human feces produced from EcoSan toilets and treatment process required to produce sanitized feces may limit the scalability of the technology.

Urine-diversion dehydration toilets (UDDTs) are one of the most common EcoSan technologies used in developing countries (Figure 3). These toilets can be more complex to implement and sustain than traditional on-site technologies such as VIP latrines because of their need for proper use and maintenance. However, when properly used, these toilets provide a long-term solution to sanitation in resource-limited settings. These toilets are well suited for areas where average temperatures are high and microbial die-off in excreta is accelerated, access to water is limited, and terrain is not suitable for excavation.

Although there are several UDDT designs, most include a double vault system with a mobile toilet seat to allow households to alternate use between each vault. Once the first vault is full, it is sealed for six to 12 months and then the contents are deemed acceptable for agricultural use (25).

While the principles of ecological sanitation are well-accepted, UDDTs must be properly maintained to ensure complete enteric pathogen inactivation (26). There are several factors that affect the survival of pathogens in human feces and urine: time, temperature, pH, ammonia, moisture, and presence of other microorganisms (Figure 4). UDDT vaults must remain dry to allow desiccation of the excreta. Programs implementing UDDTs recommend that households add bulking agents such as ash, lime, sawdust, or husks after each defecation to vaults to promote pathogen inactivation (27). Unfortunately, these agents aren't always readily available or used according to the recommended guidelines. When UDDTs are not properly maintained, complete pathogen inactivation in human excreta cannot be ensured, and the application of EcoSan fertilizers may release fecal pathogens into the environment. While the primary feature of UDDTs is sustainability through their capacity to convert human excreta into fertilizer, it is imperative that pathogens are fully inactivated to alleviate the risk of introducing pathogens on to crops intended for human consumption.

Several studies have assessed the rate of pathogen inactivation based on the primary factors that affect their survival. EcoSan studies of pathogen survival commonly test for the presence of *Ascaris lumbricoides* because of the its prolonged persistence in the environment compared to other pathogens (25). However, it is difficult to predict pathogen survival time in UDDTs due to the variability in household practices and

factors that promote pathogen inactivation. Consequently, the complex factors associated with pathogen survival highlight the challenges in adapting standard maintenance recommendations across all regions of the world.

Several discrepancies exist in the literature regarding pathogen survival in EcoSan toilets. A study in Bolivia reported that application of ash after each defecation and a storage time of greater than six months produced highest rates of *Ascaris* ova inactivation (28). However, a study testing biosolid samples from 35 EcoSan toilets in Bolivia found that over 66% of samples tested positive for *Ascaris* (29). Studies from El Salvador concluded that persons using UDDTs were 15.5 times more likely to be infected with *Ascaris lumbricoides* than persons with no household sanitation facility (26). According to studies conducted in Vietnam, complete pathogen inactivation was achieved within six-months when one to two cups of ash were added after each defecation practice (25). Based on current literature, it is unclear whether UDDTs are efficacious at achieving full pathogen inactivation, which poses significant risks to human health and well-being. The distinct environmental and population characteristics of different geographic regions makes it difficult to draw general conclusions from the previous studies to predict the efficacy of various maintenance practices for producing safe EcoSan fertilizers.

Use of human feces and urine for agricultural purposes

The use of treated human feces and urine as fertilizer can provide unique agricultural benefits that other fertilizers cannot. These fertilizers are advantageous because of their ability to replenish the specific nutrients depleted during seasonal

harvest. The nutrient content of human excreta varies greatly depending on the local diet. Because of the nutrient content of human excreta being similar to the local diet, EcoSan fertilizers may serve as a customized product for soil application (30). Bolivian studies comparing potato yields between agricultural plots using cow manure and EcoSan fertilizers derived from vermicomposting found that EcoSan fertilizers produced two times the volume of crops than cow manure (31). Several field studies using the combination of human urine and feces treated with low temperature composting in regions where soil quality is poor increased produced the highest crops yields (21). Both urine and sanitized feces should be handled utilizing proper safety precautions and worked into soil to reduce the risk of exposure to possible pathogens (32).

Although the nutrients found in human urine are more readily plant available than human feces, together they reflect the nutrient content of crops previously harvested (30). The major plant nutrients nitrogen (N), phosphorus (P), and potassium (K) are found in human excreta and urine (30). The N content in urine is excreted primarily as urea (75% to 90%), followed by ammonium, which are the two most common N fertilizers (21). P and K are also found in urine and are readily available making urine a unique biological fertilizer (30).

The plant availability of the nutrients found in human excreta are lower than human urine (21). However, the high content of organic material allows human excreta to serve as a valuable conditioner to improve soil quality (21). Additionally, the P found in excreta is directly plant available and the organic material in feces degrades the N and P nutrients making them plant available (21). The high levels of P, K, and organic material in human feces can substantially increase agricultural yields (21).

It is estimated that adults excrete 0.12 to 0.4 kilograms (kg) per day which is equivalent 44 to 146 kg per year depending on diet and quantity of food consumed (25, 33). Human feces is approximately 80% water and during the UDDT desiccation process, the moisture content is reduced greatly (33). The WHO recommended guidelines on duration of human excreta storage are at least six-months, and the water content in human excreta reduces to approximately 25% (33). Thus, the annual amount of fecal material produced by an average size human after six-months of storage time ranges between 20 and 66 kg. The amount of fertilizer an EcoSan toilet produces depends on the vault size and number of persons per household using the toilet. Application of EcoSan feces should occur at least one-month before crop harvest to ensure safety.

Adults excrete on average 0.8 to 1.5 liters of urine per day which over a year accumulates to 290 to 550 liters per person (25). According to the WHO guidelines on safe use of excreta, wastewater, and greywater, the longer urine is stored, the lower the risk of contamination (25). EcoSan guidelines suggest the use of urine for agriculture production after at least one-month of storage (30). EcoSan urine should be applied at least one month prior to crop harvest (25). Humans excrete larger quantities of urine than feces and it requires less intensive treatment processes than feces. This allows large quantities of urine to be readily available throughout the year for agriculture.

Knowledge, Attitudes, and Practices (KAP) of Sanitation in Bolivia

In Bolivia, many organizations have worked to expand coverage of improved sanitation facilities by utilizing innovative approaches and technologies. Evaluations show that uptake of EcoSan facilities was less than 50% in some communities in Bolivia

(34). Additionally, studies in Bolivia that inspected EcoSan 6 years post-intervention found that less than 50% of the latrines constructed were still being maintained and used for their intended purposes (35).

Bolivia is home to over 36 indigenous and ethnic nations, and their respective languages make implementation of sanitation interventions challenging (36). Although these nations share common lifestyle patterns, they are not homogenous in their cultural beliefs and traditions. The distinct differences between ethnicities pose challenges to identifying the barriers to sanitation coverage and uptake.

In many regions of Bolivia, social and cultural regulations govern the disposal of excreta (34). A study assessing the anthropological view of sanitation issues in Bolivia concluded that smaller children defecate near the house whereas adults prefer to defecate in open fields (34). Bolivians report being aware of the health risks of exposure to human feces, but many believe that excreta surrounding the household dries up and is taken away by animals, nature, and wind (34).

Similar to many parts of the world, discussion about human excreta is taboo in Bolivia, making it difficult to understand household sanitation preferences and practices (34). The most common reasons households report not using sanitation systems as intended include unpleasant odor; poor technical design and construction; inadequate training related to use and maintenance; and lack of comfort and hygiene (34). For sanitation interventions to be effective, it is important to address these concerns through the development of appropriate strategies and technologies.

CHAPTER II: RESEARCH OBJECTIVES AND RATIONALE

Study objectives

1. Describe basic demographic characteristics of study households in 12 communities in Bolivia based on the type of sanitation facility.
2. Describe EcoSan toilet maintenance practices among EcoSan users.
3. Examine differences in agricultural practices among EcoSan users and EcoSan non-users.

Rationale

Although progress has been made to reduce the number of people with sustainable access to improved sanitation facilities, the millennium development goal (MDG) to increase access to improved sanitation facilities by 2015 was not met. In Bolivia, only 46% of the population has access to improved sanitation facilities (15). Furthermore, it is evident that increased access to sanitation does not always translate into reductions in disease. With about 2.5 billion people globally living without access to improved sanitation, it is becoming increasingly important to identify sustainable solutions that can improve health and well-being.

Several studies have concluded that EcoSan toilets can be effective at inactivating pathogens found in human excreta when properly maintained (21, 28, 31, 37, 38). However, few studies have explored the maintenance and agricultural practices of households with EcoSan toilets to determine whether the toilets and the fertilizers produced are being used as intended. Understanding common maintenance practices among EcoSan users as well as the proportion of households using EcoSan urine and

feces as fertilizer for agricultural practices will help identify potential health risks of EcoSan fertilizers. As organizations continue to promote EcoSan as a sustainable approach to addressing sanitation challenges, more research is needed to determine if EcoSan toilets are increasing access to sanitation while safely converting excreta into valuable agricultural products.

CHAPTER III: MANUSCRIPT

Introduction

Sanitation is a fundamental component for human health and social and economic development. According to WHO, sanitation is defined as the provision of facilities and services for the safe disposal of human urine and feces, and maintenance of hygienic conditions (5). Globally, 2.5 billion people remain without reliable access to any type of improved sanitation facility (16). These individuals rely on public and shared sanitation facilities, facilities that do not meet minimum hygiene standards, or practice open defecation (16).

The United Nations MDG target to halve the proportion of the population without sustainable access to safe drinking and basic sanitation by 2015 was met for water in 2010, five years ahead of schedule. While this is a tremendous achievement, the target to halve the proportion of the population with sustainable access to basic sanitation was not met. Moreover, MDG sanitation efforts have focused primarily on increasing access to improved sanitation infrastructure and have failed to ensure adequate uptake and sustainability of these facilities. Furthermore, health benefits associated with sanitation cannot be assumed by simply constructing latrines (39). Increasing sanitation requires

implementing long-term solutions for populations that would be willing to use and maintain them on a regular basis.

In Bolivia, sanitation coverage remains alarmingly low in comparison to other countries in Latin America and the Caribbean (LAC). Overall, 82% of the LAC population has access to improved sanitation facilities; however, Haiti and Bolivia are among 46 countries throughout the world where less than half the population has access to improved sanitation facilities (16). Bolivia's National Basic Sanitation Plan for 2008-2015 aimed to increase sanitation coverage from 47% to 80% by 2015 but failed to meet this ambitious goal (36). As of 2008, over half of Bolivia's population lack access to sanitation, with the rural population being disproportionately affected. Moreover, evaluations of sanitation interventions in Bolivia reveal that even when facilities are constructed, they are not always routinely used (34).

Efforts to increase sanitation coverage throughout Bolivia, especially in rural settings, have heavily focused on the implementation of EcoSan technologies. EcoSan is a promising approach that aims to close the nutrient loop between sanitation and food security by treating and re-using human excreta for agricultural purposes. These systems require more intensive maintenance compared to conventional sanitation approaches to ensure long-term sustainability and safety of their products. EcoSan systems provide the opportunity to improve health through the containment and treatment of human feces and urine while also offering the possibility to generate household income and promote food security by reusing treated feces and urine on household gardens and crops to enhance production. Limited research explores the uptake of EcoSan fertilizers on household gardens and crops. EcoSan toilets can produce a high quality fertilizer with rich nutrient

content, but without optimal operations and maintenance, the safety of EcoSan fertilizers remains equivocal (40). Previous studies have found the maintenance practices and survival of pathogens vary depending on geographic location and type of EcoSan technology used (26, 28, 37, 38, 40). As organizations continue to invest in sustainable approaches for sanitation, it is necessary to understand how EcoSan toilets are maintained and whether or not fertilizers are appropriate for agricultural practices. Comparing agricultural practices between EcoSan users and non-users provides insight to EcoSan fertilizer uptake and actual practice of recycling human excreta into fertilizers for agriculture production. Additionally, understanding use of EcoSan fertilizers can indicate the proportion of households that may be at risk of exposure to pathogens if EcoSan toilets are not properly maintained.

The original purpose of this dataset was to evaluate the success of EcoSan interventions implemented by five non-profit organizations (NGO) from 2000 to 2007 in Bolivia. To capitalize on the time and financial investment in this data, new objectives were developed to analyze the data and provide insight about EcoSan toilet maintenance as well as the use of EcoSan fertilizers for agricultural purposes. Since the data were collected for purposes other than this study, there are several limitations that will be further explained in the discussion section.

Methods:

Population and Sample

This study involves the secondary analysis of data collected from a cross-sectional KAP sanitation survey of 228 Bolivian households in nine rural and three peri-urban communities surrounding the departments and regions of 1) Cochabamba (Valley); 2) La Paz (Highland); and 3) Santa Cruz (Tropical) (Table 1). In addition to the cross sectional survey, the study collected 35 biosolid samples and conducted 50 EcoSan toilet inspections that were not analyzed as part of the objectives of this paper.

Research Design

In July 2007, local enumerators and Emory University staff administered household surveys throughout the three ecological zones in Bolivia. Nine communities were conveniently selected with assistance from the Bolivian Ministry of Water and a local NGO, *Sumaj Huasi* based on feasibility for data collection staff to travel daily to each community. The study communities all received EcoSan interventions between 2000 and 2007 in collaboration with one of five NGOs: 1) Plan International; 2) UNICEF; 3) DIFAR; 4) Bibosi; and 5) Agua Tuya. Additionally, household surveys were administered in three communities with no sanitation interventions in the Department of La Paz to serve as comparison communities.

Convenience samples of five to 30 households were collected in each community based on willingness to participate, community size, and time. A household was defined as any group of people living and sleeping in the same physical establishment. A head of household was defined as any adult, or eldest child, responsible for making decisions

regarding household sanitation. All participants were required to give written consent prior to survey administration.

Survey Instruments

A twenty-minute KAP survey was administered in Spanish by research assistants employed at *Sumaj Huasi* to head of households throughout the twelve communities. The survey consisted of a series of open and closed-ended questions covering the following topics: 1) demographic information; 2) general sanitation questions; 3) toilet use; 4) participation in sanitation intervention; 5) maintenance of sanitation facilities; 6) agricultural practices; 7) sanitation attitudes and practices; 8) marketing preferences, and 9) ecological sanitation. In communities where no EcoSan intervention was implemented, a modified version of the survey instrument was used that did not include questions specific to EcoSan.

Ethical Considerations

The Ministry of Water in Bolivia and the Institutional Review Board (IRB) of Emory University approved the study protocol prior to data collection. Protocol for the study was developed by a former Emory Master of Public Health student, in collaboration with the Center for Global Safe Water (CGSW) at Emory University. IRB approval was obtained for use of the data set for secondary analysis.

Data Analysis

Survey data were double-entered, cleaned, and stored in EpiInfo, version 3.5. All data were coded to maintain confidentiality. Data were transferred and stored in Microsoft Outlook by the CGSW. Data were retrieved from Microsoft Outlook with approval from CGSW and exported into SAS for data analysis. SAS data comparison methods were used on multiple databases to ensure the most current data set was used for analyses.

EcoSan users versus non-users

Using a hard copy of the survey instrument, all values were coded as missing if they did not fall into a response category on the survey instrument. The variable for type of household sanitation facility and the variable indicating whether or not a household had access to a sanitation facility were combined to create a dichotomous variable for bathroom type: EcoSan users and non-users. Respondents who had EcoSan toilets were categorized as EcoSan users whereas respondents were categorized as non-users if they had no sanitation facility or any other type of sanitation facility (Figure 1). The PROC FREQ procedure was used to calculate frequencies and percentages stratified by type of sanitation facility for study demographics and agricultural practices. Mantel-Haenszel (MH) odds ratios and chi-square tests were calculated to compare EcoSan users to non-users. Confidence intervals for odds ratios were produced using PROCSURVEY SELECT and bootstrapping resampling procedures drawing 1000 samples of 228 households from the original data set to create empirical confidence intervals. P-values were not reported due to convenience sampling techniques.

Survey questions indicating households with gardens and/or field crops were combined to create one categorical variable: crops versus no crops. Variables for the use of urine on gardens and/or field crops were combined to create a dichotomous variable for urine use on agriculture. Variables for the use of animal feces on gardens and/or field crops were combined to create a dichotomous variable for the use of animal feces. Variables for the use of human feces on gardens and/or field crops were combined to create a dichotomous variable for use of human feces. MH odds ratios were estimated comparing EcoSan users and non-users. Chi-square tests were used to compare agricultural practices of EcoSan users to non-users. Confidence intervals for odds ratios were produced using PROCSURVEY SELECT and bootstrapping resampling procedures drawing 1000 samples of 228 households from the original data set to create empirical confidence intervals. P-values were not reported due to convenience sampling techniques.

Maintenance practices of EcoSan users

Frequencies were calculated using PROC FREQ for variables in the ecological sanitation module portion of the survey instrument to assess maintenance practices among EcoSan users. Variables with missing responses were coded as missing and not included in the analysis. Continuous variables were analyzed using PROV UNIVARIATE procedures to calculate mean, median, range, and standard deviation.

Results

Study population and demographics

Survey data were collected from 228 households in 12 different communities of the Altiplano, Tropical and Valle regions of Bolivia (Table 1). Among study participants, 6(50%) of the communities were located in the Altiplano region, 2(16.7%) in the Tropical region and 4(33.3%) in the Valle region. Of the communities included in the study, 3(25%) were peri-urban and 9(75%) were rural. Nine of the 12 communities had EcoSan interventions between 2000 and 2007. All three communities with no EcoSan interventions were located in the Altiplano region of Bolivia.

Of the 228 households surveyed, 97(42.5%) had EcoSan toilets constructed between 2000 and 2007. Among the households with non-EcoSan toilets, 3(1.32%) had septic tanks, 3(1.32%) had flush toilets and 26(11.4%) had pit latrines. The remaining 99(43.4%) households had no toilet.

Household demographics were compared between study participants by type of sanitation facility (Table 2). The average age of EcoSan toilet respondents was 40.7 years, 36.9 for respondents with other toilet types and 41.4 for respondents with no toilet. Among EcoSan users, half of the respondents were women, 28.9% were male and 20.6% were children. Among households with other toilet types, 34.4% respondents were women, 34.4% were men, 28.1% were children, and 3.1% were other adults living in the household. Among households with no toilet, 41.4% were women, 46.5% were men, 10.1% were children and 2% were other adults living in the household.

Household size varied slightly between households with EcoSan toilets, other toilet types, and no toilets. Among EcoSan users, nearly half (45.4%) had a household size of three to five members. Among households using non-EcoSan toilets, over half (56.3%) had a household size of 6 or more members. Among households with no toilet, half had a household size of three to five members.

Education levels were slightly higher for households using non-EcoSan toilets compared to households with EcoSan toilets or no toilet. Among female head of households for EcoSan users, 59.5% had an education grade level between one and six. For non-EcoSan toilets, 37.7% female head of households had an education level between one and six. Among female head of households for households with no toilet, 67.4% had an education level between one and six.

Similar to female head of household education levels, households using toilets other than EcoSan had slightly higher education levels compared to households with EcoSan toilets or no toilet. Among male head of households for EcoSan users, half had an education level between one and six. For households using other toilets, 35.5% male head of households had an education level between one and six. Among households with no toilet, 62.1% male head of households had an education level between one and six.

Ethnicity varied slightly between the three groups (Table 2). Among EcoSan users, most were either Aymara (30.2%) or Quechua (29.1%). Among households with other toilet types, most were Quechua (55.2%), but many were Mestizo (14%) or Asian (17%). Among households with no toilet, most were Aymara (57%) or Quechua (22%).

Household drinking water sources were aggregated into two categories: improved and unimproved. There were substantial differences in type of drinking water by

household sanitation facility (Table 2). Of the 97 households with EcoSan toilets, 79.2% had access to improved drinking water sources. Of the 32 households with other toilet types, 93.8% had access to improved drinking water sources. Only 35.7% of the 99 households with no toilet facility reported access to improved drinking water sources.

Since income was not reported, household assets were used to provide an understanding of the socio-economic status for each of the three sanitation groups (Table 2). Household floor materials varied slightly between household toilets. For EcoSan users, most (64.2%) had dirt floors. For households using other types of toilets, most (60%) had cement floors. For households with no toilet, most (79.8%) had dirt floors.

Access to electricity varied greatly between the three groups (Table 2). Among EcoSan users, 78.4% reported having electricity. For households with other toilet facilities, 96.9% reported having electricity. Only 20% of households with no toilet reported having electricity.

Households that reported owning a television varied greatly by the type of sanitation facility (Table 2). For households with EcoSan toilets, 54.6% reported owning and television. Of the households with toilets other than EcoSan, 93.8% reported owning a television. Among households with no toilet, 20% reported owning and television.

Owning a refrigerator was less common among all respondents compared to owning a television (Table 2). Among the 97 households with EcoSan toilets, only 19.1% owned a refrigerator. Of the 32 households with non-EcoSan toilets, 71.9% owned a refrigerator. Owning a refrigerator was less common among households with no toilet compared to the households owning a toilet. Only 2.1% of households with no toilet reported owning a refrigerator.

Households who own a phone varied slightly between the three groups (Table 2). Phone ownership was highest among households with non-EcoSan toilets with 67.7% owning a phone. Phone ownership was lowest among households with no toilet with 20% owning a phone.

Maintenance practices among EcoSan users

Maintenance practices among EcoSan users were examined to investigate whether or not households were following recommended maintenance practices and to predict the safety of the EcoSan fertilizer. Only households with EcoSan toilets were included in the analysis (Table 3).

Ash was the most common drying additive used (Table 3). Of the 97 households interviewed, 68.0% used ash as the primary drying additive used in the EcoSan chambers. Additionally, 5.2% used dirt/sand, 4.1 used sawdust, 1% used nothing and 21.7% used other additives. Most other additives included a mixture of the listed bulking agents.

The majority of EcoSan users reported using additives after each use (Table 4). Among respondents, 91.8% added materials after each use, 2.1% added materials at least once a day and 5.2% added materials less than once a month. Overall, 70.1% of households added 1 cup of drying material after use, and 29.9% used two or more cups after each use.

The majority of EcoSan households reported having a tool for mixing the chamber contents. Among EcoSan users, 80.4% had something to mix the chamber contents. Of the 78 households with a mixing tool, 47.9% mixed the chamber contents once a week, 12.5% mixed once every two weeks, 17.7% mixed the chamber contents

once a month, 1% mixed the chamber contents less than once a month and 2.1% never mixed the chamber contents and 17.8% didn't know.

Disposal of the chamber contents varied between EcoSan users (Table 3). Most households used the biosolids for agricultural practices (52.3%) or burnt them (25%). Only 45.4% of households were able to answer this question suggesting they may not have emptied the chamber contents yet.

Households with EcoSan reported an average of 4.4(SD 2.4) cleanings per month with a minimum of 1 and maximum of 60 (Table 3). Of the 97 households with EcoSan toilets, only 66% provided information about duration of storing chamber contents before emptying them. The average number of months the chamber contents were stored was 15.6 months. However, some households reported storage durations that suggest the chambers have never been emptied. The median number of months the chamber contents were stored before being emptied was 12 months.

Agricultural practices for EcoSan users and non-users

Household gardens

In attempt to overcome limitations due to small sample sizes, a dichotomous variable was created to compare EcoSan users to non-users for agricultural practices. All households without EcoSan toilets were aggregated into an EcoSan non-user group. Since households were not randomly selected and the option to participate in EcoSan interventions was not given to all survey participants, we were limited in our ability to draw conclusions representative of the whole population. Survey households with home gardens did not differ greatly between EcoSan users and non-users (Table 4). Among the

97 EcoSan users, 27.8% reported having a household garden. Among the 131 non-users, 23.7% reported having a household garden.

Reported use of urine on household gardens varied slightly between EcoSan users and non-users (Table 4). Among the 27 EcoSan users with household gardens, 29.6% used urine as fertilizer on gardens. Among the 31 non-users with gardens, 16.7% used urine as fertilizer on gardens.

Reported use of animal feces on household gardens did not differ significantly between EcoSan users and non-users (Table 4). Among EcoSan users with household gardens, 44.4% used animal feces. Among non-users with gardens, 67.7% used animal feces.

Reported use of human feces on household gardens varied significantly between EcoSan users and non-users (Table 4). Among EcoSan users with household gardens, 37% used human feces on household gardens compared to non-users whereas only 3.3% of respondents used human feces on gardens.

Field Crops

Survey households with field crops were significantly different between EcoSan users and non-users (Table 4). Among the 97 EcoSan users, 73.2% had field crops compared to 31% among the 131 non-users. Reported use of urine on field crops varied significantly between EcoSan users and non-users (Table 4). Among the 71 EcoSan users with field crops, 36.2% used urine. Among the 41 non-users with field crops, 17.1% reported used urine. The odds of using of urine as fertilizer on field crops for EcoSan users were 2.70(95% CI 1.36, 8.0) times the odds for non-users (Table 4). Reported use of animal feces on field crops did not vary between EcoSan users and non-users (Table 4). Among EcoSan users with field crops, 87.3% used animal feces and 85.4% of non-

EcoSan users used animal feces on field crops. Reported use of human feces on field crops varied significantly between EcoSan users and non-users (Table 4). Among EcoSan users with field crops, 18.3% reported using human feces on field crops, but only 5% of non-EcoSan users used human feces on field crops.

Household Gardens and Field Crops

Households with either a garden, field crops or both were aggregated to explore differences in general agricultural practices between EcoSan users and non-users (Table 5). The proportion of survey households who reported having a garden and/or field crops was significantly different between EcoSan users and non-users. Among EcoSan users, 83.5% had gardens and/or field crops compared to 44.3% of non-EcoSan users who had a garden and/or field crops. The odds for EcoSan users to own a garden and/or field crops were 5.92(CI 3.91, 10.13) higher than the odds for non-users (Table 5).

Reported use of urine on household gardens and/or field crops varied significantly between EcoSan users and non-users. Among the 80 EcoSan users with household gardens and/or field crops, 38.2% used urine. Among non-EcoSan users with gardens and/or field crops, 17.2% used urine. The odds of using urine as fertilizer on household gardens and/or field crops for EcoSan users were 2.88(1.67, 6.02) times higher than the odds for non-users (Table 5). Use of animal feces on household gardens and/or field crops did not vary significantly between EcoSan users and non-users (Table 5). Among EcoSan users with gardens and/or field crops, 80.3% used animal feces. Among non-EcoSan users with gardens and/or field crops, 77.6% used animal feces on household gardens and/or field crops. Reported use of human feces on household gardens and/or

field crops varied significantly between EcoSan users and non-EcoSan users (Table 5). Among EcoSan users with gardens and/or field crops, 25.9% used human feces as fertilizer compared to 5.3% among non-EcoSan users with gardens and/or field crops.

To determine which type of EcoSan fertilizer was more commonly used by EcoSan users, a chi-square test of association for use of urine compared to human feces was conducted. Among the 81 households with gardens and/or field crops, EcoSan users were 9.6(3.01, 30.68) times more likely to use urine on gardens and/or field crops than human feces.

Use of EcoSan fertilizer among EcoSan users by Ecological Zone

The use of EcoSan fertilizer varied substantially between the three ecological zones (Table 6). Among the 97 EcoSan users, 37.1% resided in the Altiplano zone, 35.1% in the tropical zone and 27.8% in the Valle zone of Bolivia. Among the 36 EcoSan users in the Altiplano zone, 97.2% had gardens and/or field crops. In the Tropical zone, 61.8% of the 34 EcoSan users had gardens and/or field crops and in the Valle zone 92.6% of the 27 households had gardens and/or field crops. The use of urine among EcoSan users was lowest in the tropical zone (Table 6). Overall, 28.6% of households in the tropical zone used urine as fertilizer on gardens or field crops compared to 34.3% of households in the Altiplano and 52% of households in the Valle zone. The use of animal feces varied between ecological zones (Table 6). All households in the Altiplano region reported the use of animal feces as fertilizer on gardens and/or field crops. In the Tropical zone only 33.3% used animal feces as fertilizer whereas 92.0% in the Valle zone used animal feces.

The use of human feces as fertilizer among EcoSan users varied greatly in the Altiplano zone compared to the Tropical and Valle zones (Table 6). In the Altiplano zone, none of the EcoSan users with gardens and/or field crops reported using human feces whereas 47.6% of EcoSan users in the Tropical zone and 44% of EcoSan users in the Valle zone reported using human feces as fertilizer on gardens and/or crops.

Perceived value of EcoSan fertilizer among EcoSan users

In general, EcoSan users reported EcoSan products as valuable in agricultural production. Among the 97 EcoSan households, 82.5% reported the fertilizer generated from their EcoSan toilet was valuable for agricultural production.

Use of urine for medicinal purposes

The survey instrument also investigated the use of urine for medicinal purposes. Although the use of urine for medicinal purposes is not considered part of agricultural practices, many study participants reported using urine as medicine. Among the 97 EcoSan users, 54.6% used urine as medicine and of the 131 non-EcoSan users, 45.4% used urine as medicine.

Discussion

This cross sectional survey was conducted in conjunction with 50 toilet inspections and 35 biosolid samples collected from EcoSan chambers to gain a more comprehensive understanding of EcoSan toilet interventions in Bolivia (41, 42). Although the objectives of this study were not a planned component of the original study design, they bring additional insight and triangulation to previous study findings.

This study provides an overview of the basic demographic information for 12 rural and peri-urban communities in Bolivia, of which nine received EcoSan interventions between 2000 and 2007. While many EcoSan studies have investigated pathogen survival and EcoSan uptake and use, few studies have explored the reported use of EcoSan treated excreta and urine for agricultural production. This study investigates whether EcoSan interventions in Bolivia actually 'closed the nutrient loop' by describing maintenance practices and the proportion of households who used EcoSan fertilizers. It also differentiates fertilizer use by household gardens and field crops to identify where EcoSan fertilizers are commonly used. It provides insight to changes in agricultural practices in the presence of EcoSan toilets and considers the potential health risks associated with applying EcoSan fertilizers on gardens and field crops.

Demographic characteristics of study population

There were differences in demographic characteristics between households based on type of sanitation facility used. Since many developing countries cannot rely on numeric indicators of socio-economic status (SES), proxies such as educational level, living conditions (household structure, water, and electricity) and household assets

(television and refrigerator) are commonly used to measure household wealth (43). Among the study population, households with types of toilet facilities other than EcoSan reported higher education levels, improved living conditions and household assets compared to EcoSan households or households with no toilet facilities. In general, households with EcoSan toilets were more similar to households with no toilets. However, trends in our data suggest that households with no toilets were the poorest population in this study. Literature on sanitation demand suggests that households with higher education levels and SES are more likely to purchase or build their own sanitation infrastructure (44, 45). Although it cannot be determined from this study whether or not households with sanitation facilities other than EcoSan received financial or technical assistance to acquire household toilets, the differences in SES indicators may explain why some households in this study had sanitation facilities prior to, or external to, EcoSan interventions.

Maintenance practices of EcoSan users

The majority of EcoSan users reported following recommended maintenance practices to treat the chamber contents suggesting that EcoSan toilets should achieve pathogen inactivation. With time, pH, and moisture being the overall factors affecting pathogen survival in the environment, actual pathogen inactivation in EcoSan toilets under field conditions can vary depending on user practices and climate (32). On average, households reported storing chamber contents for 15 months, with the majority reporting of households reporting 12 months. Overall, 95% of households reported that they stored the chamber contents for at least six months, and 69% reported storing the chamber

contents for at least one year, which suggests most EcoSan households met WHO guidelines for safely treating excreta and/or that the households knew what they should be doing to use and maintain their EcoSan toilet (25).

Nearly all households reported using a drying material after each toilet use. Similar to other EcoSan studies in Bolivia, ash was the most common chamber additive used (28). Studies from Vietnam found that adding a cup of ash after each toilet use achieved total pathogen die-off after six months (46). Additionally, in El Salvador the use of ash and lime was more effective for pathogen inactivation (47). Based on household responses and previous literature, evidence suggests that most EcoSan users in these study communities met the storage time and pH requirements to treat human excreta and create pathogen-free fertilizers that are safe for agricultural purposes.

Key differences exist between the results derived from the household surveys and analyses of the biosolid samples. Since over half of all households reported storing the chamber contents for over a year and using drying additives after each use, the EcoSan toilets in these communities should be effective at pathogen inactivation. However, the results from the analysis of 35 biosolids samples revealed that 66% of the samples tested positive for viable *Ascaris* ova (29). This suggests that user reporting may not be sufficient to determine the effectiveness of the EcoSan toilets. In addition, these findings imply that households were well informed about the recommended maintenance practices by implementing organizations. In order to ensure pathogen inactivation, organizations must employ rigorous measures to test and identify factors that promote effective pathogen inactivation within the geographic and cultural context of Bolivia. Monitoring

maintenance practices and the viability of *Ascaris* in treated feces may identify better strategies to reduce the prevalence of *Ascaris* in EcoSan toilet contents in Bolivia.

The contradictory results from reported household maintenance practices and biosolid samples pose challenges to fully understanding the proper maintenance procedures required to produce pathogen-free human fertilizers. Even with reports of adequate storage time and use of drying agents after each defecation, over half of the EcoSan biosolid samples tested positive for *Ascaris*. With the prevalence of *Ascaris* being high in biosolid samples, it is important to understand household disposal and agricultural practices to determine the potential exposure to dangerous pathogens from the treated EcoSan feces.

EcoSan systems are more than toilets, they are long term solutions to the complex sanitation challenges (48). These closed loop systems organically treat and convert human excreta and urine into valuable fertilizers to enhance agricultural production (49). However, if human waste is not treated accordingly and then used for agricultural purposes, these systems may release pathogens into the environment.

Gardens and Field Crops

Among EcoSan users, only 28% had patio gardens compared to the 72% who had field crops, suggesting that the implementing organizations targeted more agricultural communities. It is common among EcoSan interventions to target agricultural communities to promote the use EcoSan fertilizers (34, 40). EcoSan households reported using urine more frequently on field crops (36.2%) than on gardens (29.6%). Interestingly, EcoSan households reported using human feces more often on gardens

(37%) than field crops (18.3%). The annual volume of urine produced by EcoSan toilets and ease of transport may explain why urine is more common among field crops. Since human feces requires longer storage time and produces lower quantities of fertilizer, it may be more feasible for application on household gardens (33). However, using EcoSan feces on gardens may pose greater risk of disease transmission for young children near the home.

Although the percentage of households with gardens was similar between EcoSan users and non-users, 72% of EcoSan users had field crops whereas only 31% of non-users had field crops. Again, this may be explained by the implementing organizations' targeting strategies. Even in the absence of EcoSan toilets, approximately 17% of households reported using urine on their gardens and crops. These findings demonstrate that EcoSan interventions may provide benefits to households that do not have field crops.

Use of human feces

Implementation of EcoSan toilets shifted agriculture practices slightly among households with gardens and/or field crops. However, EcoSan fertilizer does not appear to be a strong driver for EcoSan toilet use. Consistent with EcoSan interventions in Africa, approximately one quarter of EcoSan households reported using human feces on gardens and/or crops (23). In the Altiplano region of Bolivia, no households reported use of human feces for agriculture which is where the prevalence of *Ascaris* in biosolid samples was lowest (33%) (42). Differences in ethnicity and climate across the three ecological zones may explain variations in EcoSan fertilizer use. Over half of the

Altiplano households were Aymara, whereas the Tropical and Valley regions were primarily Quechua. These cultural differences may affect sanitation and agricultural practices, but more evidence is needed to fully understand the regional factors that drive uptake of EcoSan fertilizers.

While in theory EcoSan interventions promote full utilization of treated feces to maximize the benefits and sustainability of the technology, the presence of *Ascaris* in biosolid samples suggests that recycling human excreta may introduce pathogens into the environment and impede the goal of increasing sanitation coverage to reduce exposure to fecal contamination (29, 37, 38, 46, 50). The use of human feces was more commonly applied on household gardens than field crops. With gardens being closer to households, community members are more likely to come in contact with EcoSan fertilizers, illustrating the importance of ensuring full pathogen die-off. EcoSan interventions may consider a secondary treatment process such as vermicomposting or solar heat have been proven more successful in regions where the environmental conditions are not favorable for pathogen inactivation (31). However, even with secondary treatment such as vermicomposting, presence of *Ascaris* can be detected at unsafe levels (51). As a result, EcoSan technologies that incorporate a secondary treatment mechanism may be more favorable in regions of Bolivia where there is demand for EcoSan fertilizers.

Use of urine

Urine provides more nutrients that are readily plant available making it a valuable resource for agricultural production (30). Additionally, the treatment process and risk of exposure to pathogens is minimal compared to human feces (25, 30). Although few

pathogens may be present in urine, no studies find them to be a public health concern (25). Interestingly, the use of urine was reported among both EcoSan users (38%) and non-users (17%) with gardens and/or crops. Urine was more frequently used than human feces for agricultural practices. Households with EcoSan toilets were nine times more likely to report using urine as fertilizer than human feces. Among EcoSan users, 82% reported the products derived from EcoSan toilets to be valuable. Since few households reported use of human feces, evidence suggests urine is more widely used and considered more valuable than human feces in agricultural production.

The use of urine for medicinal purposes is reported in many developing countries (48). Over half (54%) of the 228 households in this study reported using urine as medicine with no differences based on the type of household sanitation facility. These findings suggest that there is a demand for urine that extends beyond the agriculture benefits. A study assessing treatment for headaches in Bolivia found that the application of urine on a cloth and then placed over the forehead was commonly used among indigenous ethnicities (52). However, it is unclear how urine is used as medicine in Bolivia from this study. More research on urine therapy in Bolivia is needed to determine the safety of the practice.

Conclusion

Globally, 2.5 billion people remain without adequate access to improved sanitation facilities, with Bolivia lagging behind all other countries in Latin America (16). As organizations and the Bolivian government work to address this serious problem, the selection of sanitation technologies must consider factors that promote long-term

sustainability and successful adoption to ensure full containment of human excreta from the environment. While EcoSan toilets serve as a promising approach to containing excreta and recycling human feces and urine into valuable agricultural products, less than half of EcoSan users reported utilizing EcoSan fertilizer on gardens, with use of urine being more common than use of feces among all study participants. Furthermore, nearly all households reported compliance with recommended maintenance and storage guidelines yet 66% of samples taken from EcoSan chambers detected *Ascaris.* This suggests that reported household maintenance practices are not adequate to predict the safety of EcoSan fertilizers. With recycling human waste being an fundamental component of EcoSan, more rigorous research is needed to determine what specific factors limit EcoSan toilets from achieving full pathogen inactivation. Organizations interested in implementing EcoSan toilets should develop ongoing monitoring and evaluation programs to better understand maintenance practices and system performance. Promoting the use of EcoSan fertilizers, especially feces, may introduce pathogens into the environment that sanitation coverage aims to eliminate. These findings suggest that it may be safer and more culturally accepted to focus on urine reuse and train households to safely bury feces versus promoting feces for agricultural use. However, if organizations can work with communities to identify and overcome challenges to producing a pathogen-free fertilizer, EcoSan fertilizers can be a sustainable solution to increase sanitation coverage while delivering long-term health and economic benefits of the full closed loop system.

The study contributes to the small evidence base on promising approaches to addressing sanitation challenges in developing countries. Although there are several

limitations to this study, it provides an overview of demographic information and maintenance and agricultural practices among households who received EcoSan interventions for five EcoSan implementing organizations. The geographical spread of the data encompasses all three ecological zones and provides information on sanitation and agricultural practices throughout the country. This enables implementing organizations to understand key differences in sanitation and agricultural practices and to develop and tailor sanitation solutions.

Few EcoSan studies go beyond reported toilet use to explore the maintenance and agricultural practices of households. This study provides insight to the proportion of households who use report using EcoSan fertilizers to boost agricultural production. Furthermore, it disaggregates the use of human feces and urine to show which EcoSan fertilizer is most commonly used. Additionally, it provides detailed information on agricultural practices to understand whether EcoSan fertilizers are commonly on gardens or field crops. Understanding agricultural practices can guide future EcoSan implementation strategies in Bolivia.

While this study provides insight about the maintenance and agricultural practices among EcoSan users, it has several limitations. The cross-sectional nature of the study prohibits the inference of causal relationships. Moreover, non-probability sampling may not be an adequate representation of the study population. Additionally, imputation using non-random bootstrapping sampling techniques provides empirical confidence intervals that limit the utility of p-values and point estimates.

Although many demographic characteristics of EcoSan users and non-users were similar, this study does not control for confounding factors. Key differences in ethnicity,

geographic region, climate, agricultural practices and SES may indicate that these 12 communities are not comparable for their sanitation practices alone. Additionally, dichotomizing the use of EcoSan toilets required the combination of potentially heterogeneous groups of households with no toilet and households with other toilets types.

Small sample sizes and differences in the survey questions determined the type of sanitation used but limit the comparability of variables between EcoSan users and non-users. The EcoSan module provides insight to the acceptability and maintenance of EcoSan toilets but does not provide a comparison group or adequate sample sizes to disaggregate households by geographical locations or by intervention program. This limits the analysis of the data to basic descriptive statistics.

Survey results are subject to reporting bias. Overall, the majority of households reported maintaining EcoSan toilets, but over half of the biosolid samples tested positive for *Ascaris*. Additionally, over half of EcoSan users reported EcoSan fertilizers as valuable, but less than half reported using the EcoSan fertilizers on household gardens and/or crops.

CHAPTER IV: LESSONS LEARNED AND RECOMMENDATIONS

Lessons Learned

Although this study provides insight about EcoSan interventions in Bolivia, a more rigorous study design employing random sampling methods would increase the ability to conduct advanced analyses and draw more generalizable conclusions that

reflect the population of interest. The survey instrument attempted to gather information on a wide range of sanitation topics but did not allow for meaningful comparisons. This study explored differences between EcoSan users and non-users in attempt to utilize all study participants. Future studies that aim to evaluate EcoSan interventions should allocate adequate time and resources to develop a more rigorous study design:

- Students interested in conducting field research should matriculate in courses on survey design, monitoring and evaluation, and sampling methods to develop the most useful research plan.
- The survey instrument should be concise and focus on key questions that answer the research question to avoid extraneous data collection.
- To effectively assess whether EcoSan toilets change agricultural practices, a before-after study design with a control group should be considered to attribute changes in the study population to the intervention.
- Monitoring and process evaluation of maintenance practices should be conducted by implementing organizations to determine gaps in knowledge and practices.
- Routine collection and testing of biosolid samples and technical inspections should be conducted by by implementing organizations to ensure the safety of fertilizers.
- The survey instrument should include details about type of crop production and disaggregate questions on use and preferences based on type of EcoSan fertilizer.
- The frequency of using EcoSan fertilizer should be assessed to determine if EcoSan fertilizer is an integral part of agriculture production

- Stratified random sampling should be used to explore differences based on ecological zone or implementing organization; cluster random sampling should be used to explore differences based on community.
- Qualitative research methods should be employed to gain a more comprehensive understanding of household sanitation KAP.

Recommendations

- Organizations interested in implementing EcoSan toilets should explore technologies proven successful in regions with similar environmental factors.
- EcoSan toilet interventions should include a monitoring component to understand and overcome the barriers to pathogen inactivation.
- Because of the variability in pathogen inactivation by region, EcoSan fertilizers should be sampled and tested for *Ascaris* before promotion for agricultural use.
- Implementing organizations may consider promoting urine for agriculture and train households to safely bury feces to reduce the risk of disease transmission.

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Table 1. Summary of characteristics for survey communities

Community	**Number of Households**	**Number of Interviews** (N=228) N (%)	**Zone**	**Population Density**	**Ecological Sanitation Intervention**
12 de Octubre	98	23(10.9)	Tropical	Rural	Yes
Barrio Copacabana	58	21(9.21)	Tropical	Peri-Urban	Yes
Camata Sur	90	10(4.39)	Altiplano	Rural	Yes
Challa Grande	30	5(2.19)	Altiplano	Rural	Yes
Challacaba	90	28(12.28)	Valle	Peri-Urban	Yes
Izata	34	12(5.26)	Valle	Rural	Yes
Julian Apaza I	10	7(3.07)	Altiplano	Rural	No
Julian Apaza II	40	29(12.72)	Altiplano	Rural	No
Mantecani	60	25(10.96)	Altiplano	Rural	Yes
Pulkina Arriba/Rio Arriba	105	21(9.21)	Valle	Peri-Urban	Yes
Toma Punku	36	11(4.82)	Valle	Rural	Yes
Valle Hermoso	50	36(15.79)	Altiplano	Rural	No

Table 2. Study demographics by type of sanitation facility

	Ecological Toilet	**Other Toilet**	**No Toilet**
	N (%)	N (%)	N (%)
Sanitation Facilities			
Number of households	97(42.5)	32(14.1)	99(43.4)
Ecological Zone			
Altiplano	36(37.1)	0	76(76.8)
Tropical	34(35.1)	8(25.0)	29(2.0)
Valle	27(27.8)	24(75.0)	21(21.2)
Average Household Size			
1-2	15(15.5)	1(3.1)	14(14.3)
3-5	44(45.4)	13(40.6)	49(50.0)
6+	38(39.2)	18(56.3)	35(35.7)
Average Household Education Level			
Female Head of Household			
0-6	50(59.5)	12(37.7)	58(67.4)
6+	34(40.5)	19(61.3)	28(32.6)
Not sure	13	1	13
Male Head of Household			
0-6	51(56.0)	11(35.5)	53(62.1)
6+	40(44.0)	20(64.5)	31(36.9)
Not sure	6	1	15
Ethnic Group			
Aymara	26(30.2)	1(3.5)	54(57.5)
Quechua	25(29.1)	16(55.2)	21(22.3)
Mestizo	2(2.3)	4(13.8)	1(1.1)
Chiquitano	1(1.2)	0	0
Guarani	0	0	0
White	0	0	1(1.1)
Afro-Boliviano	0	0	0
Asian	12(14.0)	5(17.2)	2(2.1)
Other	20(23.3)	3(10.3)	15(16.0)
Primary drinking water source			
Improved	76(79.2)	30(93.8)	35(35.7)
Unimproved	20(20.8)	2(6.2)	63(64.3)

Household floor material			
Cement	14(14.7)	18(60.0)	16(16.2)
Brick	14(14.7)	2(6.7)	
Dirt	61(64.2)	9(30.0)	79(79.8)
Wood	0	0	1(1.0)
Other	6(6.3)	1(3.3)	3(3.0)
Electricity			
Yes	76(78.4)	31(96.9)	33(33.7)
No	21(21.7)	1(3.1)	65(66.3)
Television			
Yes	53(54.6)	30(93.8)	19(20.0)
No	44(45.4)	2(6.2)	76(80.0)
Refrigerator			
Yes	18(19.1)	23(71.9)	2(2.1)
No	76(80.9)	9(28.1)	95(97.9)
Phone			
Yes	28(29.5)	21(67.7)	25(26.0)
No	67(70.5)	10(32.3)	71(74.0)

Table 3. Maintenance practices among ecological sanitation users

	Total **N=97 (%)**
Type of drying material used	
Dirt/Sand	5(5.2)
Ash	66(68.0)
Lime	0
Sawdust	4(4.1)
Corn Husk	0
Nothing	1(1.0)
Other	21(21.7)
How often drying materials are added?	
After each use	89(91.8)
At least once a day	2(2.1)
Less than once per day	5(5.2)
Don't know	1(1.0)
How many cups of drying materials are added each time?	N=95
1 cup	67(70.1)
2 cups	22(23.2)
3 cups	5(5.3)
More than 3 cups	1(1.1)
Do you have something to mix the chamber contents?	
Yes	78(80.4)
No	18(18.6)
Don't know	1(1.0)
How often are chamber contents mixed?	N=96
Once a week	46(47.9)
Once every 2 weeks	12(12.5)
Once a month	17(17.7)
Less than once a month	1(1.0)
Never	2(2.1)
Don't know	18(17.8)
What is done with chamber contents once removed?	N=44
Discarded	4(9.1)
Used for agricultural purposes	23(52.3)
Sold	0
Given away	0

Buried	11(25.0)
Collected by garbage services	1(2.3)
Other	2(4.6)
Don’t know	3(6.8)
For the last time you emptied, how many months were the chamber contents stored before being emptied?	(N=64)
Mean	15.6
Median	12.0
SD	13.9
Min	1
Max	84
Number of cleanings per month reported by households with ecological sanitation facilities	(N=96)
Mean	4.4
SD	2.4
Min	1
Max	15

Table 4. Agricultural practices among EcoSan users and EcoSan non-users

	Ecological toilet: Yes N (%)	**Ecological toilet: No** N (%)	**OR[a]**	**CI**
Households with home garden				
Yes	27(27.8)	31(23.7)	1.24	(0.73,1.97)
No	70(72.2)	100(76.3)		
Households with gardens using urine as fertilizer	(N=27)	(N=31)		
Yes	8(29.6)	5(16.7)	2.11	(0.73,7.5)
No	19(70.4)	25(83.3)		
Households with gardens using animal feces as fertilizer				
Yes	12(44.4)	21(67.7)	0.38*	(0.13,0.88)
No	15(55.6)	10(32.4)		
Households with gardens using human feces as fertilizer				
Yes	10(37.0)	1(3.3)	17.06*	(4.44,21.00)
No	17(63.0)	29(96.7)		
Households with field crops				
Yes	71(73.2)	41(31.3)	5.69*	(3.72,9.19)
No	26(26.8)	90(68.7)		
Households with crops using urine as fertilizer	(N=71)	(N=41)		
Yes	26(36.2)	7(17.1)	2.70*	(1.36,8.0)
No	45(63.4)	34(82.9)		
Households with crops using animal feces as fertilizer				
Yes	62(87.3)	35(85.4)	1.16	(0.39,3.12)
No	9(12.7)	6(14.6)		
Households with crops using human feces as fertilizer				

Yes	13(18.3)	2(5.0)	4.33*	(1.69,8.23)
No	58(81.7)	38(95.0)		
Households that use urine for medicine				
Yes	53(54.6)	71(54.2)	1.02	(0.68,1.51)
No	44(45.4)	60(45.8)		

[a]Mantel-Haenszel odds ratio
* Significant at p=<0.05

Table 5. Combined household garden and field crop agricultural practices among EcoSan users and non-users

	Ecological toilet: Yes N (%)	**Ecological toilet: No** N (%)	**OR[a]**	**CI**
Households with home garden or field crops				
Yes	81(83.5)	58(44.3)	5.92*	(3.91,10.13)
No	16(16.5)	73(55.7)		
Households using urine as fertilizer	(N=81)	(N=58)		
Yes	31(38.2)	10(17.2)	2.88*	(1.67,6.02)
No	50(61.7)	48(82.8)		
Households using animal feces as fertilizer				
Yes	65(80.3)	45(77.6)	1.16	(0.56,2.19)
No	16(19.8)	13(22.4)		
Households using human feces as fertilizer				
Yes	21(25.9)	3(5.3)	6.41*	(4.63,15.75)
No	60(74.1)	54(94.7)		

[a]Mantel-Haenszel odds ratio
* Significant at p=<0.05

Table 6. Agricultural practices among EcoSan users by ecological zone

	Altiplano	**Tropical**	**Valle**
	N=36	N=34	N=27
Households with home garden or field crops			
Yes	35	21	25
No	1	13	2
Households using urine as fertilizer			
Yes	12	6	13
No	23	15	12
Households using animal feces as fertilizer	N=35	N=21	N=25
Yes	35	7	23
No		14	2
Households using human feces as fertilizer			
Yes	0	10	11
No	35	11	14

Figure 1. Study population by type of sanitation facility

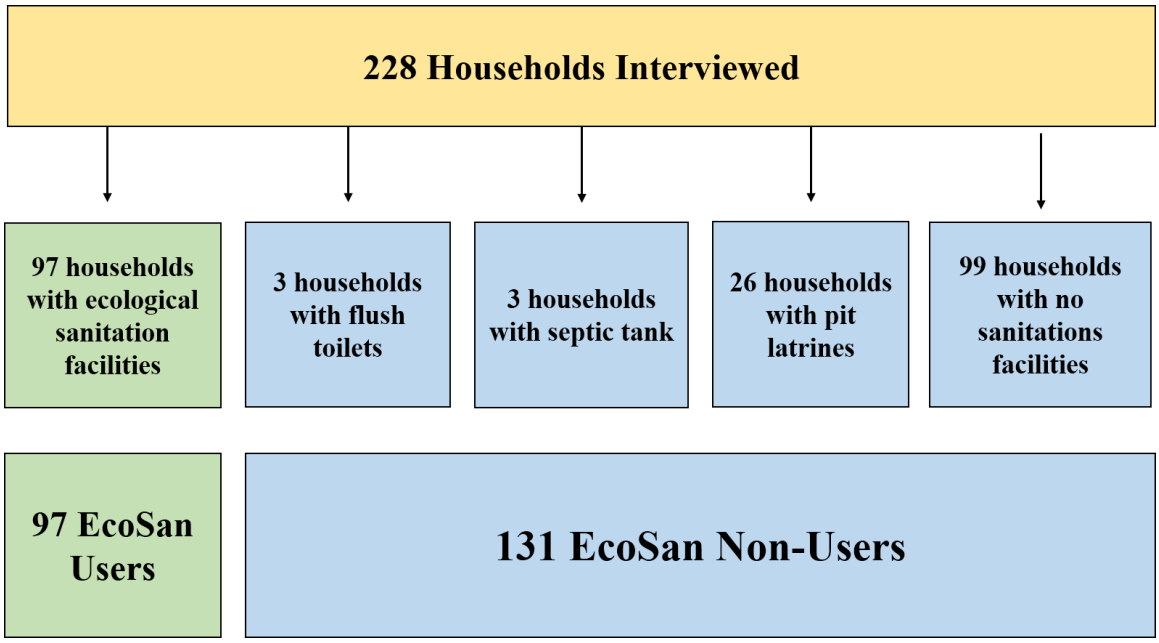
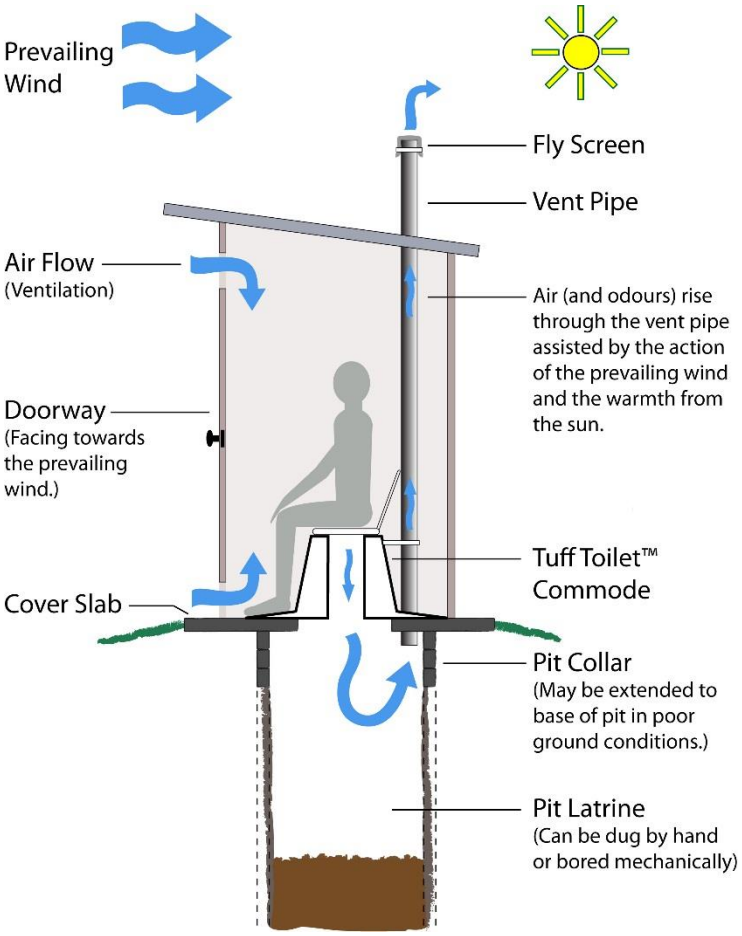
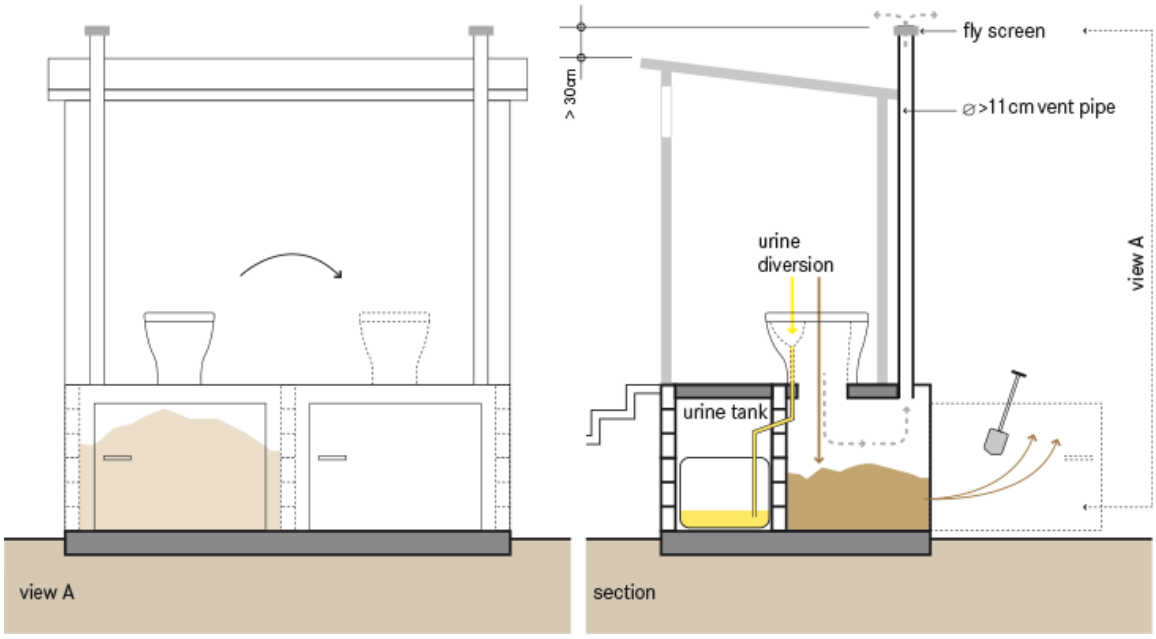


Figure 2. VIP Latrine



Reference: Solpont. Bellatrines VIP- how it works. 2012.

Figure 3. Ecological Sanitation Facility/Urine Diverting Dry Toilet (54).



Reference: Gislason H. Ecological Sanitation Systems. 2010.

Table 4. Factors affecting pathogen survival.

Temperature	Most microorganisms survive well at low temperatures (<5C) and rapidly die off at high temperatures (>40-50C). This is the case in water, soil, sewerage and on crops. To ensure activation, temperatures around 55-65C are needed to kill all types of pathogens.
pH	Many microorganisms are adapted to a neutral pH. Highly acidic or alkaline conditions will have an inactivating effect. Addition of lime to excreta in dry latrines and to sewage sludge can increase pH and will inactivate microorganisms. The speed of inactivation depends on the pH value. A pH of 9-12 is ideal.
Ammonia	In natural environments, ammonia chemically hydrolyzed or produced by bacteria can be deleterious to other organisms. Added ammonia-generating chemical will also facilitate the inactivation of pathogens in excreta or sewage sludge.
Moisture	Moisture is related to the organism survival in soil and in faeces. A moist soil favours the survival of microorganisms and a drying process will decrease the number of pathogens.
Presence of other microorganisms	The survival of microorganisms is generally longer in material that has been sterilized than an environmental sample containing other organisms. Organisms may affect each other by predation, release of antagonistic substances or competition.

Reference: Werner C, Panesar A, Rüd SB, et al. Ecological sanitation: Principles, technologies and project examples for sustainable wastewater and excreta management. Desalination 2009;248(1–3):392-401.

Appendix

--Household Questionnaire – Knowledge, Attitudes, and Practices of Household Sanitation

Community Name: _____ Community Code: __ __ __

Interviewer: _____ Date of Interview: __ __ / __ __ / __ __
First Last day month year

Beginning Time: __ __: __ __ Ending Time: __ __: __ __
hour minutes* hour minutes*

*of 24 hours

Interviewer Instructions: *Please begin the interview by reading the introductory statement directly following this paragraph. Ensure that the respondent has given verbal informed consent before beginning the questionnaire. Read the questions and answer choices one at a time, allowing sufficient time for the respondent to answer. Where appropriate, circle the answer choice given by the respondent. Do not read the options unless otherwise instructed, including "Don't Know" as an answer choice; only mark this answer choice if you find that the respondent does not know the answer to the given question. Any additional interviewer instructions are provided* ***in italics*** *below their corresponding question. At conclusion of the interview, be sure to thank the respondent for their time and participation.*

Declaración de Introducción y Consentimiento

Hola, me llamo _____, y estoy aquí por la parte de la Fundación Sumaj Huasi. que es una ONG Boliviana que trabaja desde el año 1998 a nivel nacional e internacional, con la misión de mejorar las condiciones de agua y saneamiento de las poblaciones más necesitadas. Actualmente estamos realizando un estudio acerca del saneamiento en la vivienda y quisiéramos que usted participe dándonos información referida al tipo de baño que utiliza dentro de su casa, y si no lo tuviera, del lugar donde hace habitualmente sus necesidades. La información que nos proporcione es muy valiosa para nosotros y nos servirá para planificar nuevos proyectos de mejor manera, si tiene un baño dentro de su casa también desearíamos realizar una revisión del mismo y en algún caso colectar una muestra de los residuos para examinar la presencia de posibles microbios y asegurarnos de que funciona apropiadamente.

Este cuestionario voluntario tomará aproximadamente 30 minutos y sus respuestas se quedarán ambos anónimo y confidencial. Usted no tiene que responder a ninguna pregunta que usted no quiere, y puede terminar el cuestionario en cualquier momento. Si tiene preguntas, favor de contactar Sumaj Huasi a 591-2-211-6098, contacto@sumaj.org. Si tiene preguntas acerca de sus derechos como participante del estudio, favor de contactar Colleen DiIorio, Institutional Review Board, Emory University, 0010-1-404-712-0720, irb@emory.edu.

¿Puedo empezar el cuestionario?

Does the respondent give voluntary consent to participate in this survey?

☐ Yes ☐ No

Nº	Demographic Information	Categories/Codes
HH101	Determine the position of the respondent in the household *(Do not need to ask directly)*	01…Head of household - Woman 02…Head of household - Man 03…Head of household - Child 04…Other adult in household
HH102	How old are you?	__ __ __ years 99…Don't know
HH103	With which ethnic group do you most identify yourself?	01…Aymara 02…Quechua 03…Mestizo 04…Chiquitano 05…Guaraní 06…White 07…Afro-Boliviano 08…Asian 88…Other, specify: _____ 99…Don't know
HH104	How many people currently live in your household?	__ __ __ people 99…Don't know
HH105	What is the household's primary source of drinking water?	01…Piped into dwelling 02…Public tap at school 03…Public tap outside compound 04…Open well in compound 05…Open public well 06…Covered well/Borehole in compound 07…Covered public well/Borehole 08…Protected spring 09…Unprotected spring/river/stream/lake 10…Rainwater/Roof catchment 11…Water vendor 12…Bottled water 13…No water available 88…Other, specify: _____ 99…Don't know
HH106	Do you consider the water you use to be safe for drinking?	01…Yes 02…No 99…Don't know
HH107	In the past year, during how many months was there water scarcity for your home?	__ __ months 99…Don't know
HH108	What type of roof does your house have?	01…Tile 02…Aluminum 03…Thatch 88…Other, specify: _____

		99…Don't know
HH109	What type of floor does your house have?	01…Cement 02…Brick 03…Earthen 04…Wood 88…Other, specify: _____ 99…Don't know
HH110	Do you have electricity?	01…Yes 02…No 99…Don't know
HH111	Do you have a radio in your house?	01…Yes 02…No 99…Don't know
HH112	Do you have a television in your house?	01…Yes 02…No 99…Don't know
HH113	Do you have a telephone (cellular or landline)?	01…Yes 02…No 99…Don't know
HH114	Do you have a refrigerator?	01…Yes 02…No 99…Don't know
HH115	What level of education has the mother or female head of household completed?	__ __ course 99…Don't know
HH116	What level of education has the father or male head of household completed?	__ __ course 99…Don't know
Nº	**General Sanitation Questions**	**Categories/Codes**
HH201	Does your household currently have a toilet facility?	01…Yes → *GO TO HH206* 02…No 99…Don't know → *GO TO HH203*
HH202	What is the primary reason that your household does not have a bathroom?	01…Cost 02…Too much work 03…Not enough available choices 04…Do not need/want a bathroom 05…Use a public bathroom (not located on your property) 06…Prefer open-air defecation → *GO TO HH204* 07…Lack of water 08…Having a bathroom can contaminate the water 88…Other, specify: _____ _____ 99…Don't know
HH203	Where do you go to the bathroom?	01…Open-air → *GO TO HH205* 02…River → *GO TO HH205* 03…Forrest/Mountain → *GO TO HH205* 88…Other, specify: → *GO TO HH205* _____ 99…Don't know → *GO TO HH601*

HH204	Why do you prefer open-air defecation?	_____ _____
HH205	How many minutes do you have to walk in order to find a private place for open-air defecation?	__ __ __ minutes → *GO TO HH601* 99…Don't know → *GO TO HH601*
HH206	In what month and year was your bathroom built? *(If they don't remember, probe)*	__ __ month ___ __ __ __ year
HH207	Is your toilet facility shared with other households?	01…Yes 02…No → *GO TO HH209* 99…Don't know → *GO TO HH209*
HH208	How many households share your toilet facility? *(If they don't know, probe)*	__ __ __ households 99…Don't know
HH209	What type of toilet facility does your household currently have?	01…Pit latrine 02…VIP latrine 03…Septic tank 04…Ecological bathroom *(please complete additional Ecological Sanitation module at conclusion of questionnaire)* 05…Flush toilet (sewage connection) 88…Other, specify: _____ _____ 99…Don't know
HH210	What improvements would you like in your bathroom?	_____ _____ _____
HH211	What type of material do you use for anal cleansing after going to the bathroom? *(Circle all that apply)*	01…Toilet paper 02…Newspaper 03…Other type of paper 04…Tree/Leaf 05…Nothing → *GO TO HH301* 88…Other, specify: _____ _____ 99…Don't know
HH212	After, what do you do with this material? *(Circle all that applied)*	01…Throw it in a can 02... Throw it in the garbage 03…Throw it in the same chamber 04…Burn it 05…Bury it 06…Collected by a garbage service 07…Throw it in the river 88…Other, specify: _____ _____ 99…Don't know
Nº	**Bathroom Use**	**Categories/Codes**
HH301	Please complete the following table *(based on the people currently living in your household)*: Number of adults (> 18 years old)…..... __ __ → How many of them use the bathroom?.....__ __ Number between 6 and 18 years..…..... __ __ → How many of them use the bathroom? ……....__ __ Number between 3 and 5 years.....__ __ → How many of them use the bathroom? ……....__ __ Number of children <3 years…..__ __ → How many of them use the bathroom? ……....__ __	

HH302	If someone in the household does not use the bathroom, why not? *(Circle all that apply)*	01…Do not know how to use it 02…Uncomfortable 03…Afraid of using it 04…Lack of custom 05…The seat is too high 06…Never at home 07…No door 08…Too many flies 09…Smells bad 10…The bathroom is located too far from the house 11…Prefer open-air defecation 12…Everyone in the household uses the bathroom 88…Other, specify: _____ 99…Don't know
HH303	What do you do with the feces of young children/babies?	01…Nothing 02…Throw it in the bathroom 03…Bury it 04…Throw it in the garbage 05…Does not care for a young child/baby 88…Other, specify: _____ 99…Don't know
Nº	**Participation**	**Categories/Codes**
HH401	Who participated in selecting your current bathroom? *(Circle all that apply)*	01…Respondent 02…Other head of household 03…Child 04…Local authorities 05…NGO/Aid Workers 06…Neighborhood group 07…Neighbors 08…Other, specify: _____ _____ 99…Don't know
HH402	What help did you receive in the construction of your current bathroom?	01…Materials and labor for the whole bathroom 02…Materials for the whole bathroom 03…Cash subsidy 04…Toilet and concrete base 05…Receive no help at all 88…Other, specify: _____ _____ 99…Don't know

HH403	Did you pay anything for the construction of your current bathroom?	01…Yes 02…No → *GO TO HH406* 03…Don't know → *GO TO HH406*
HH404	How much did you pay?	__ __ __,__ __ Bs
HH405	Do you think the price you paid for your current bathroom was fair?	01…Paid too much 02…Paid a fair price 03…Did not pay enough 88…Other, specify: _____ _____ 99…Don't know
HH406	Who participated in the construction of your bathroom? *(Circle all that apply; probe)*	01…Respondent 02…Other household head 03…Child 04…Local authorities 05…NGO/Aid workers 06…Neighborhood group 07…Neighbors 88…Other, specify: _____ _____ 99…Don't know
HH407	Are you in agreement with the location of your bathroom?	01…Yes 02…No 99…Don't know
HH408	Has the technical assistance you have received been sufficient? *(Read the answer choices)*	01…Very satisfied 02…Satisfied 03…Neither satisfied nor dissatisfied 04…Dissatisfied 05…Very dissatisfied
HH409	If you had not received technical assistance, would you still have a bathroom?	01…Yes 02…No 03…Depends on the price 99…Don't know
Nº	**Maintenance**	**Categories/Codes**
HH501	Who cleans the bathroom?	01…Respondent 02…Other household head 03…Child 04…A hired service 05…The bathroom has never been cleaned → *GO TO HH503* 88…Other, specify: _____ _____ _____ 99…Don't know
HH502	How often is your bathroom cleaned? *(If they don't know, probe)*	__ __ __ times/month 99…Don't know

HH503	Has your bathroom required any repairs since construction?	01…Yes 02…No → *GO TO HH601* 99…Don't know
HH504	Who repairs your bathroom?	01…Respondent 02…Other household head 03…Child 04…A hired service 88…Other, specify: _____ 99…Don't know
HH505	What type of repairs has your bathroom undergone? *(Circle all that apply)*	01…The roof 02…The door 03…The ventilation tube 04…The wall 05…The toilet seat 88…Other, specify: _____ 99…Don't know
Nº	**Agricultural Use**	**Categories/Codes**
HH601	Does your household practice home gardening? *(If necessary explain the difference between home gardening and field crops)*	01…Yes 02…No → *GO TO HH613* 99…Don't know → *GO TO HH613*
HH602	Do you use urine as fertilizer in your garden?	01…Yes 02…No → *GO TO HH606* 99…Don't know → *GO TO HH606*
HH603	Where do you obtain this urine?	01…Household 02…Neighbor 03…Purchased 88…Other, specify: _____ 99…Don't know
HH604	Who applies the urine as fertilizer to the home garden?	01…Respondent 02…Other household head 03…Child 04…A hired service 88…Other, specify: _____ 99…Don't know
HH605	How often is the urine applied as fertilizer to the home garden?	__ __ __ times/month 99…Don't know
HH606	Does your household use animal feces as fertilizer on your home garden?	01…Yes 02…No → *GO TO HH608* 99…Don't know → *GO TO HH608*
HH607	What type of animal feces do you use as fertilizer on your home garden? *(Read answer choices 01 and 02)*	01…Composted animal feces 02…Fresh animal feces 99…Don't know
HH608	Does your household use human feces as fertilizer for your home garden?	01…Yes 02…No → *GO TO HH613* 99…Don't know → *GO TO HH613*
HH609	What type of human feces do you use as fertilizer on your home garden? *(Read answer choices 01 and 02)*	01…Composted human feces 02…Fresh human feces 99…Don't know

HH610	Where do you obtain the human feces for fertilizer on your home garden?	01…Household 02…Neighbor 03…Purchased 88…Other, specify: _____ 99…Don't know
HH611	Who applies the human feces as fertilizer to the home garden?	01…Respondent 02…Other household head 03…Child 04…A hired service 88…Other, specify: _____ 99…Don't know
HH612	How often are the human feces applied as fertilizer to the home garden?	__ __ __ times/month 99…Don't know
HH613	Does your household have field crops? *(If necessary explain the difference between home gardening and field crops)*	01…Yes 02…No → *GO TO HH625* 99…Don't know → *GO TO HH625*
HH614	Does your household use urine as fertilizer for your field crops?	01…Yes 02…No → *GO TO HH618* 99…Don't know → *GO TO HH618*
HH615	Where do you obtain the urine for fertilizer for your field crops?	01...Household 02…Neighbor 03…Purchased 88…Other, specify: _____ 99…Don't know
HH616	Who applies the urine as fertilizer on your field crops?	01…Respondent 02…Other household head 03…Child 04…A hired service 88…Other, specify: _____ 99…Don't know
HH617	How often is urine applied as fertilizer to your field crops?	__ __ __ times/month 99…Don't know
HH618	Does your household use animal feces as fertilizer for your field crops?	01…Yes 02…No → *GO TO HH620* 99…Don't know → *GO TO HH620*
HH619	What type of animal feces are used as fertilizer on your field crops? *(Read answer choices 01 and 02)*	01…Composted animal feces 02…Fresh animal feces 99…Don't know
HH620	Does your household use human feces as fertilizer for your field crops?	01...Yes 02…No → *GO TO HH625* 99…Don't know → *GO TO HH625*
HH621	What type of human feces are used as fertilizer on your field crops? *(Read answer choices 01 and 02)*	01…Composted human feces 02…Fresh human feces 99…Don't know
HH622	Where do you obtain the human feces for fertilizer for your field crops?	01…Household 02…Neighbor

		03…Purchased 88…Other, specify: _____ 99...Don't know
HH623	Who applies the human feces as fertilizer for your field crops?	01…Respondent 02…Other household head 03…Child 04…A hired service 88…Other, specify: _____ 99…Don't know
HH624	How often are the human feces applied as fertilizer to your field crops?	__ __ __ times/month 99…Don't know
HH625	Does your household use urine as medicine?	01…Yes 02…No → *GO TO HH701* 99…Don't know → *GO TO HH701*
HH626	Who uses urine as medicine? *(Circle all that apply)*	01…Respondent 02…Other household head 03…Child 88…Other, specify: _____ 99…Don't know
HH627	How is the urine used as medicine?	_____ _____ _____
Nº	**Sanitation Attitudes and Preferences**	**Categories/Codes**
HH701	Are you satisfied with your current bathroom conditions? *(Read the answer choices)*	01…Very satisfied 02…Satisfied 03…Neither satisfied nor dissatisfied 04…Dissatisfied 05…Very dissatisfied
HH702	When you go to the bathroom, do you prefer to sit or squat?	01...Sit 02…Squat 03…Doesn't have a preference
HH703	What is your primary reason for wanting an improved bathroom? *(Read answer choices 01 through 08 to the respondent)*	01…Reduce flies in the compound 02…Reduce odor 03…Cleaner surroundings 04…Avoid the physical discomforts of open-air defecation 05…Avoid the dangers of the night 06…Protect against gastrointestinal diseases 07…Less embarrassment when friends visit 08…Privacy 99…Don't know
HH704	What are the other reasons for wanting an improved bathroom? *(Read answer choices 01 through 08 to the respondent, circle all that apply)*	01…Reduce flies in the compound 02…Reduce odor 03…Cleaner surroundings 04…Avoid the physical discomforts of open-air defecation 05…Avoid the dangers of the night 06…Protect against gastrointestinal diseases 07…Less embarrassment when friends visit

		08…Privacy 88…Other, specify: _____ 99…Don't know
Nº	**Marketing Specific Questions**	**Categories/Codes**
HH801	Would you be willing to pay for an improvement in sanitation conditions?	01…Yes 02…No 03…Depends on the price 99…Don't know
HH802	In what mode of communication do you trust when receiving health information? *(Circle all that apply)*	01…Radio 02…Television 03…Neighbor 04…Relatives 05…Through children/teachers 06…Community leadership 07… Poster/Flyer 08…Government officials 09…Doctor 88…Other, specify: _____ 99…Don't know
HH803	In what mode of communication do you trust when considering the purchase of a new household good or product? *(Circle all that apply)*	01…Radio 02…Television 03…Neighbor 04…Relatives 05…Through children/teachers 06…Community leadership 07…Poster/Flyer 08…Government officials 09…Doctor 88…Other, specify: _____ 99…Don't know
HH804	Where do you buy construction materials/clearing supplies?	01…Ferretería → *GO TO HH806* 02…Tienda → *GO TO HH806* 03…Mercado → *GO TO HH806* 04…Feria 88…Other, specify: → *GO TO HH806* _____ 99…Don't know → *GO TO HH806*
HH805	What days of the week are the ferias?	_____ _____
HH806	How many minutes do you have to travel to buy these things?	__ __ __ minutes

Is the answer to HH209 "04… Baño ecológico"? ☐Yes ☐No

If the answer is 'Yes', please complete the Ecological Sanitation Module
If the answer is 'No', thank the respondent for their time and participation

Ending Time: __ __: __ __
hour minutes

Ecological Sanitation Module

Nº	Ecological Sanitation Questions	Categories/Codes
HH901	Which of these problems with your ecological bathroom? *(Circle all that apply)*	01…Adding drying material (too difficult/hard to find) 02…Emptying the filled chamber 03…Cleaning the bathroom 04…The chambers are too full 05…The urine diversion design 06…Mixing the chamber 07…Odor 08…Flies 88…Other, specify: _____ 99…Don't know
HH902	Who trained you how to use the ecological bathroom?	01…Health promoter 02…Health Inspector 03…Community leader 04…Not trained → *GO TO HH904* 05…Project technician 88…Other, specify: _____ 99…Don't know
HH903	How long ago did you receive the training?	__ __ months __ __ years
HH904	What type of drying material do you use?	01…Dirt/sand 02…Ash 03…Lime 04…Sawdust 05…Corn husk 06…Nothing → *GO TO HH907* 88… Other, specify: _____ 99…Don't know
HH905	How often do you add this material to the chamber?	01…After each use 02…At least once a day 03...Rarely (less than once a day) 99…Don't know
HH906	How much drying material do you add each time (number of cups)?	01…One cup 02…Two cups 03…Three cups 04…More than three cups 99…Don't know
HH907	Do you have something for mixing the contents of the chamber?	01…Yes 02…No → *GO TO HH909*

		99…Don't know
HH908	How often do you mix the contents of the chamber in use?	01…Once a week 02…Once every two weeks 03…Once a month 04…Less than once a month 05…Never 99…Don't know
HH909	Do you use both chambers at the same time?	01…Only one at a time 02…Both at the same time → *GO TO HH911* 99…Don't know → *GO TO HH911*
HH910	If only one, how long do you use one chamber before changing to the other (in months)?	__ __ __ months 99…Don't know
HH911	Who empties the contents of the chamber?	01…Respondent 02…Other household head 03…Child 04…A hired service 05…Has never been emptied → *GO TO HH916* 88…Other, specify: _____ _____ 99…Don't know
HH912	What is done with the contents of the chamber once removed?	01…Discarded 02…Used for agricultural purposes → *GO TO HH915* 03…Sold → *GO TO HH914* 04…Given away → *GO TO HH915* 05…Buried → *GO TO HH915* 06…Collected by a garbage service → *GO TO HH915* 88…Other, specify: → *GO TO HH915* _____ _____ 99…Don't know → *GO TO HH915*
HH913	Where do you discard the contents of the chamber?	_____ _____ → *GO TO HH915*
HH914	How much do you receive for the contents of one chamber?	__ __ __ , __ __ Bs
HH915	At this time, does your household have a chamber that is filled and sealed off?	01…Yes 02…No → *GO TO HH917* 03…Has not yet filled a chamber → *GO TO HH918* 99…Don't know
HH916	**How many months has the filled chamber been closed and sealed off?** *(If they don't remember, probe)*	__ __ **months** **99…Don't know**
HH917	The last time you emptied the chamber, how many months were the contents stored before removal?	__ __ months 99…Don't know
HH918	Do you feel that the fertilizer generated from your ecological latrine is valuable in agricultural production? *(Read the answer choices)*	01…Yes 02…No 99…Don't know
HH919	During the rainy season, what happens to your ecological bathroom? *(Circle all that apply)*	01…Water enters the 'caseta' 02…The chamber floods 03…Nothing occurs 88…Other, specify: _____ 99…Don't know

Thank you for your time and participation!

Ending Time: __ __: __ __
hour minutes

Appendix C.2: Household Questionnaire and Informed Consent Form (Spanish)

--Encuesta Social –
Mantenimiento, Actitudes, y Uso de Sanitarios Familiares

Nombre de comunidad: _____ Código de comunidad: __ __ __

Entrevistador: _____ Fecha de entrevista: __ __ / __ __ / __ __
Nombre Apellido día mes año

Hora de empezar: __ __: __ __ Hora de terminar: __ __: __ __
hora minutos* hora minutos*

Instrucciones para el entrevistador: *Antes de empezar el cuestionario, lea al entrevistado la declaración de introducción que sigue en la caja después de este párrafo. Asegúrese que el entrevistado ha dado su consentimiento informado verbal antes de empezar el cuestionario. Lea cada pregunta claramente, permitiendo tiempo suficiente para responder. Donde es apropiado, circula la respuesta dado por el entrevistado. No lea las opciones de respuesta a menos que de otro modo instruido, incluyendo 'No Sabe' como una elección de respuesta; solo marca esta elección de la respuesta si usted encuentra que el entrevistado no sabe la respuesta a la pregunta dada. Instrucciones adicionales al entrevistador se proporcionan* ***en itálico*** *debajo de su pregunta correspondiente. Al fin de la entrevista, esté seguro dar gracias al entrevistado para su tiempo y participación.*

Declaración de Introducción y Consentimiento

Hola, me llamo _____, y estoy aquí por la parte de la Fundación Sumaj Huasi. que es una ONG Boliviana que trabaja desde el año 1998 a nivel nacional e internacional, con la misión de mejorar las condiciones de agua y saneamiento de las poblaciones más necesitadas. Actualmente estamos realizando un estudio acerca del saneamiento en la vivienda y quisiéramos que usted participe dándonos información referida al tipo de baño que utiliza dentro de su casa, y si no lo tuviera, del lugar donde hace habitualmente sus necesidades. La información que nos proporcione es muy valiosa para nosotros y nos servirá para planificar nuevos proyectos de mejor manera, si tiene un baño dentro de su casa también desearíamos realizar una revisión del mismo y en algún caso colectar una muestra de los residuos para examinar la presencia de posibles microbios y asegurarnos de que funciona apropiadamente.

Este cuestionario voluntario tomará aproximadamente 30 minutos y sus respuestas se quedarán ambos anónimo y confidencial. Usted no tiene que responder a ninguna pregunta que usted no quiere, y puede terminar el cuestionario en cualquier momento. Si tiene preguntas, favor de contactar Sumaj Huasi a 591-2-211-6098, contacto@sumaj.org. Si tiene preguntas acerca de sus derechos como participante del estudio, favor de contactar Colleen Dilorio, Institutional Review Board, Emory University, 0010-1-404-712-0720, irb@emory.edu.

¿Puedo empezar el cuestionario?

¿Da el entrevistado el consentimiento voluntario a tomar parte en esta encuesta?

☐ Si ☐ No

Nº	Demográficos	Categorías/Códigos
HH101	Determina la posición del entrevistado en la casa *(No necesita pregúntale exactamente)*	01…Jefa de familia - mujer 02…Jefe de familia - hombre 03…Jefe de familia – hijo mayor 04…Otro adulto en la casa
HH102	¿Cuantos años tiene?	__ __ __ años 99…No sabe
HH103	¿Con que grupo originario se identifica usted?	01…Aymara 02…Quechua 03…Mestizo 04…Chiquitano 05…Guaraní 06…Blanco 07…Afro-Boliviano 08…Oriental 88…Otro, especifique: _____ 99…No sabe
HH104	¿Cuantas personas viven en su casa en este momento?	__ __ __ personas 99…No sabe
HH105	¿Cual es la fuente principal de agua para beber y preparar sus alimentos en su casa?	01…Agua por red de cañería dentro la propiedad 02…Pileta pública en la escuela 03…Pileta pública afuera de su propiedad 04…Pozo (norija) abierto en su propiedad 05…Pozo (norija)abierto público 06…Bomba en su propiedad 07…Bomba pública 08…Manantial protegida 09…Manantial no protegida/rió/lago 10…Lluvia/zona de captación en el techo 11…Un Vendedor de agua 12…Agua en botella 13…No hay agua disponible 88…Otro, especifique: _____ 99…No sabe
HH106	¿Considera usted que el agua que usa es seguro para beber y preparar sus alimentos?	01…Si 02…No 99…No sabe
HH107	En el año pasado, ¿Cuántos meses eran de escasez de agua en su casa?	__ __ meses 99…No sabe

HH108	¿Qué tipo de techo tiene su casa?	01…Teja 02…Calamina 03…Paja 88…Otro, especifique: _____ 99…No sabe
HH109	¿Qué tipo de piso tiene usted en su casa?	01…Cemento 02…Ladrillo 03…Tierra 04…Madera 88…Otro, especifique: _____ 99…No sabe
HH110	¿Tiene electricidad en su casa?	01…Si 02…No 99…No sabe
HH111	¿Tiene una radio en su casa?	01…Si 02…No 99…No sabe
HH112	¿Tiene una televisión en su casa?	01…Si 02…No 99…No sabe
HH113	¿Tiene teléfono (tipo celular o fijo)?	01…Si 02…No 99…No sabe
HH114	¿Tiene un refrigerador en su casa?	01…Si 02…No 99…No sabe
HH115	¿Hasta que curso ha estudiado la mama o la jefa mujer?	__ __ curso 99…No sabe
HH116	¿Hasta que curso ha estudiado el papa o el jefe hombre?	__ __ curso 99…No sabe
Nº	**Preguntas Generales de Saneamiento**	**Categorías/Códigos**
HH201	¿Tiene su casa en este momento un baño?	01…Si → *IR A HH206* 02…No 99…No sabe →*IR A HH203*
HH202	¿Cual es la razón principal por la que no tiene un baño?	01…Precio 02…Cuesta bastante trabajo 03…No hay bastante elecciones disponibles 04…No necesita/quiere un baño 05…Usa un baño publico (no ubicado en su propiedad) 06…Prefiere defecación al aire libre → *IR A HH204* 07…Por falta de agua 08…Un baño puede contaminar al agua 88…Otro, especifique: _____ _____ 99…No sabe
HH203	¿Dónde hace sus necesidades?	01…Al aire libre → *IR A HH205* 02…Rio → *IR A HH205* 03…Monte → *IR A HH205* 88…Otro, especifique: →*IR A HH205* _____

		99…No sabe → *IR A HH601*
HH204	¿Por qué prefiere usted defecar al aire libre?	_____ _____
HH205	¿Cuantos minutos tiene que caminar para encontrar un lugar privado para defecar al aire libre?	__ __ __ minutos → *IR A HH601* 99…No sabe → *IR A HH601*
HH206	¿En que mes y año fue construido su baño? *(Si no recuerda, pregúntale mas de una vez)*	__ __ mes ___ __ __ __ año
HH207	¿Comparte el baño de su casa con otras casas o familias?	01…Si 02…No → *IR A HH209* 99…No sabe → *IR A HH209*
HH208	¿Cuantas casas comparten su baño? *(Si no sabe, pregúntale mas que una vez)*	__ __ __ casas 99…No sabe
HH209	¿Qué tipo de baño tiene su casa en este momento?	01…Pozo ciego 02…Letrina mejorada de pozo ventilado 03…Tanque séptico 04…Baño ecológico *(favor de cumplir la sección adicional sobre el Saneamiento Ecológico al fin del cuestionario)* 05…Alcantarillado 88…Otro, especifique: _____ _____ 99…No sabe
HH210	¿Qué mejoras quisiera en su baño?	_____ _____ _____
HH211	¿Qué material utilizan para la limpieza anal? *(Marcar todo lo mencionado)*	01…Papel higiénico 02…Papel del periódico 03…Otro tipo de papel 04… Árbol/Hoja 05…Nada → *IR A HH301* 88…Otro material, especifique: _____ _____ 99…No sabe
HH212	¿ Después, que hace con este material de la limpieza anal? *(Marcar todo lo mencionado)*	01…Lata 02...Cesto 03…En la misma cámara 04…Lo quema 05…Lo entierra 06…Colectado por un servicio de basura 07…Tira en el río 88…Otro, especifique: _____ _____ 99…No sabe
Nº	**Uso Actual**	**Categorías/Códigos**
HH301	Favor cumplir esta tabla *(sólo incluye la gente que actualmente vive en la casa)*: Número de Adultos (> 18 años de edad)..... __ __ → ¿Cuantos usan el baño?.....__ __ Número entre 6 y 18 años……..... __ __ → ¿Cuantos usan el baño? ……..__ __ Número de niños entre 3 y 5 años → ¿Cuantos usan el baño?	

HH302	¿Si alguien de la casa no usa el baño, por que? *(Circula todo mencionado)*	01…No sabe como usarlo 02…Incomodad 03…Tiene miedo de usarlo 04…Falta de costumbre 05…La taza es muy alta 06…Nunca esta en casa 07…No tiene puerta 08…Hay muchos vectores 09…Hay olor 10…El baño esta ubicado demasiado lejos de la casa 11…Prefiere defecación al aire libre 12…Todos de la casa usan el baño 88…Otro, especifique: _____ 99…No sabe
HH303	¿Que hace con las heces de los niños/bebes?	01…Nada 02…Echar en el baño 03…Enterrar 04…Botar a la basura 05…No cuida a un bebe/niño 88…Otro, especifique: _____ 99…No sabe
Nº	**Participación**	**Categorías/Códigos**
HH401	¿Quien participó en la selección de su baño? *(marcar todo lo mencionado, pregúntale mencionar toda la gente que participó)*	01…Entrevistado 02…Otro jefe de casa 03…Hijo 04…Autoridades locales 05…Aporte local 06…Junta vecinal 07…Vecinos 08…Otro, especifique: _____ _____ 99…No sabe
HH402	¿Que ayuda recibió en la construcción de su baño?	01…Materiales y mano de obra para todo del baño 02…Materiales para todo del baño 03…Subsidio de dinero en efectivo 04…Losa y taza 05…No recibió ninguna ayuda 88…Otro, especifique:

		_____ _____ 99…No sabe
HH403	¿Pagó algo para la construcción de su baño?	01…Si 02…No → *IR A HH406* 03…No sabe → *IR A HH406*
HH404	¿Cuanto pagó?	__ __ __,__ __ Bs
HH405	¿Le parece el precio justo?	01…Pagó demasiado 02…Pagó un precio justo 03…No pagó suficiente 88…Otro, especifique: _____ _____ 99…No sabe
HH406	¿Quien participó en la construcción de su baño? *(Marcar todo lo mencionado, pregúntale mencionar toda la gente que participó)*	01…Entrevistado 02…Otro jefe de casa 03…Hijo 04…Autoridades locales 05…Aporte local 06…Junta vecinal 07…Vecinos 88…Otro, especifique: _____ _____ 99…No sabe
HH407	¿Esta de acuerdo con la ubicación de su baño?	01…Si 02…No 99…No sabe
HH408	¿Ha sido suficiente la ayuda técnica que ha recibido? *(Lea las respuestas)*	01…Muy satisfecho 02…Satisfecho 03…Sin opinión 04…Insatisfecho 05…Muy insatisfecho
HH409	¿Si no hubiera recibido nada de ayuda técnica, tendría baño?	01…Si 02…No 03…Depende en el precio 99…No sabe
Nº	**Mantenimiento**	**Categorías/Códigos**
HH501	¿Quien hace la limpieza de su baño?	01…Entrevistado 02…Otro jefe de casa 03…Niño 04…Un servicio pagado 05…El baño nunca ha sido limpiado → *IR A HH503* 88…Otro, especifique: _____ _____ _____ 99…No sabe

HH502	¿Con que frecuencia limpia el baño? *(Si no sabe, pregúntale mas que una vez)*	__ __ __ veces/mes 99…No sabe
HH503	¿Ha requerido su baño cualquier reparación desde la construcción?	01…Si 02…No → *IR A HH601* 99…No sabe
HH504	¿Quien arregla su baño?	01…Entrevistado 02…Otra jefe de casa 03…Hijo 04…Un servicio pagado 88…Otro, especifique: _____ 99…No sabe
HH505	¿Qué tipo de reparación se ha realizado en su baño? *(Marcar todo lo mencionado)*	01…El techo 02…La puerta 03…El tubo de ventilación 04…La pared 05…La taza 88…Otro, especifique: _____ 99…No sabe
Nº	**Uso agrario**	**Categorías/Códigos**
HH601	¿Tiene su familia un jardín (o carpa) en su propiedad? *(Si es necesario, explique la diferencia entre un jardín en su patio y los cultivos que trabajan en el campo)*	01…Si 02…No → *IR A HH613* 99…No sabe → *IR A HH613*
HH602	¿Utiliza la orina como abono en su jardín en su propiedad?	01…Si 02…No → *IR A HH606* 99…No sabe → *IR A HH606*
HH603	¿De donde obtiene la orina?	01…Su propia familia 02…Vecino 03…Comprar 88…Otro, especifique: _____ 99…No sabe
HH604	¿Quién aplica la orina como abono al jardín en su propiedad?	01…Entrevistado 02…Otro jefe de casa 03…Hijo 04…Servicio pagado 88…Otro, especifique: _____ 99…No sabe
HH605	¿Con que frecuencia aplica la orina como abono al jardín en su propiedad?	__ __ __ veces/mes 99…No sabe
HH606	¿Utiliza las heces de ganado como abono en su jardín en su propiedad?	01…Si 02…No → *IR A HH608* 99…No sabe → *IR A HH608*
HH607	¿Que tipo de heces de ganado utiliza como abono en su jardín en su propiedad? *(Lea las respuestas 01 y 02)*	01…Heces secas de ganado 02…Heces frescas de ganado 99…No sabe
HH608	¿Utiliza las heces humanas como abono en su jardín en su propiedad?	01…Si 02…No → *IR A HH613* 99…No sabe → *IR A HH613*
HH609	¿Que tipo de heces humanas utiliza como abono en su jardín en su propiedad?	01…Heces secas de humanos 02…Heces frescas de humanos

	(Lea las respuestas 01 y 02)	99…No sabe
HH610	¿De donde obtiene las heces humanas para abono en su jardín en su propiedad?	01…Su propia familia 02…Vecino 03…Compra 88…Otro, especifique: _____ 99…No sabe
HH611	¿Quien aplica las heces humanas como abono en su jardín en su propiedad?	01…Entrevistado 02…Otro jefe de casa 03…Hijo 04…Servicio pagado 88…Otro, especifique: _____ 99…No sabe
HH612	¿Con que frecuencia aplica las heces humanas como abono en su jardín en su propiedad?	__ __ __ veces/mes 99…No sabe
HH613	¿Tiene en su propiedad cultivos? *(Si es necesario, explique la diferencia entre un jardín en su patio y los cultivos que trabajan en el campo)*	01…Si 02…No → *IR A HH625* 99…No sabe → *IR A HH625*
HH614	¿Utiliza la orina como abono en sus cultivos?	01…Si 02…No → *IR A HH618* 99…No sabe → *IR A HH618*
HH615	¿De donde obtiene la orina para abono en sus cultivos?	01...Su propia familia 02…Vecino 03…Compra 88…Otro, especifique: _____ 99…No sabe
HH616	¿Quien aplica la orina como abono en sus cultivos?	01…Entrevistado 02…Otro jefe de casa 03…Hijo 04…Servicio pagado 88…Otro, especifique: _____ 99…No sabe
HH617	¿Con que frecuencia aplica la orina como abono en sus cultivos?	__ __ __ veces/mes 99…No sabe
HH618	¿Utiliza las heces de ganado como abono en sus cultivos?	01…Si 02…No → *IR A HH620* 99…No sabe → *IR A HH620*
HH619	¿Que tipo de heces de ganado utiliza como abono en sus cultivos? *(Lea las respuestas 01 y 02)*	01…Heces secas de ganado 02…Heces frescas de ganado 99…No sabe
HH620	¿Utiliza las heces humanas como abono en sus cultivos?	01...Si 02…No → *IR A HH625* 99…No sabe → *IR A HH625*
HH621	¿Que tipo de heces humanas utiliza como abono en sus cultivos? *(Lea las respuestas 01 y 02)*	01…Heces secas de humanos 02…Heces frescas de humanos 99…No sabe

HH622	¿De donde obtiene las heces humanas para abono en sus cultivos?	01…Su propia familia 02…Vecino 03…Compra 88…Otro, especifique: _____ 99...No sabe
HH623	¿Quien aplica las heces humanas como abono en los cultivos?	01…Entrevistado 02…Otro jefe de casa 03…Hijo 04…Servicio pagado 88…Otro, especifique: _____ 99…No sabe
HH624	¿Con que frecuencia aplica las heces humanas como abono en los cultivos?	__ __ __ veces/mes 99…No sabe
HH625	¿Utiliza la orina como medicina?	01…Si 02…No → *IR A HH701* 99…No sabe → *IR A HH701*
HH626	¿Quien utiliza la orina como medicina? *(Marcar todo lo mencionado)*	01…Entrevistado 02…Otro jefe de casa 03…Hijo 88…Otro, especifique: _____ 99…No sabe
HH627	¿Como utiliza la orina como medicina?	_____ _____ _____
Nº	**Preferencias y Actitudes**	**Categorías/Códigos**
HH701	¿Está satisfecho usted con sus condiciones actuales de hacer sus necesidades? *(Lea las respuestas)*	01…Muy satisfecho 02…Satisfecho 03…Sin opinión 04…Insatisfecho 05…Muy insatisfecho
HH702	¿Cuando hace sus necesidades, prefiere sentarse en taza o acuclillar?	01...Sentarse en taza 02…Acuclillar 03…No tiene preferencia
HH703	¿Cual es su razón **principal** de querer mejores condiciones de hacer sus necesicdades? *(Lea las respuestas 01 hasta 08 al entrevistado)*	01…Reducir moscas en la vivienda 02…Reducir el olor 03…Una vivienda mas limpia 04…Evitar las molestias físicas de defecación al aire libre 05…Evitar los peligros de noche 06…Proteger contra las enfermedades gastrointestinales 07…Menos vergüenza cuando amigos visitan 08…Intimidad 99…No sabe
HH704	¿Cuales son **otras** razones de querer mejores condiciones de hacer sus necesidades? *(Lea las respuestas 01 hasta 08 al entrevistado, marcar todo lo mencionado)*	01…Reducir moscas en la vivienda 02…Reducir el olor 03…Una vivienda mas limpia 04…Evitar las molestias físicas de defecación al aire libre

		05…Evitar los peligros de noche 06…Proteger contra las enfermedades gastrointestinales 07…Menos vergüenza cuando amigos visitan 08…Intimidad 88…Otro, especifique: _____ 99…No sabe
Nº	**Preguntas para uso en Marketing**	**Categorías/Códigos**
HH801	¿Estaría usted dispuesto a pagar por una mejora en sus condiciones de hacer sus necesidades?	01…Si 02…No 03…Depende en el precio 99…No sabe
HH802	¿En que medio de comunicación confía usted cuando recibe información de la salud? *(Marcar todo lo mencionado)*	01…Radio 02…Televisión 03…Vecino 04…Parientes 05…A través de los niños/Profesor 06…Autoridades locales/Dirigentes 07…Afiches /Volantes 08…Oficiales del gobierno 09…Medico 88…Otro, especifique: _____ 99…No sabe
HH803	¿En que medio de comunicación confía usted para recibir información cuando esta considerando la compra de un bien o producto para la casa? *(Marcar todo lo mencionado)*	01…Radio 02…Televisión 03…Vecino 04…Parientes 05…A través de los niños/Profesor 06…Autoridades locales/Dirigentes 07…Afiches /Volantes 08…Oficiales del gobierno 09…Medico 88…Otro, especifique: _____ 99…No sabe
HH804	¿Donde compra sus materiales para la construcción y el mantenimiento de su baño??	01…Ferretería → IR A HH806 02…Tienda → IR A HH806 03…Mercado → IR A HH806 04…Feria 88…Otro, especifique: → IR A HH806 _____ 99…No sabe → IR A HH806
HH805	¿Qué días son las ferias?	_____ _____
HH806	¿Cuantos minutos tiene que viajar para comprar estas cosas?	__ __ __ minutos

A la pregunta HH209 es la respuesta “04… Baño ecológico”? ☐ Si ☐ No

Si la respuesta es ‘Si’, sigue al Modulo de Saneamiento Ecológico
Si la respuesta es ‘No’, dar gracias al entrevistado para su tiempo y participación

Hora de terminar: __ __: __ __
hora minutos

Módulo de Saneamiento Ecológico

Nº	Preguntas de Saneamiento Ecológico	Categorías/Códigos
HH901	¿Cuáles de estos problemas tiene con su baño ecológico? *(Marcar todo lo mencionado.)*	01…Echar material secante (cuesta tanto trabajo/es difícil encontrar) 02…Sacar las heces 03…Limpieza 04…Demasiado contenido en las cámaras 05…El diseño de taza separador de orina 06…Mezclar la cámara 07…Olor 08…Vectores 88…Otro, especifique: _____ 99…No sabe
HH902	¿Quién le enseñó como usar el baño ecológico?	01…Patrocinador de la salud 02…Inspector de la salud 03…Líder de la comunidad 04…Nadie le enseño → *IR A HH904* 05…Técnico del proyecto 88… Otro, especifique: _____ 99… No sabe
HH903	¿Hace cuánto tiempo que alguien le enseñó?	__ __ meses __ __ años
HH904	¿Qué materiales secantes echa en las cámaras?	01…Tierra/Arena 02…Ceniza 03…Cal 04…Aserrin 05…Cáscara de arroz 06…Nada → *IR A HH907* 88… Otro, especifique: _____ 99…No sabe
HH905	¿Con qué frecuencia echa este material secante a las cámaras?	01…Después de cada uso 02…Al menos una vez por día 03...Pocas veces (menos que una vez por día) 99…No sabe
HH906	¿Cuánto material secante echa cada vez que usa el baño (número de tazas)?	01…Uno taza 02…Dos tazas

		03…Tres tazas 04…Más de tres tazas 99…No sabe
HH907	¿Tiene algo para mezclar el contenido de la cámara?	01…Si 02…No →*IR A HH909* 99…No sabe
HH908	¿Con qué frecuencia mezcla el contenido de la cámara en uso?	01…Una vez por semana 02…Una vez por dos semanas 03…Una vez por mes 04…Menos que una vez por mes 05…Nunca 99…No Sabe
HH909	¿Usa ambas cámaras al mismo tiempo o solo una?	01…Solo una a la vez 02…Ambos al mismo tiempo → *IR A HH911* 99…No sabe → *IR A HH911*
HH910	¿Si solo usa una a la vez, cuantos meses usa una cámara antes de cambiar a la otra?	__ __ __ meses 99…No sabe
HH911	¿Quién saca las heces del baño?	01…Entrevistado 02…Otro jefe de casa 03…Hijo 04…Servicio pagado 05…No ha sido vaciado todavía → *IR A HH916* 88…Otro, especifique: _____ _____ 99…No sabe
HH912	¿Que hace con las heces secas de la cámara?	01…Desecha 02…Usa por agricultura → *IR A HH915* 03…Vende → *IR A HH914* 04…Da a otra persona → *IR A HH915* 05…Entierra → *IR A HH915* 06…Servicio de la basura → *IR A HH915* 88…Otro, especifique: → *IR A HH915* _____ _____ 99…No sabe → *IR A HH915*
HH913	¿Dónde desecha las heces secas de la cámara?	_____ _____ →*IR A HH915*
HH914	¿Cuánto dinero recibe por el contenido de una cámara?	__ __ __ , __ __ Bs
HH915	¿Tiene en este momento una cámara llena y sellada?	01…Si 02…No → *IR A HH917* 03…No todavía hemos llenado → *IR A HH918* 99…No sabe
HH916	**¿Hace cuantos meses cerró la cámara llena y empezó usar la otra cámara?** *(Si no recuerda, pregúntale mas que una vez)*	__ __ **meses** **99…No sabe**
HH917	¿Cuántos meses quedo el contenido en la cámara antes de sacar, la última vez?	__ __ meses 99…No sabe
HH918	¿Cree que el material seco de su baño ecológico tiene valor como abono? *(Lea las respuestas)*	01…Si 02…No 99…No sabe
HH919	¿En época de lluvia que pasa con su baño ecológico? *(Marcar todo lo mencionado)*	01…Entra el agua a la caseta del baño 02…Se inunda la cámara

		03…No pasa nada 88…Otro, especifique: _____ 99…No sabe