

Designing a Plan for Composting Toilets in Monteverde, Costa Rica

An Interactive Qualifying Project
Final Report



WPI

Submitted to the faculty of WORCESTER POLYTECHNIC INSTITUTE in partial fulfillment of the requirements for the Degree of Bachelor of Science

Submitted by:

Andrew Doucette
Michelle Amber Foote
Stephanie Salerno
Jacquelyn Valsamis

Submitted to:

Dr. Melissa Belz
Dr. Courtney Kurlanska
Worcester Polytechnic Institute



Gabriela McAdam
Monteverde Commission for
Resilience to Climate Change
(CORCLIMA)

March 1, 2019

This report represents the work of four WPI undergraduate students submitted to the faculty as evidence of completion of a degree requirement. WPI routinely publishes these reports on its website without editorial or peer review. For more information about the projects program at WPI, please see: <http://www.wpi.edu/Academics/Projects>

Abstract

Due to its lush cloud forests, many people in Monteverde, Costa Rica believe the region has an abundance of water. However, climate change and tourism are altering the region's water availability. Our sponsor, CORCLIMA, is dedicated to conserving water and reducing carbon emissions by using innovative technologies. The goal of this project was to aid CORCLIMA's water conservation efforts in Monteverde by determining the best design options for composting toilets and creating informational materials for use within the community. We surveyed community perceptions on composting toilets and visited various models installed throughout the region. With our findings and deliverables, CORCLIMA will be able to start a conversation about water scarcity and the benefits of composting toilets.

Creating a Plan for Composting Toilets in Monteverde, Costa Rica

Andrew Doucette (ME), Michelle Amber Foote (CHE), Stephanie Salerno (EVE), and Jacquelyn Valsamis (EVE)

Introduction

In order to protect water resources, the Monteverde Commission for Resilience to Climate Change (CORCLIMA) is focused on improving water management strategies. CORCLIMA is dedicated to conserving water and reducing carbon emissions by using innovative technologies, such as composting toilets. They aim to promote the use of composting toilets throughout the region. The purpose of this project is to assist CORCLIMA and the Monteverde community in achieving this goal by providing extensive research and informational materials on composting toilets.

Composting Toilets

The overarching idea behind composting toilets is ecological sanitation. The goal is to “close the loop” in the nutrient cycle by returning the nutrients found in human waste to the environment. By managing human waste naturally, ecological sanitation eliminates the need for traditional

wastewater treatment. Therefore, using a composting toilet in lieu of a flushing toilet reduces pollution and energy consumption, all while saving water. There are many different types of composting toilets adaptable for almost every living situation. The only requirements are to keep a proper balance of temperature, drainage, aeration, and ventilation.

While composting toilets are an effective option for reducing a person’s carbon footprint, there are many issues that need to be addressed in order for their use to be more widespread. One of the greatest challenges in the widespread use of this technology is society’s perception of composting toilets. People are deterred from the idea of composting toilets because of the social stigma related to the odor and idea of humanure in general (Branstrator, 2014). People are hesitant to use a new technology that challenges conventional beliefs. If these hesitations can be overcome, people may be more willing to use and install composting toilets.



[Team Photo]

Methodology

The goal of this project was to aid CORCLIMA’s water conservation efforts in Monteverde by determining the best design options for composting toilets and creating informational materials for use within the community. To achieve this most effectively, we were focused on the following objectives:

1. Understand the user experience of composting toilets already installed in Monteverde.
2. Assess the design characteristics of composting toilets already installed in Monteverde.

3. Understand perceptions about composting toilets in the community.
4. Develop and test informational materials for composting toilets in Monteverde.

We interviewed community members of Monteverde who already own or have built composting toilets to compile data on various models. Learning about the current owners' personal experiences provided a clearer understanding of how the composting toilets were built, how they are maintained, the origin of the design, and factors that lead to both success and failure.

Our observations were organized and analyzed to create a design metric. The metric compared both quantitative and qualitative data to determine the best designs for Monteverde.

The opinions of the local residents needed to be understood to uncover root causes of a potential social stigma surrounding composting toilets. This was accomplished through free listing at various locations throughout Monteverde. Even if an excellent technical design is found and suggested, if community members do not want to use it, then all of the technical research proves pointless.



[A picture of a dry composting toilet]

Findings

Our findings cover two main themes related to the success of composting toilets in the Monteverde region: community awareness and design specifications. Community awareness includes both the lack of knowledge and misconceptions about composting toilets among Monteverde residents. Design specifications emphasize the individuality of each composting toilet system, while also addressing the essential features to include in every design.

Community Awareness

Through analysis of our free listing responses, we found that **many Monteverde residents had never heard of composting toilets.** When we asked residents what they think of when they hear the phrase "composting toilet," 48% of fifty respondents answered that they did not know.

With further analysis of our free listing responses, we found that **many residents had misconceptions about composting toilets.** Twelve percent of the respondents had inaccurate or negative responses to the prompt. Eight percent of participants responded that composting toilets are unsanitary and another 4% of respondents felt overall negative connotations with the phrase. Because people are unaware of composting toilets, they are unable to distinguish the difference between composting toilets and latrines. This gap in knowledge leads people to form misconceptions because they have no prior knowledge about composting toilets to base their opinions on.

**Composting Toilets
reduce toilet water
usage by**

100%

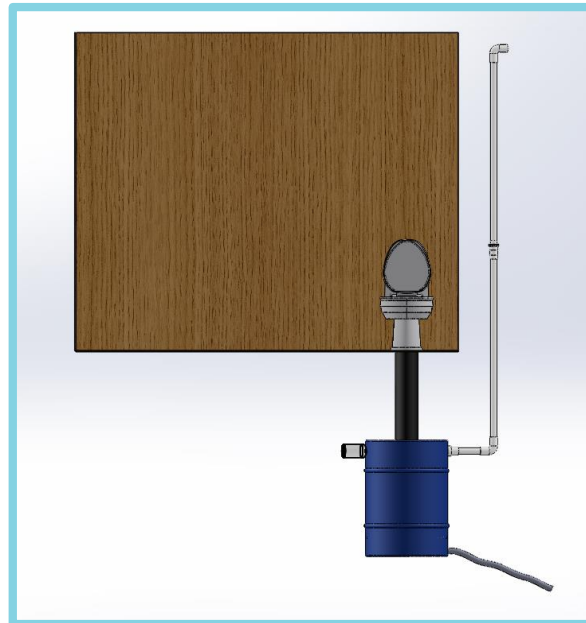
Design Specifications

Based on our seven interviews with composting toilet owners and builders, **these five aspects are fundamental for building any composting toilet in Monteverde:**

- Maintenance
- Urine Diversion
- Ventilation
- Appearance
- Distance from Waste

The importance of these aspects was tracked based on the frequency of how often they were mentioned during the various interviews.

During our interviews with composting toilet owners, builders, and owner-builders, we saw a variety of designs. The design of each composting toilet varied depending on the location. Composting toilets inside family homes, outside hiking shelters, and on farms each had unique design specifications. **While there were a set of standard features across all of the designs, we discovered that each owner or builder had different opinions on the best design for a composting toilet.** These features are dependent on the needs of the owner.



[A CAD representation of our design]

Our design was based on 14 different design characteristics obtained from interview and field observation data. We prioritized using materials that can be purchased locally. This design is a base model that additional features can be added to.

Recommendations

Our deliverables aim to start a conversation among the community members of Monteverde so that they acknowledge better potential water supply management practices, such as installing a composting toilet. They also serve as a resource for people who want

to install this technology but do not know where to begin.

Based on the areas of need, we recommend the following deliverables:

- Design proposal
- Instructional manual
- Promotional video
- Informational brochure
- Blog Post

Opportunities

With more time, we could have built a prototype of our design in a public space to expose local residents to composting toilets, showcasing their similarities to conventional toilets. It would also help create a conversation about water scarcity and how flushing toilets waste water. Additional time would have allowed us to test our instructional manual to make it easier to understand and modify our final design.

Conclusion

Although the installation of composting toilets will not single-handedly erase the issues of water scarcity in the Monteverde region, it is our hope that our design proposal and deliverables will have a positive impact on the community.

Acknowledgements

We would like to thank everyone who took the time to help us with our project during our time in Monteverde. Our project would not have been possible without the help of our Interactive Qualifying Project advisors, Dr. Melissa Belz and Dr. Courtney Kurlanska. We would especially like to thank our sponsor, Gabriela McAdam, for her continuous guidance and feedback throughout our seven weeks in Monteverde. In addition, we would like to extend our gratitude to everyone who participated in our interviews and surveys.



Table of Contents

Abstract	i
Executive Summary.....	ii
Acknowledgements.....	v
List of Figures.....	viii
Authorship	ix
Background	1
Introduction.....	1
Contributing Factors to Water Scarcity in Monteverde	1
Current Water Conservation Efforts in Monteverde.....	2
Composting Toilets	3
How they work	4
Challenges of Composting Toilets	6
Odor, Moisture, & Pathogens	7
Social Acceptance	7
CORCLIMA	8
Methodology.....	8
Objective 1: Understand the user experience of composting toilets already installed in Monteverde.....	8
Interviews with Composting Toilet Owners and Builders	8
Objective 2: Assess the design characteristics of composting toilets already installed in Monteverde.....	9
Field Observation	9
Evaluating Designs	10
Objective 3: Understand perceptions about composting toilets in the community.....	10
Free Listing	11
Objective 4: Develop informational materials for composting toilets in Monteverde.....	11
Instructional Manual	11
Videography	12
Informational Brochure and Blog Post	12
Results, Discussion, and Recommendations	12
Findings	12
Community Awareness	12
Finding 1. Many people in the Monteverde community are unaware of what composting toilet systems are.	12
Finding 2. Some local residents hold negative opinions towards composting toilets due to misconceptions.....	13

Design Specifications	15
Finding 3. The composting toilet design most suitable for the Monteverde region should focus on five design aspects.....	15
Maintenance	16
Urine Diversion	16
Ventilation.....	17
Appearance.....	17
Distance from Waste.....	17
Finding 4. Certain composting toilet design specifications need to be selected on an individual basis because each system has a unique set of circumstances.	18
Recommendations	19
Design Proposal	19
Instructional Manual	20
Promotional Video	20
Informational Brochure	21
Limitations	21
Conclusion	21
References	22
Appendices	26
Appendix A. Objective 1 Interview with Composting Toilet Owners.....	26
Appendix B. Objective 1 Interview with Composting Toilet Builders	29
Appendix C. Objective 2 Field Observation.....	31
Appendix D. Frequency of Design Aspect Mentions in Interviews	33
Appendix E. Objective 3 Survey for Monteverde Institute	34
Appendix F. Free Listing Data for First Prompt.....	36
Appendix G. Free Listing Data for Second Prompt.....	39
Appendix H. Informed Consent for Video Recording	40
Appendix I. Instructional Manual	41
Appendix J. Informational Brochure.....	71
Appendix K. Blog Post.....	73

List of Figures

Figure 1. Ecological Sanitation Cycle.....	3
Figure 2. Clivus Multrum Pedestal.....	4
Figure 3. Schematic of a Central Composting System.....	5
Figure 4. Types of Composting Toilets.....	6
Figure 5. Design Aspect Category Tree.....	10
Figure 6. Community opinions about composting toilets.....	13
Figure 7. Misconceptions about composting toilets.....	14
Figure 8. Design characteristics mentioned during interviews.....	15
Figure 9. Composting toilet with blacked-out bowl.....	18
Figure 10. Comparison of Composting Toilet Design Specifications.....	19

Authorship

<i>Section</i>	<i>Writing</i>
Abstract	All
Executive Summary	All
Acknowledgements	All
Background	
Introduction	All
Water Scarcity	Amber Foote
Contributing Factors	Amber Foote
Flushing Toilets	Andrew Doucette
Current Efforts	Andrew Doucette
Composting Toilets	Andrew Doucette
Ecological Sanitation	Stephanie Salerno
How they work	Stephanie Salerno & Jacquelyn Valsamis
Types of Composting Toilets	Jacquelyn Valsamis
Challenges	Jacquelyn Valsamis
CORCLIMA	All
Methodology	
Objective 1	Jacquelyn Valsamis
Interviews with Composting Toilet Owners and Builders	Amber Foote & Stephanie Salerno
Objective 2	Amber Foote
Field Observation	Stephanie Salerno
Create an Evaluation Metric	Amber Foote & Jacquelyn Valsamis
Objective 3	Jacquelyn Valsamis
Free Listing	Jacquelyn Valsamis
Surveys	Jacquelyn Valsamis
Objective 4	All
Videography	Andrew Doucette
Brochures and Blog Post	Amber Foote & Jacquelyn Valsamis

Instructional Manual	Stephanie Salerno
Pilot Testing	Amber Foote & Stephanie Salerno
Results, Discussion, and Recommendations	
Finding 1	Amber Foote
Finding 2	Andrew Doucette
Finding 3	Stephanie Salerno & Jacquelyn Valsamis
Maintenance	Stephanie Salerno
Urine Diversion	Jacquelyn Valsamis
Ventilation	Jacquelyn Valsamis
Appearance	Amber Foote
Distance from Waste	Andrew Doucette
Finding 4	Stephanie Salerno
Recommendation 1	Andrew Doucette
Recommendation 2	Jacquelyn Valsamis
Recommendation 3	Amber Foote
Recommendation 4	Stephanie Salerno
Limitations	Andrew Doucette & Stephanie Salerno
Conclusion	Andrew Doucette
Appendices	All

All editing was done as a team and all members contributed equally.

Background

Introduction

Despite 70% of the Earth being covered in water, water scarcity is a global challenge. At the turn of the 21st century, nearly four billion people faced some degree of water scarcity (Eisner & Florke, 2016). By 2025, it is estimated that 1.8 billion people will experience absolute water scarcity and two-thirds of the global population will experience water shortage (United Nations, 2018). In particular, Central America has experienced a steep increase in water scarcity since the 1960s largely due to sporadic weather caused by climate change (Eisner & Florke, 2016).

When thinking about climate change, one's first thought is not the bathroom. It may not even be the tenth thought. However, using the bathroom has significant impacts on the planet. When a toilet is flushed, water is wasted in the transportation process as well as in the treatment and disposal of human waste. During this process, energy is also wasted transporting and treating the water. Instead of flushing human waste, what if it were reused? In Monteverde, Costa Rica, people are exploring this opportunity.

Due to the cloud forests and its lush, green landscapes, many people believe that Monteverde has abundant water resources. However, this is not true. In order to protect water resources, Monteverde is focused on improving its water management strategies. Recent studies have shown success using composting toilets for water conservation in tropical environments similar to Monteverde (SOIL, 2011). The Monteverde Commission for Resilience to Climate Change (CORCLIMA) is dedicated to conserving water and reducing carbon emissions by using innovative technologies, such as composting toilets. They aim to promote the use of composting toilets throughout the region. The purpose of this project is to assist CORCLIMA and the Monteverde community in achieving this goal by providing extensive research and informational materials on composting toilets.

In this chapter, we begin by exploring the contributing factors of water scarcity and how composting toilets could help to combat the situation. We then describe ecological sanitation and identify challenges of composting toilets. In our second chapter, we highlight specific methods employed to achieve each of our outlined objectives. Our third chapter focuses on the findings from our fieldwork in Monteverde. Based off of our findings, we developed five recommendations for CORCLIMA that are outlined in the final chapter.

Contributing Factors to Water Scarcity in Monteverde

The four critical contributing factors to water scarcity in Monteverde are climate, geography, tourism, and inefficient water use. Monteverde is known for its tropical climate, which experiences both wet and dry seasons. The wet season typically lasts from June to November and the dry season lasts from December to May. Irregular rainfall between the two seasons further exacerbates water scarcity issues. With an average of four inches of rainfall in the dry season, but thirteen inches of rainfall in the wet season, Monteverde depends heavily on water storage throughout its dry months (Anchukaitis & Evans, 2010).

The Monteverde region's unique topography creates complex water supply issues. Monteverde is located just west of Costa Rica's continental divide at an elevation of nearly 5,000 feet above sea level. Many watersheds begin in the high elevation of the Monteverde Cloud Forest Reserve and flow down to communities located throughout the region (Rhodes et al., 2004). Water

is taken from these springs and streams for potable drinking water and irrigation (Bernes, VanDusen, & Welch, 2016). Communities located further downstream on the Pacific slope receive 2.5 times less rainfall than Monteverde, and therefore rely on the Monteverde watersheds for their water supply. The increased demand for water at the top of the watershed results in drier stream flows at lower elevations (Rhodes et al., 2004). In the middle to lower parts of the watershed, river levels drop to about 25% of their normal levels (Porras & Miranda, 2005). Toward the end of the dry season, the Guacimal River, one of the region's main watersheds, is reduced to a fraction of its original size by the time it reaches the Gulf of Nicoya. Furthermore, changes in precipitation and infiltration patterns impact the groundwater supply, decreasing the amount of stored water. Local water associations have been investing in water storage to help mitigate water supply concerns. However, these strategies may not be enough to satisfy the demand in the long term (Bernes et al., 2016).

Tourism further exacerbates water scarcity in Monteverde. The region is well-known as "an ecotourism destination that was founded on ideals of conservation," (Brown, 2008) drawing in 200,000 tourists annually (Guswa & Rhodes, 2007). Since the most popular time to visit Monteverde tends to be December through April, the tourist season overlaps with the dry season (Guswa & Rhodes, 2007). This simultaneous occurrence creates complex challenges for the local community attempting to manage their water resources. Tourists are often less aware of the water shortage and therefore tend to consume more water than the 6,750 residents of Monteverde (Monteverde Travel Guide, 2018).

Inefficient water use serves as one of the leading contributing factors to water scarcity in Monteverde (Mcknight, 2014). Both residents and tourists could adopt a more sustainable mindset to adjust their daily water consumption. About 8% of the world's water supply is used for health and sanitation reasons but there are certain modifications people can make to lessen their water footprint (Curry, 2010).

Along with other water uses, flushing toilets can produce detrimental effects on water storage levels in communities that suffer through dry seasons or droughts. A study was conducted in Melbourne, Australia on individual and household water usage during a drought, which had similar impacts to those experienced during the dry season in Monteverde (Welch, 2008). It was discovered that approximately 19% of the water used in each home was due to flushing toilets. On average, most households flushed their toilet over 2,300 times a month; each of these flushes wasted approximately 6 to 12 liters of water (Gato-Trinidad, 2011). Assuming a mean liters per flush of 9 liters, the water used per month from flushing the toilet alone would be approximately 20,700 liters. Even the majority of sustainable toilets use over 3 liters per flush, which still wastes at least 6,900 liters per month (Viola, 2009). A large amount of water is wasted through flushing toilets, which contributes to the water scarcity problem currently affecting Monteverde during the dry season.

Current Water Conservation Efforts in Monteverde

Although Monteverde is being threatened by water scarcity, the community has taken steps towards finding possible solutions to the problem, such as rainwater collection systems and artificial wetlands. Rainwater collection systems have been implemented around the Monteverde community. These systems work by adding channels to a roof that the rainwater can flow down into a pipe where it gets stored in water tanks for future use. The Centro de Educación Creativa in Monteverde is currently using these systems on the roofs of all of their school buildings and administrative offices and predict reducing their total annual water consumption by 35%

(Monteverde Community Fund, 2019). Similarly, the Monteverde Institute collects rainwater and stores it in tanks so that it can be used in toilets later on (Monteverde Institute, 2018). Unfortunately, these rainwater collection systems are a seasonal solution. The water tanks hold limited amounts of water, so once the dry season starts and they are not filled regularly from rainfall, their effectiveness decreases drastically.

The reuse of greywater, which is semi-clean water that was previously used in sinks, baths, and other appliances, serves as a practice to combat water scarcity in Monteverde. Although treated greywater is not safe to drink, local environmental organizations, such as CORCLIMA, teach people how it can be used for applications such as watering a garden or in toilets (CORCLIMA, 2017). To treat greywater, artificial wetlands are utilized to filter harmful material. They are both low cost and low maintenance, making them a viable option for most locations (Avellán, 2019). Artificial wetlands researched in Monteverde have been found to be effective at removing contaminants. Research showed this treated greywater was safe for irrigation and other uses (Dallas, 2005). By using artificial wetlands, carbon emissions are reduced because it eliminates the need for water treatment in industrial centers, which require a significant amount of electricity.

Composting Toilets

While both greywater reuse and rainwater collection systems reduce the amount of water consumed by the residents of Monteverde, another solution to help combat water scarcity is the use of composting toilets. Although the vast majority of people living in Monteverde have standard toilets with septic systems, some composting toilets have already been implemented across the community to conserve water resources.

Ecological Sanitation

The overarching concept behind composting toilets is ecological sanitation (eco-san). Eco-san is an approach to sanitation that aims to save water, eliminate pollution, and “return the nutrients in human excreta to the soil” (Winblad, U., & Simpson-Hebert, M., 2004, p. III). The idea is to “close the loop” in the nutrient cycle, as depicted in the figure below.

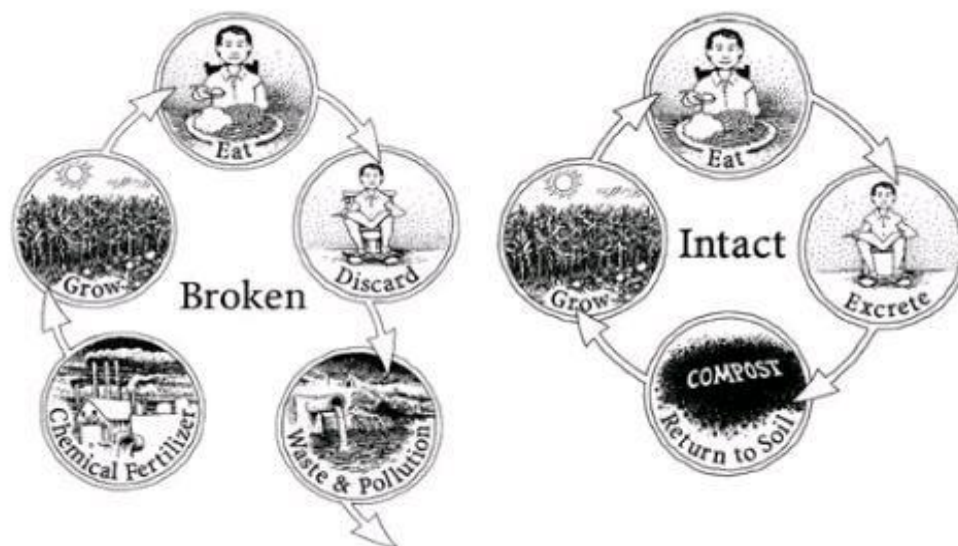


Figure 1. The Ecological Sanitation Cycle (Jenkins, 1999)

Eco-san turns human waste into a resource for agriculture. The term human waste describes human excreta, specifically fecal matter and urine. Once the human waste is composted, it can be used for fertilizer called humanure. Before composting, human excreta is a pollutant that threatens public health. As humanure, human excreta is transformed into a beneficial resource (Jenkins, 1999).

There are many benefits to an eco-san approach to sanitation. Eco-san reduces the health risks associated with sanitation and contaminated water. By providing an alternative treatment process, it prevents surface and groundwater contamination that can result when human waste enters water sources (Werner & al., 2003). When the nitrogen and phosphorus naturally present in human excreta are returned to the soil, it helps promote healthy soil fertility and increases the water storage capacity of the soil (Trueworthy et al., 2017). Finally, it optimizes the management of nutrient and water resources (Werner & al., 2003). Although some people may choose to use the humanure for agriculture, there is a risk of transferring pathogens (Branstrator, 2014). Despite the risk, humanure is greatly beneficial for agriculture and mitigating water scarcity (SOIL, 2011).

The concept of eco-san is not a modern concept. In ancient China, people would store their waste in ceramic bowls for long periods of time to create fertilizer, called night soil, for their fields. These ceramic bowls are considered the first composting toilets (EnviroToilets, 2018). Modern composting toilets are more advanced, but the basic process of composting has not changed significantly. The first modern composting toilet, known as the Clivus Multrum, was invented in 1939 in Sweden. Since the invention of the Clivus Multrum, the design and function of composting toilets has “changed little in principle” (Branstrator, 2014, p. 13).



Figure 2. Clivus Multrum Pedestal (Clivus Multrum, n.d)

How they work

Composting toilets have two main parts, the toilet itself and the composting compartment(s). All composting toilet designs require little to no water. Instead of relying on water to move the excreta, composting toilets utilize gravity. Depending on the design, the composting tank can perform different functions, but the waste is broken down aerobically in all tanks, sometimes with the assistance of earthworms (Baldwin & Hill, 2012). Due to the high nitrogen content of human excreta, users must add supplemental materials such as sawdust, lime, food waste, or leaves to aid in the composting process (Green Building Alliance, 2016). The additives adjust the carbon to nitrogen ratio in the tank in order to homogenize the compost (Anand & Apul, 2014).

To be most effective, composting toilets require a proper balance of temperature, drainage, aeration, and ventilation. At high temperatures, the composting process occurs faster and pathogens are killed. Without proper drainage, liquids may prevent the compost from retaining heat (Green Building Alliance, 2016). Liquids also hinder the aerobic conditions necessary for proper composting. To further maintain aerobic conditions, enough air must cycle throughout the compost pile. Proper aeration speeds up the composting process and prevents odor. Vents and fans allow oxygen to enter the containment chamber and prevent odors from leaving the room where the toilet is located (Green Building Alliance, 2016). When maintained properly, composting toilets can reduce the original volume of waste by 10 to 30% (United States Environmental Protection Agency, 1999).

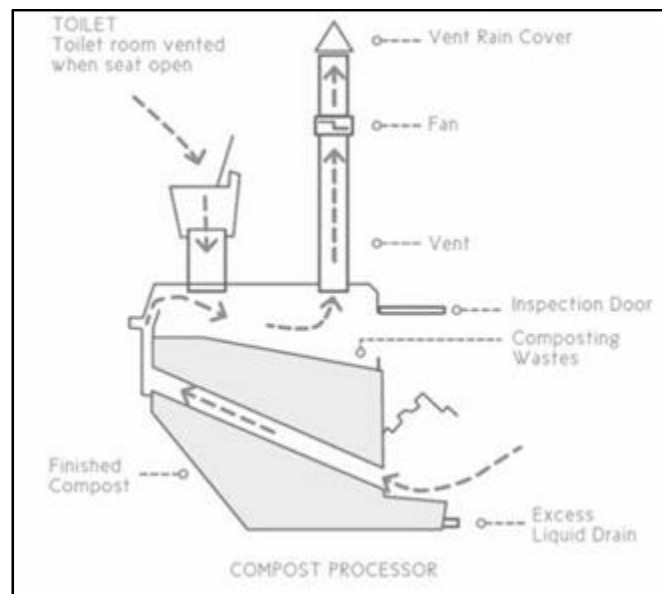


Figure 3. Schematic of a Central Composting System (Clivus Multrum, 2018)

There are two major benefits specific to composting toilets: reduced water use and on-site waste treatment. Since composting toilets require little to no water, they can be disconnected from the water supply and the wastewater infrastructure (Anand & Apul, 2014). The current water infrastructure in most developed countries produces potable water for all uses. This means that toilet water is the same quality as drinking water (Anand & Apul, 2014). By eliminating the need for water all together, composting toilets save the energy used to treat toilet water. Furthermore, the excreta is often treated on-site, so it does not need to be transported to a wastewater treatment facility. This eliminates the need for excess water and energy used in wastewater transportation and treatment. It also prevents excess water loss from aging infrastructure that often leaks or breaks (Anand & Apul, 2014). Therefore, composting toilets reduce stress on water resources as well as municipal infrastructure.

Types of Composting Toilets

There are many different types of composting toilets adaptable for almost any living situation. The two main categories, self-contained and central, vary with how the waste is collected and stored. In self-contained systems, the waste is composted in a bin within the toilet itself (Anand & Apul, 2014). Central composting systems require the waste be transported through a pipe to a bin in a different location. Central composting systems are ideal for when there are multiple toilets

in the house and the user wishes to have all the compost located in one container (Anand & Apul, 2014). After choosing between a self-contained or central composting system, the systems can contain a variety of features. There are five feature categories outlined in the figure below. The selection of features depends on the user's preferences and living situation.

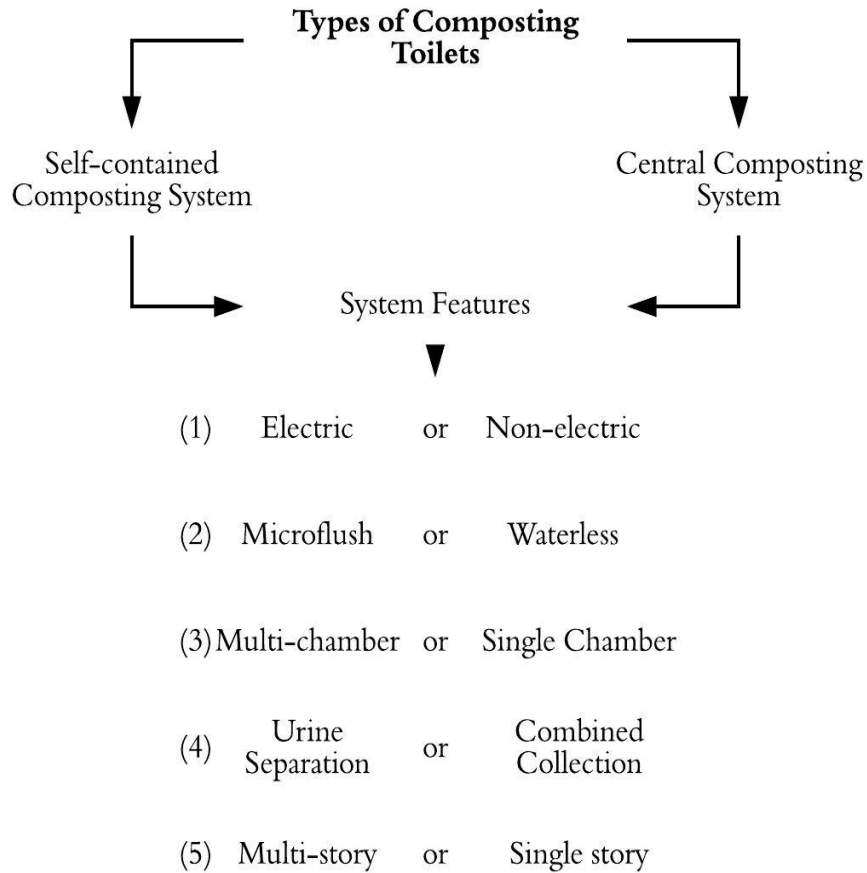


Figure 4. Types of Composting Toilets (Valsamis, 2018)

Challenges of Composting Toilets

While composting toilets are an effective option for reducing a person's carbon footprint by conserving water, there are many issues that need to be addressed in order for their use to be more widespread. These challenges include maintainability, odor, moisture, pathogens, and social acceptance.

Maintainability

One of the main reasons why many people have not switched to composting toilets is because of the maintenance associated with them (Anand & Apul, 2014). After using a flushing toilet, the user no longer has a responsibility to the waste. Flushing toilets require minimal maintenance by the users. The majority of the maintenance associated with flushing toilets is to clean it regularly and occasionally unclog it. However, composting toilets require more overall maintenance: materials must be added, the compost must be turned in the bin every few months,

and the bin must be emptied when it becomes full (Jenkins, 1999). There is also the issue of what happens to the waste after it is collected in the composting bin. In some cases, it can be composted on site and used later. However, some designs, specifically certain self-contained units, require the waste to be transported off-site to be composted (SOIL, 2011).

Odor, Moisture, & Pathogens

Unlike flushing toilets, there are other factors to be conscious of when owning a composting toilet. Because there is no water involved, waste material may remain in the toilet bowl. This can create an odor that people often associate with composting toilets, which drives many people away from using them (Branstrator, 2014). Bad odor is associated with something being unclean and therefore deters people (Branstrator, 2014). Odor problems can be mitigated by adding a ventilation fan or herbs and chemicals to mask the scent (Anand & Apul, 2014).

Excessive amounts of moisture in composting toilets can also result in odor. Microflush toilets use small amounts of water or foam to flush and therefore can reduce the odor in the toilet basin (Anand & Apul, 2014). However, too much liquid can disrupt the composting process in the holding bin. Urine, which is present in both microflush and waterless toilets, can also interrupt the composting process. This can be reduced by adding sawdust or ash, to the bin to absorb any excess liquid. There are also urine-diverting toilet designs that separate the urine from the rest of the waste into a separate container (Lienert & Larsen, 2010).

Lastly, potential spread of pathogens is a concern that must be addressed in all toilet designs. If the proper temperature and moisture content are not maintained, then any harmful bacteria present will not be killed (Baldwin & Hill, 2012). The diseases associated with human excreta that are most concerning in composting toilets are “amebiasis, cholera, cryptosporidiosis, gastroenteritis, infectious hepatitis, parasite-related disease, salmonellosis, shigellosis, typhoid fever, and other diarrheal diseases” (Branstrator, 2014, p. 25). Certain designs address this while others are too simple to tackle the problem. This is a concern for farmers and homeowners with gardens because the humanure cannot be used for food production. In order to prevent the spread of pathogens, humanure must sit for several months to a year to be safe to handle. If the toilet experiences a malfunction or the humanure is not stored properly, the humanure will not be safe to use. Unsafe compost is a result of “poor design, overuse, insufficient maintenance, low temperatures, anaerobic conditions, and excessive urine” (Branstrator, 2014, p. 46). It is also important that the composting bin is kept sealed and free of vermin to prevent any potential spread of disease (Branstrator, 2014).

Social Acceptance

One of the greatest challenges in the widespread use of composting toilets is society’s perception of composting toilets. This deters people from the idea of composting toilets because of the social stigma related to the odor and idea of humanure in general (Branstrator, 2014). A potential cause of this negative perception is that society has advanced to a point where “the ability to separate oneself from waste and excrete has [become] a symbol of social status” (Branstrator, 2014, p. 30). Human excreta is considered a waste that needs to be disposed of by someone else, rather than a resource for agriculture (Branstrator, 2014). A shift is needed in society’s perceptions of human waste in order for it to be seen as a resource.

Ecological sanitation experts have found that people are less hesitant about repurposing human waste when “they witness first-hand a well-managed [composting] toilet system” (Branstrator, 2014, p. 31). Composting toilets are routinely compared to latrines, which do not

meet the standards of living for many people. Once users see that a composting toilet is not like a latrine, they are more willing to use it (Branstrator, 2014). This initial reluctance to use composting toilets could potentially stem from “a lack of education, poor past experience, no past experience” and many other factors (Branstrator, 2014, p. 33). People are hesitant to use a new technology that challenges conventional beliefs. If these hesitations can be overcome, people may be more willing to use and install composting toilets.

CORCLIMA

The Monteverde Commission for Resilience to Climate Change (CORCLIMA) was established in 2016 to unite both public and private efforts to take action against climate change. The organization consists of nine commission members. Their mission is to “unite efforts in Monteverde to lower emissions, capture carbon and adapt to climate change.” CORCLIMA’s mission follows that of Costa Rica’s National Climate Change Strategy, created in 2009, with the ultimate goal of becoming a “carbon neutral” economy by 2021 through mitigating and adapting to climate change by addressing energy, agriculture and land use, consumption and waste, as well as reducing the vulnerabilities of the citizens. CORCLIMA has asked us to help by determining the best options for composting toilets in Monteverde and promoting their use within the community. By implementing sustainable technologies in the community, CORCLIMA will achieve their goals to reduce waste and adapt to the changing climate (CORCLIMA, 2017).

Methodology

The goal of this project was to aid CORCLIMA’s water conservation efforts in Monteverde by determining the best design options for composting toilets and creating informational materials for use within the community. To achieve this most effectively, we were focused on the following objectives:

1. Understand the user experience of composting toilets already installed in Monteverde.
2. Assess the design characteristics of composting toilets already installed in Monteverde.
3. Understand perceptions about composting toilets in the community.
4. Develop and test informational materials for composting toilets in Monteverde.

Objective 1: Understand the user experience of composting toilets already installed in Monteverde.

Interviewing community members of Monteverde who already own or have built composting toilets gave us the opportunity to compile data on various models, including how well they work. Learning about the current owners’ personal experience provided a clearer understanding of how the composting toilets were built, how they are maintained, the origin of the design, the motivation behind its implementation, and factors that lead to both success and failure.

Interviews with Composting Toilet Owners and Builders

We conducted seven interviews with community members who had already installed composting toilets in the Monteverde region. With the help of CORCLIMA and their network, we identified the Monteverde Institute, two households in Monteverde, the Monteverde Butterfly Gardens, a farm in the San Luis region, and two houses within the Buen Amigo community, as participants to interview. We used snowball sampling, a technique that asks current participants to

identify more potential participants, to gather more perspectives on composting toilets (Biernacki & Waldorf, 1981). Through snowball sampling, we learned of an additional four past and present community members who either designed or built composting toilets in Monteverde. We interviewed these composting toilet builders to learn more about what to avoid when designing the system and potential improvements.

We interviewed three composting toilet owners, four composting toilet builders, and four owner-builders. We conducted the interviews prior to seeing the composting toilets to allow time to record responses and ask additional questions upon seeing the system. In order to ensure comfort for those involved and to provide a convenient opportunity for field observation, interviews took place in the homes or businesses of the interviewees for thirty to forty-five minutes. The participants were made aware of the informed consent preamble prior to being interviewed. The interviews followed a semi-standardized structure. We created a list of questions to cover in each interview, such as how often they use their composting toilet and why they picked the specific toilet design. The lists of all interview questions are included in Appendices A and B. Though we asked all participants the same questions, strict sequence was not necessary. Selection of this structure allowed for flexibility in level of language, order of questions, and opportunity for probing (Berg & Lune, 2017). During our interviews, one team member focused on listening to responses so that questions not included in the original set could be asked to gather further information.

Upon obtaining permission from the participants, we recorded the audio of these interviews in order to later transcribe all significant comments. We also took notes during the interviews. To get the most information out of these interviews, we prepared our logs within twenty-four hours of the interview (Beebe, 2014). Once finished, the logs were coded to identify common responses, which allowed us to identify both preferences and problems of different designs.

Objective 2: Assess the design characteristics of composting toilets already installed in Monteverde.

By gathering data about existing composting toilets in Monteverde, we determined which features should be included in the proposed designs. We collected this quantitative data through field observation. Our observations were organized and analyzed to create our design metric. The metric compared both quantitative and qualitative data gathered from other objectives to determine the best designs for Monteverde.

Field Observation

In order to properly evaluate the existing composting toilets in Monteverde, we obtained concrete data by employing standardized field observation. For our project, the importance of field observation was two-fold. First, we used this method to gain specific information on the composting toilets. This included things such as dimensions, odor, lid, and location. Our observations were logged in a standardized form (Appendix C) and provided a general idea of common types of composting toilets currently in Monteverde that were used for immediate analysis (Beebe, 2014). By standardizing the observations, we found patterns in the data (Ryan and Weisner, 1998). The patterns among the composting toilets indicated the most desirable design specifications.

Second, field observation enabled us to distinguish between what people say and what people actually do. For instance, if an owner said that they properly maintain their toilet, but it still smells, and we noticed that there was no additive present in the bathroom, that would indicate the

toilet was not being maintained properly, which possibly suggests a need for more public awareness and training. This allowed us to gauge the validity of our interviews through methods triangulation (Beebe, 2014).

Evaluating Designs

In order to properly assess which aspects of composting toilets tend to be most successful and socially accepted, we evaluated different toilet designs. Design specifications, such as those found in Appendix C, and owners’ opinions were both considered. Through these considerations, we narrowed the design characteristics down to fourteen, which were then divided into six main categories. This decision process is outlined in the tree diagram below.

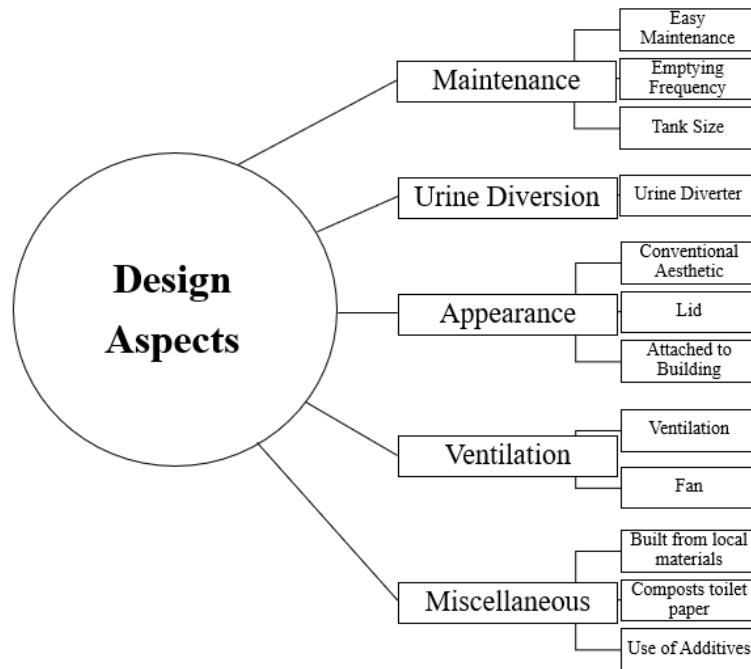


Figure 5. Design Aspect Category Tree

In order to rank the categories by their importance to our final design, we recorded how frequently each was mentioned throughout our interviews with composting toilet owners, builders, and owner-builders (Appendix D). The miscellaneous design category was not considered to be important design features and was therefore not ranked. The five most important design categories were maintenance, urine diversion, ventilation, appearance, and distance from waste. These categories will be referred to as design aspects later in the paper.

Objective 3: Understand perceptions about composting toilets in the community.

Composting toilets have a negative connotation for many people (Branstrator, 2014). Even if an excellent technical design was found and suggested, if community members do not want to use it, then all of the technical research proves pointless. The opinions of the local residents needed to be understood to uncover root causes of a potential social stigma surrounding composting toilets. It is also important to note the age, gender, and cultural background of participants, as these demographics may influence their perspectives. Once community perspectives are understood, they can be taken into account when selecting the best designs.

Free Listing

The first method we used to address this objective was free listing, which involved participants listing a set of responses to our prompts. We noted the frequency of responses from the set of informants to determine how people conceptualize composting toilets (Flinn, 1998). This method was chosen in order to collect data about personal biases and any potential misconceptions in regard to composting toilets. This study was targeted at both non-users and users of composting toilets. Two free listing prompts were distributed at different locations throughout the town to ensure a random sampling. We aimed to give the prompt to thirty participants. The first prompt was, “what do you think of when you hear the phrase *los inodoros secos*?” *Los inodoros secos* translates to dry toilets. After the first few participants responded, we recognized a need to clarify our prompt. For example, our free listing prompt was interpreted differently depending on the translation we used. *Inodoros secos* and *baños de compostaje* received different reactions. Depending on the age demographic of our participant, there was often confusion with the word *inodoro*; some of these people preferred *baño* or *servicio*. We decided to add “*como inodoros de compostaje*,” which translates to “like a composting toilet,” onto the end of the prompt. We also followed up by asking about their opinion of composting toilets. This enabled us to distinguish between their knowledge about and feelings towards composting toilets.

After our first-time free listing, we decided to alter our strategy. By only asking the initial prompt, people were confused and not sure how to respond. To collect better data, we added the question, “from your perspective, what is the difference between a latrine and a composting toilet?” Once fifty responses were collected for the first prompt and thirty responses for the second prompt, we were no longer receiving any significantly different answers, so central themes were identified through tracking of repetitive words (Flinn, 1998). The frequency of these repetitive words indicated recurrent themes, which helped us to determine common perceptions of composting toilets (Flinn, 1998).

Surveys

We distributed electronic surveys (see Appendix E) via email to the members of the Monteverde Institute to understand their experiences with the on-site composting toilet. Through these ten survey responses, we understood how often people used the toilet and potential reasons why they did not. Once these responses were collected, we analyzed the data to identify common thoughts about composting toilets. We tracked the frequency of common responses to use as weighted factors in our evaluation metric.

Objective 4: Develop informational materials for composting toilets in Monteverde.

Creating awareness of water scarcity among the local people and tourists in Monteverde allowed us to promote composting toilets as a means to combat this scarcity. The platforms that we used to communicate these messages included videos, brochures, blogs, and other media platforms. We not only wanted to relay information verbally, but visually as well.

Instructional Manual

Creating an instructional manual provides people who want to install a composting toilet with a starting point. This targets people who are interested in having a composting toilet in their own business or home. Our design analysis allowed us to include how to get started, required

maintenance, installation steps, and troubleshooting in the instructional manual. Computer Aided Design (CAD) was used to create models of what we determined to be the ideal composting toilet model for the Monteverde region. This provides people with concise visual information about the different parts necessary to install a composting toilet by themselves.

Videography

We utilized videography to encourage people to use composting toilets through images and auditory media. We used a Tascam, GoPro, and Saramonic Wireless Microphone to create a video. If the people we previously interviewed seemed passionate about supporting the use of composting toilets, we reached out to them again asking if they were willing to be featured in this short film. The video contained footage from interviews as well as other clips we took throughout our time in Monteverde. Additional people were interviewed, in regard to water scarcity experiences, to create more content for the introductory portion video.

Informational Brochure and Blog Post

In order to provide community members with more specific information on composting toilets, we created an informational brochure. We gave the informational brochure to CORCLIMA to distribute as they see fit. In order to distribute the same information electronically, we also created a blog post and infographic.

Results, Discussion, and Recommendations

Our findings cover two main themes related to the success of composting toilets in the Monteverde region: community awareness and design specifications. Community awareness includes both the lack of knowledge and misconceptions about composting toilets among Monteverde residents. Design specifications address what to include in every design, while also emphasizing the individuality of each composting toilet system. The discussion of our findings is followed by recommendations and limitations.

Findings

Community Awareness

Finding 1. Many people in the Monteverde community are unaware of what composting toilet systems are.

During our time in Monteverde, we discovered a lack of community awareness and a lack of discussion about both composting toilets and water scarcity in general. During an interview with a male employee of the Santa Elena Rural Aqueduct Association (ASADA), it was mentioned that “the nature of people is to not respond to environmental natural resource issues...until [they] reach a crisis point.” He referenced how several years ago, when the community was experiencing daily moratoriums of water, there was significantly “more dialogue about how [they could] save water.” Community members reconsidered consumptive uses, such as washing cars and cleaning dishes, and how to diminish their impact on the water supply. However, once the infrastructure was updated to meet the water demand, the majority of dialogue disappeared. To further validate this point, one of our free listing participants told us “We have water, so why not use it?” Such responses are reflective of how people react more drastically when they experience direct effects

of a crisis. Therefore, our deliverables aim to start a conversation among community members about potential water supply management practices, such as installing a composting toilet.

Through analysis of our free listing responses, we found that many Monteverde residents had never heard of composting toilets. When we asked residents what they think of when they hear the phrase “composting toilet,” 48% of fifty respondents answered that they did not know (Figure 6). These responses show that CORCLIMA needs to bring attention to the water scarcity problem and to the concept of composting toilets. Before CORCLIMA can encourage people to use composting toilets, they need to inform the community about the fundamentals of composting toilets.

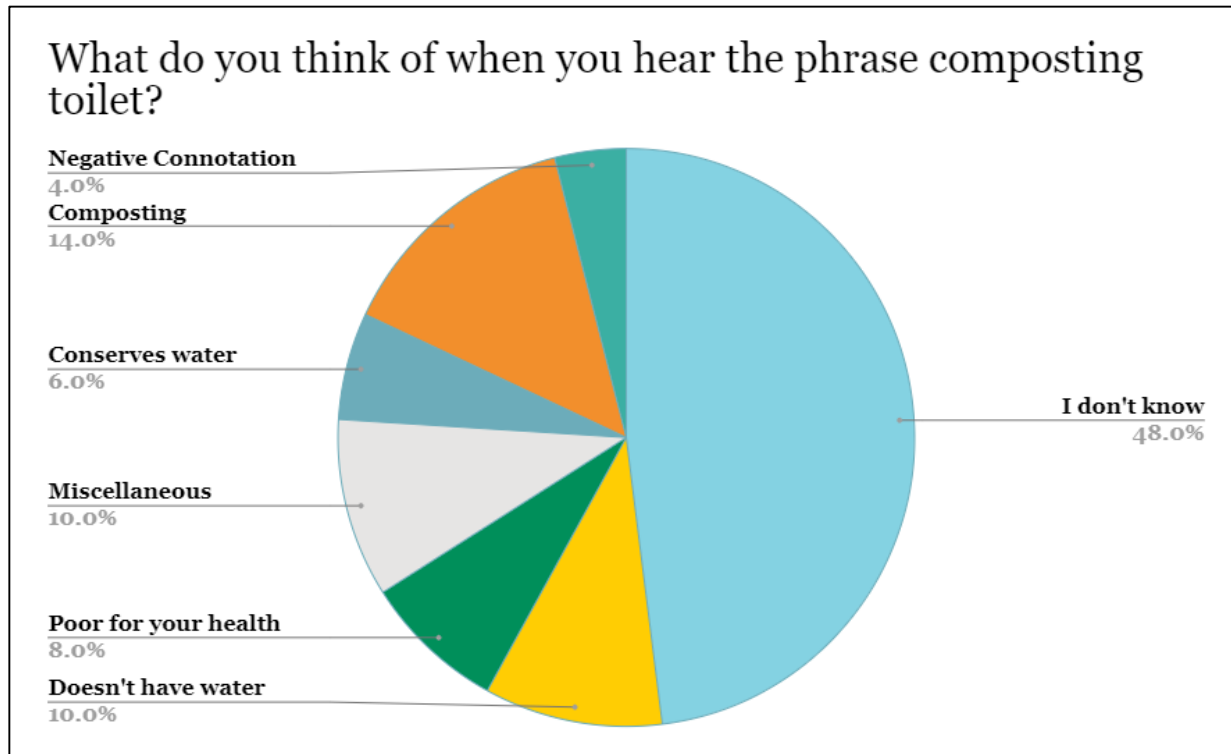


Figure 6. Community opinions about composting toilets.

Finding 2. Some local residents hold negative opinions towards composting toilets due to misconceptions.

In order to learn about how people perceive composting toilets, we employed free listing and interviews. With further analysis of our free listing responses, we found that many Monteverde residents had misconceptions about composting toilets. As stated previously, when we asked residents what they think of when they hear the phrase “composting toilet,” 48% of fifty respondents answered that they did not know what a composting toilet was. Twelve percent of the respondents had inaccurate or negative responses to the prompt. Eight percent of participants responded that composting toilets are unsanitary and another 4% of respondents felt overall negative connotations with the phrase. However, three response categories indicated the presence of accurate community knowledge. Fourteen percent of respondents directly acknowledged the connection to composting, 10% of respondents commented that they do not use water, and 6% of respondents recognized that composting toilets conserve water. Although this small section of

respondents understood how composting toilets positively impact the environment, the presence of common misconceptions remains prevalent.

In another free listing prompt, when we asked residents to differentiate between composting toilets and latrines, 46.7% of thirty respondents did not know the difference or thought they were the same (Figure 7). These responses show that there is a lack of awareness among community members about composting toilets. Because people are unaware of composting toilets, they are unable to distinguish the difference between composting toilets and latrines. This gap in knowledge leads people to form misconceptions because they have no prior knowledge about composting toilets to base their opinions on, so they fill in the gaps with their knowledge of latrines.

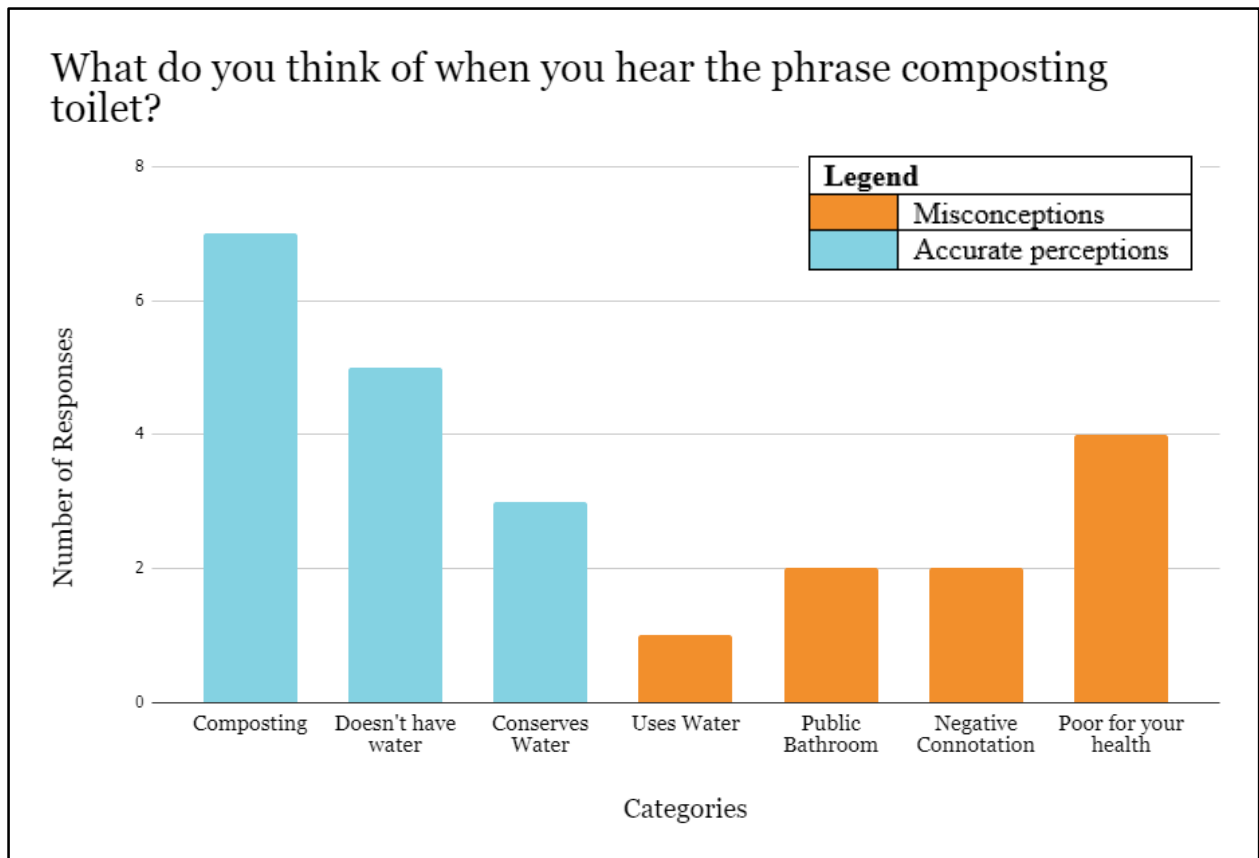


Figure 7. Misconceptions about composting toilets.

These misconceptions stem from the lack of awareness that is discussed in Finding 1. During a discussion with a member of CORCLIMA, we learned how in the past, many Costa Rican residents had latrines as an inexpensive alternative to conventional plumbing. Since there are a few similarities between latrines and composting toilets, some people consider them to be the same. For composting toilets to be accepted in the Monteverde region, a distinction between composting toilets and latrines must first be defined for more people to consider adopting them.

Design Specifications

Finding 3. The composting toilet design most suitable for the Monteverde region should focus on five design aspects.

Throughout our interviews and field observations, we discovered common problems and suggestions to consider when designing a composting toilet system. A notable interview involved a conversation with an owner about the challenges of building one's own composting toilet from scratch. The owner described the process of figuring out how to prevent odor from permeating throughout her home, how she tried a variety of additives before finding one that absorbed enough moisture, how certain system mechanisms would break down, and that certain building materials broke or rotted away. We used her advice and adapted the same way of thinking to formulate our own design. The interviews with all the composting toilet owners and builders revealed fourteen notable design specifications. Many of these are situational, depending on the needs of the user. However, based on interviews with experienced composting toilet builders and a review of pertinent literature, there are five aspects that need to be addressed in the design otherwise the toilet will not be able to function properly or it will be unpleasant to use. The importance of these aspects was determined by tracking repetitive statements during our interviews with owners and builders, which can be seen in Figure 8. These aspects are maintenance, urine diversion, ventilation, appearance, and distance from waste.

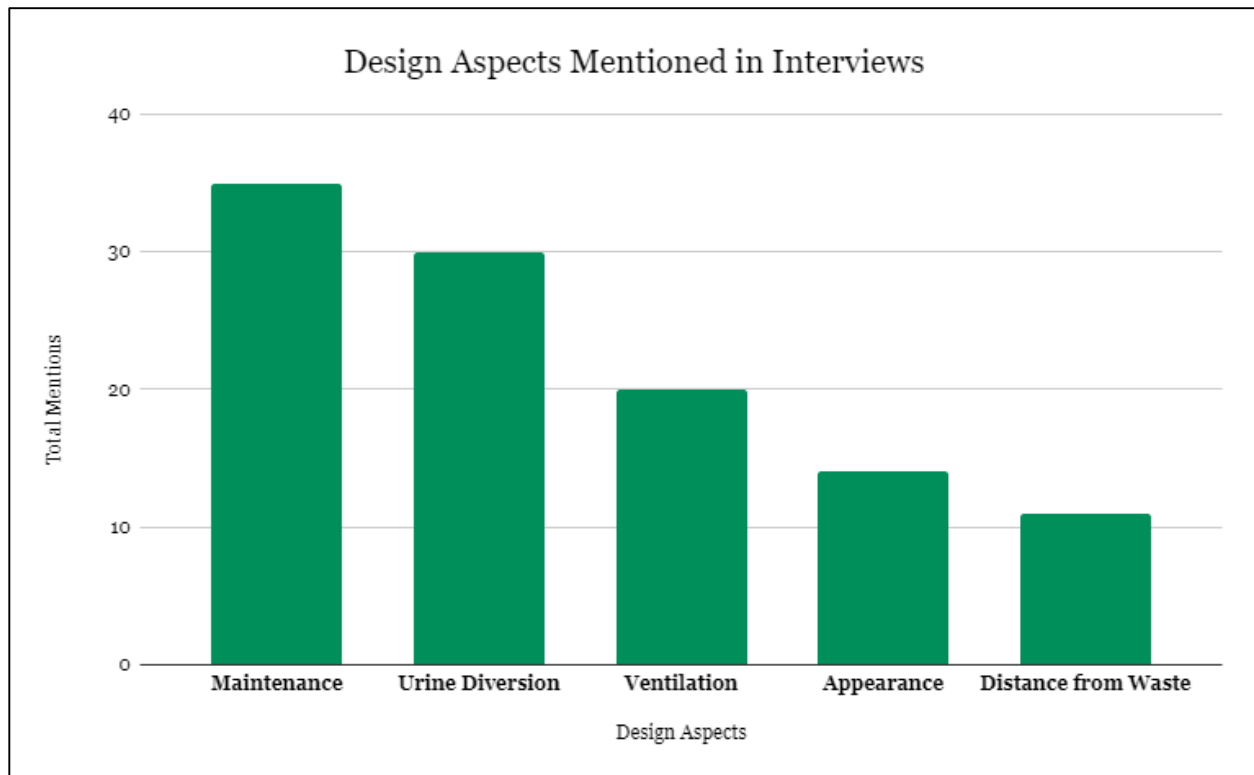


Figure 8. Design aspects mentioned during interviews.

Maintenance

The most important design aspect to consider, maintenance, was mentioned thirty-five times throughout our seven interviews with composting toilet owners and builders. Our first interviewee, a composting toilet owner, had previously changed her original composting toilet to decrease the amount of maintenance. The original design included 55-gallon drums that had to be changed every six months and a computer fan for increased air flow. After some time using the system, she made modifications to improve the overall function. The 55-gallon drums were replaced with a 660-gallon tank that needs to be emptied approximately every three years. For the owner, this modification was most important because it decreased the emptying frequency of her tank. This factor was taken into consideration when deciding how to design a composting toilet to be installed in a family home. While the tank does not need to be emptied as often, there may be difficulty when trying to empty a tank of that size. In our final design, we chose to find a balance between emptying frequency and tank size in order to simplify the emptying process. This modification, along with a few others, were made by the owner to improve upon the original design.

Another person we interviewed, who designed and built multiple composting toilets in Monteverde, told us to focus on training people about maintaining and cleaning the composting toilets. He stressed this because improper maintenance can cause problems that discourage the use of composting toilets. He said, “[if] the maintenance isn’t done...then the systems fail and people say, ‘see they don’t work, this doesn’t work.’” Therefore, the design needs to be easily maintained or people will choose to have a flushing toilet over a composting toilet. While our proposed design is easy to maintain, it may still need modifications to fit the needs of the user.

Urine Diversion

Urine diversion is one of the most integral features to composting toilet systems. The importance of urine diversion was mentioned by the composting toilet builders thirty times throughout our seven interviews. We experienced the importance of urine diversion when we visited a composting toilet in someone’s home and they did not have a way to separate liquids from solids. This created a bad smell whenever the lid was lifted. Without proper separation of solids and liquids the compost will not be able to form properly and it will result in a bad odor. In our interviews we discovered that urine is the main source of odor. There are ratios of nitrogen to carbon that must be achieved in order to create viable compost. At least a 1:30 nitrogen to carbon ratio is needed for good compost. When urine and feces are not separated, a 1:3 ratio is achieved. When solely feces are in the bin, a 1:8 ratio is achieved. By diverting the urine and using additives, an ideal ratio of 1:50 can be reached (Jenkins, 1999).

There are many different types of urine diverter designs, depending on the type of toilet seat that is used. Through our interviews, we learned which types of urine diverters work and which have failed. The size of the urine diverter plays a large role in its potential success. If it is too big, solids will get caught in it, but if it is too small, it will not be viable for females to use. One of our interviewees had a urine diverter tube installed in her seat, but due to the small diameter of the tube, the urine would repeatedly crystallize, resulting in more maintenance for the owner. Another interviewee used a portion of a car tire underneath the seat of his toilet to catch any urine before it entered the tank below. This design worked well for this owner’s needs but would not satisfy the needs of many. The car tire was clunky and would be inappropriate to use in bathrooms inside people’s homes. Another owner had an entirely separate dry toilet for urine, which was then leached into the ground; this solution of urine separation is also inappropriate for most people as it requires a lot of space.

Ventilation

Proper ventilation was emphasized repeatedly by many composting toilet experts; it was mentioned a total of twenty times across seven interviews. Adequate ventilation in the composting tank helps to prevent the bad odor that many people expect to encounter when using a composting toilet. In order for compost to form properly, it needs enough aeration throughout the compost pile for the microorganisms to thrive. This was accomplished in a variety of ways by our composting toilet owners and builders. Our first interviewee used a combination of a vent pipe with an elbow pipe end to prevent rainwater from getting in. Computer fans were also added to assist air flow through the system. Over time, the computer fans would break due to condensation in the pipe, so she stopped replacing them. She found the pipe alone was adequate. A composting toilet builder we spoke with emphasized the importance of ventilation underneath the compost. He created a perforated bottom above a gap in the compost bin to allow the air to travel to the compost at the bottom of the bin. This system used the difference in densities of dry and moist air to instigate the ventilation process. The gap also allows liquid to drip out of the bottom.

We witnessed the importance of this design characteristic when we visited a toilet without a ventilation system. Their composting tank was created using concrete blocks with no ventilation pipes. This created a suction when the lid was opened. The bad odor was then channeled upwards through the toilet seat and made for an unpleasant user experience.

Appearance

Appearance serves as another crucial design aspect to consider. Although it is not crucial for proper function, appearance serves as a critical point people will consider when forming first impressions about whether they would use the model or not. Many people tend to associate composting toilets with latrines. Analysis of our free listing reveals that 46.7% of thirty respondents either did not know the difference between composting toilets and latrines or thought that they are the same thing. This misconception is explored in greater detail throughout Finding 2.

This feedback from community members led to the decision that composting toilets must look like a flushing toilet and be attached to the building in which it is installed. One of our interviewees mentioned that people tend to hold onto conventional practice and stressed the importance of designing a composting toilet that resembles a flushing toilet. If the composting toilet is installed within the building, not as a freestanding structure, it will be associated less with an outhouse. Responses to our survey about the Monteverde Institute's composting toilet showed that 85.7% of seven respondents had not used the onsite composting toilet due to how far from the building it is located. Designing the composting toilet as similar to a flushing toilet as possible, including its installation indoors, will encourage more people to want to use a composting toilet.

Distance from Waste

When trying to encourage people to use composting toilets, the outer appearance of the pedestal is not the only factor to take into consideration. When the toilet lid is opened, what the user can see has the potential to affect their perspective of composting toilets. When one composting toilet owner was asked about the biggest challenges she faces with her composting toilet, she mentioned her experience convincing other people to use it. She said that the “most difficult thing for other people is proximity to poop.”

There are different ways to significantly reduce the amount of waste that people can see in the composting tanks. Through our field observations, we noticed that the length of the chute

leading to the composting tank affects how well the waste could be seen. The longer chutes made it more difficult to see down into the tank. We also learned from another builder that the color of the chute impacts the visibility into the tank. By using darker colors for the chute, it becomes harder to see into the composting bin, making it seem like the user is farther away from the waste (Figure 9). During discussions with our sponsor, we also heard about composting toilet designs that have flaps in the chute that are activated by pressure. When someone sits on the toilet seat, the pressure causes the flap to fall, revealing the opening to the chute. When the pressure is released from the toilet seat, the flap goes back up, which covers the waste in the tank and prevents the user from seeing it. Creating space and reducing visibility between the user and the waste can help reduce the hesitations that some people have towards using composting toilets.



Figure 9. A picture of a composting toilet with a blacked-out bowl.

Finding 4. Certain composting toilet design specifications need to be selected on an individual basis because each system has a unique set of circumstances.

We saw a variety of designs during our interviews with composting toilet owners, builders, and owner-builders. The design of each composting toilet varied depending on the location. Composting toilets inside family homes, outside hiking shelters, and on farms each need unique design specifications. During our interviews, we asked participants to discuss why they chose their specific composting toilet design. While there were standard features across all of the designs, we discovered that each owner or builder had different opinions on the best design for a composting toilet.

Our joint interview with a composting toilet builder and an owner-builder revealed differences in design preferences based on the location of the composting toilet. The composting toilet builder had built multiple free-standing systems outside of temporary residences for travelers. He preferred that the compost collect directly on the ground to allow worms and other organisms into the compost to assist the composting process. The owner-builder had built a composting toilet on his farm, so he preferred that the compost collect on a concrete slab to prevent any potentially harmful bacteria from leaching out and contaminating his soil.

Comparison of all our interviews and field observations revealed further design preferences. One of the major preferences was related to appearance. Some owners preferred that

their composting toilet resembled a flushing toilet, while others preferred the rustic design. One owner originally had a cement block for a pedestal. After using the composting toilet for a period of time, she had the cement block carved into the shape of a traditional pedestal. Other owners preferred the box style seat. These composting toilets were mostly in detached, free-standing structures at hiking shelters or on a farm. These owners did not mind the rustic appearance of the composting toilet since they were nicer than latrines and pit toilets they had previously used. Furthermore, a composting toilet builder expressed that repurposing a flushing toilet as a composting toilet would not be a good idea. He believed that cutting a hole out of a flushing toilet would hinder ventilation. Despite this, one of the composting toilets we visited had been built with a repurposed flushing toilet. The composting toilet did not have a noticeable odor and appeared to function properly. It is important to note that toilet was not used often, which may contribute to the lack of smell.

In order to compare the design specifications of each composting toilet we saw, we documented our field observations, as shown in Figure 10. This allowed us to identify both common and unique design specifications. Any specification that was included in at least four designs was considered a common specification that should be included in our proposed design. Specifications that were included in less than four designs were considered for our final design, but not necessarily included.

Composting Toilet	Overall Easy to Maintain	Not emptied for at least 6 months	Tank size of 55 gallons or more	Urine Diverter	Ventilation	Fan	Conventional Aesthetic	Lid	Attached to Building	Waste was not visible	Multi-Story	Use of Additives	Built from local materials	Composts Toilet Paper
	Maintenance			Urine Diversion	Ventilation	Appearance			Distance from Waste	Miscellaneous				
1	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	✓	✓	✓		✓			✓			✓	✓	✓	✓
4	✓	✓	✓					✓			✓	✓	✓	✓
5	✓	✓	✓					✓		✓	✓	✓	✓	✓
6	✓	✓	✓					✓		✓	✓	✓	✓	✓
7		✓	✓		✓	✓	✓	✓	✓		✓	✓	✓	✓

Figure 10. Comparison of Design Features

Recommendations

Design Proposal

Based on our research and findings, we have chosen a composting toilet design that is made from local materials and utilizes the most suitable and effective design aspects for the Monteverde region. We determined that home-made designs were most suitable for Monteverde. Pre-made models are expensive to begin with and the cost of importing them to Costa Rica is even higher. Most pre-made models are designed for campers or boats, intended for infrequent or temporary use. Other models are designed for large-scale use on trails, but not appropriate for indoor use. In order to accommodate an entire household, a home-made system would more practical.

Our list of priority aspects (Finding 3) discusses the reasons behind our recommendations in greater detail. Our first design recommendation is that a urine diverter is included. For ease of use, we suggest a perforated bottom where the urine can leak through the floor before leaching into the ground outside. This can be made with PVC pipes supporting and elevating a mesh platform.

Our second design recommendation is to include a ventilation system. PVC pipes are an affordable and readily available material from which to build the system. The PVC pipe should stem out horizontally from the composting tank before using an elbow piece to turn the PVC pipe vertically upward, ideally above the level of the house's roof to prevent any odor from venting near windows. The top of the PVC pipe should have a metal mesh sheet cover to keep out vermin and a metal roof or elbow piece to keep out rainwater. To optimize the ventilation system, a small fan, such as one from a computer, can be utilized inside the PVC pipe to help circulate air. This fan should be easily accessible so that it can be replaced if necessary.

Our third design recommendation is to make the composting toilet look like a flushing toilet to appeal to the largest audience. This is to help make them more inviting and ensure people do not associate them with latrines. If possible, we recommend reusing the pedestal from a flushing toilet by cutting a hole with a diameter of at least 120 millimeters out of the bottom of the bowl so the transportation chute can be added. Another aspect of appearance to consider is the location. Putting the composting toilet in the house will distinguish it from a latrine and will encourage people to use it because it will be close by.

Our fourth design recommendation is to dedicate an appropriate distance to separate the user from the waste in the compost bin. The most effective way to do this is by installing the composting toilet where there is plenty of space below it, so there is optimal distance between the user and the waste. Another way to do this would be by using a black plastic material for the chute and composting tank. This blocks light from making the contents of the bin more visible.

Our final main design recommendation is to select a 55 gallon or larger or larger tank size. We recommend this because the larger the tank size, the less frequently it needs to be emptied or rotated, which creates less overall work for the owner. In addition to the recommendations above, other included design specifications are toilet lids, availability of additives, overall structure size, etc. These can be seen in the instructional manual (Appendix I). Refer to the instructional manual for full design illustrations, detailed characteristics, and installation instructions.

Instructional Manual

To make our design accessible to anyone, regardless of technical ability, we created a manual detailing how to build and maintain a composting toilet; this can be found in Appendix I. It includes our recommended design, materials to purchase, and how to prepare a space for the toilet. We also cover how to perform any required maintenance for the specific design as well as general maintenance. In addition, we included a trial and error section, featuring a list of design specifications that have been used in other composting toilets so that if the user wishes to improve upon our design, they have something to work from. The design we propose is based on in-depth research, however, malfunctions may occur. Unfortunately, plumbers may not be familiar with composting toilets, so any problems that may arise need to be fixed by the owner. To account for this, we created a troubleshooting chapter to aid the user in addressing any common problems they may encounter. The last chapter includes additional resources for anyone looking to expand their knowledge on dry composting toilet systems.

Promotional Video

To address a wider audience online, we created a promotional video. We included Monteverde residents on-camera to appeal to the Costa Rican majority of our audience. The video opens with discussion of water scarcity in the Monteverde region, transitioning into an explanation

of how composting toilets can address this challenge within the community. It also covers the benefits of composting toilets as well as an explanation of how they work.

We hope this video will start a conversation among community members about water scarcity. The video could be embedded on CORCLIMA's website and posted on YouTube for free use among any people or organizations that wish to use it.

Informational Brochure

To raise awareness of water scarcity and composting toilets, we created an informational brochure for CORCLIMA to distribute throughout the Monteverde community. Since many of the people we free listed did not know what a composting toilet is, the brochure targets people with no prior knowledge of composting toilets. The brochure highlights the concept of composting toilets, the benefits of composting toilets, how composting toilets work, and common misconceptions. We included statistical data in the brochure to help community members understand the intensity of water scarcity in Monteverde as well as the environmental benefits of composting toilets. A layout of the informational brochure can be found in Appendix J. In order to distribute the same information electronically, we also created a blog post (Appendix K).

Limitations

When conducting our fieldwork, we encountered various limitations. We struggled to get enough participants for our surveys. People were willing to share our survey at their establishment, but we do not know how many people it was distributed to. Due to the lack of responses, we did not obtain a representative sample size. There was also a lack of indoor composting toilets installed in Monteverde. Our sponsor asked us to design a system that could be built indoors, but almost all of the composting toilets we saw were in their own free-standing structures, detached from the buildings. Our final limitation was a lack of time. With more time, we could have built a prototype of our design to expose local residents to composting toilets and help create a conversation about water scarcity and how flushing toilets waste water. More time would have allowed us to test our instructional manual and modify our final design.

Conclusion

Our team came to Costa Rica with the goal of finding the best composting toilet design option and promoting its use around the community by creating awareness. To do so, we researched instructional manuals, interviewed experts in the field, and surveyed local residents to understand their current perceptions of composting toilets. By visiting seven composting toilets and interviewing experts, we found five necessary design aspects for a composting toilet design recommendation for Monteverde. Through our surveys, we also found that the majority of people were unaware of what composting toilets are and that there are some misconceptions regarding them. Using this knowledge, we developed our deliverables, which include an instructional manual, promotional video, informational brochure, and blog post. With our findings and deliverables, CORCLIMA will be able to start a conversation among community members about water scarcity in Monteverde and the benefits of composting toilets. Although the installation of composting toilets will not single-handedly erase the issues of water scarcity in the Monteverde region, we hope that our design proposal and deliverables will have a positive impact on the community.

References

- Anand, C., & Apul, D. (2014). Composting toilets as a sustainable alternative to urban sanitation – A review. *Waste Management*, 34(2), 329–343.
<https://doi.org/10.1016/j.wasman.2013.10.006>
- Anchukaitis, K. J., Evans, M. N. (2010). *Tropical cloud forest climate variability and the demise of the Monteverde golden toad*. Bethesda, MD: U.S. National Library of Medicine.
Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2841931/>.
- Arakan Nature Lodge. (2018). *Luxury dry composting toilets*. Retrieved from <https://arakannaturelodge.com/en/blog/luxury-dry-composting-toilets>
- Avellán, T., & Gremillion, P. (2019). Constructed wetlands for resource recovery in developing countries. *Renewable and Sustainable Energy Reviews*, 99, 42–57.
<https://doi.org/10.1016/j.rser.2018.09.024>
- Baldwin, S.A. & Hill, G.B. (2012). Vermicomposting toilets, an alternative to latrine style microbial composting toilets, prove far superior in mass reduction, pathogen destruction, compost quality, and operational cost. *Waste Management* 32(10), 1811-1820.
- Beebe, J. (2014). *Rapid qualitative inquiry: A field guide to team-based assessment* (2nd ed.). Lanham: Rowman & Littlefield.
- Berg, B. L. & Lune, H. (2017). *Qualitative research methods for the social sciences* (8th ed.). Harlow: Pearson.
- Bernes, J., VanDusen, K., & Welch, J. (2016). *Pathways toward Climate Change Resilience in Monteverde, Costa Rica*. Retrieved from: <https://corclima.org/wp-content/uploads/2017/11/Pathways-Climate-Resilience-Monteverde.pdf>
- Biernacki, P., & Waldorf, D. (1981). Snowball sampling: Problems and techniques of chain referral sampling. *Sociological methods & research*, 10(2), 141-163.
- Branstrator, J. (2014). *The Barriers To Adopting Composting Toilets Into Use In Urban And Suburban Locations In The United States*. M.S. dissertation, Purdue University, State, U.S.
- Brown, R., King, R., Papa, J., Seillac, J. (2008). *The “Culture of Water” in the Monteverde Zone: Perceptions of Water Use, Availability, and Behaviors by Households and Hotels*. Tampa, FL: University of South Florida.
- CORCLIMA. (2017). Cambio Climático y Carbono Negativo Monteverde Costa Rica. Retrieved from <https://corclima.org/?lang=en>

- Curry, E. (2010). Water scarcity and the recognition of the human right to safe freshwater. *Northwestern Law, Journal of Human Rights*. 9(1), 103.
- Dallas, S. C. (2005). *Reedbeds for the Treatment of Greywater as an Application of Ecological Sanitation in Rural Costa Rica, Central America*. Ph.D. dissertation, Murdoch University, Perth, Australia.
- Dallas, S. C., Guswa, A. J., Kim, E. M., Rhodes, A. L. (2004). *Water Quality of a Tropical Montane Cloud Forest Watershed, Monteverde, Costa Rica*. Murdoch University, Perth, Australia.
- Eisner, S., Florke, M., Guillaume, J., Kummu, M., Moel, H., Porkka, M., Siebert, S., Veldkamp, T., Ward, P. (2016). The world's road to water scarcity: shortage and stress in the 20th century and pathways towards sustainability. Bethesda, MD: National Center for Biotechnology Information. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5146931/>.
- EnviroToilets. (2018). The Hidden History of Waterless Toilets. Retrieved from <https://www.envirotoilets.com/blogs/poop-scoop-blog/the-hidden-history-of-waterless-toilets>
- Flinn, J. (1998). Chapter 5: Freelists, Ratings, Averages, and Frequencies: Why So Few Students Study Anthropology. In *Using Methods in the Field*. Sage Publications.
- Gato-Trinidad, S., Jayasuriya, N., & Roberts, P. (2011). Understanding urban residential end uses of water. *Water Science and Technology*, 64(1), 36-42. <http://dx.doi.org/10.2166/Wst.2011.436>
- Green Building Alliance. (2016). Composting Toilets. Retrieved from <https://www.go-gba.org/resources/green-building-methods/composting-toilets/>
- Guswa, A. J., Rhodes, A. L. (2007). *Ecohydrology and Water Resources of Monteverde, Costa Rica: Implications of a Changing Climate*. Amherst, MA, United States: University of Massachusetts. Retrieved from https://scholarworks.umass.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=1026&context=wrrc_conf
- Hoekstra, A. Y., Mekonnen, M. M. (2016). *Four billion people facing severe water scarcity*. Washington, D.C., United States: American Association for the Advancement of Science. Retrieved from <http://advances.sciencemag.org/content/2/2/e1500323>.
- Jenkins, J. C. (1999). *The humanure handbook: A guide to composting human manure* (2nd ed.). Grove City, PA: Joseph Jenkins, Incorporated. Retrieved from: <https://humanurehandbook.com/downloads/H2.pdf>

- Langergraber, G., & Muellegger, E. (2005). Ecological Sanitation—a way to solve global sanitation problems?. *Environment international*, 31(3), 433-444. Retrieved from <https://doi.org/10.1016/j.envint.2004.08.006>
- Lienert J. & Larsen T. (2010). High Acceptance of Urine Source Separation in Seven European Countries: A Review. *Environmental Science Technology*, 44(2), 556-566. Retrieved from: <https://pubs.acs.org/doi/abs/10.1021/es9028765>
- Mcknight, J. (2014). *Water and Health in the Nandamojo Watershed of Costa Rica: Community Perceptions towards Water, Sanitation, and the Environment*. Tampa, FL: University of South Florida. Retrieved from <https://scholarcommons.usf.edu/cgi/viewcontent.cgi?referer=https://www.google.com/&httpsredir=1&article=6469&context=etd>.
- Monteverde Community Fund. (2019). *Environmental Profile*. Retrieved from <http://monteverdefund.org>
- Monteverde Institute. (2018). *Our Commitment to Sustainability*. Retrieved from <https://monteverde-institute.org/our-commitment-to-sustainability.html>
- Monteverde Travel Guide. (2018). *Monteverde Area Maps, Facts And Links*. Retrieved from <https://www.monteverdeinfo.com/monteverde-area-maps-facts-and-links>
- Porras, I. T., & Miranda, M. (2005). *Landscapes, memories and water: Narratives, perceptions and policy-making on land and water in Monteverde, Costa Rica*. Newcastle upon Tyne, UK: The Centre for Land Use and Water Resource Research (CLUWRR).
- Rhodes, A.L., A.J. Guswa, Dallas, S., Kim, E.M., Katchpole, S., Pufall, A. (2004). Water quality in a tropical montane cloud forest watershed, Monteverde, Costa Rica. In: Bruijnzeel, L.A., Juvik, J., Scatena, F.N., Hamilton, L.S., and Bubb, P. (eds), *Mountains in the Mist: Science for Conservation and Management of Tropical Montane Cloud Forests*, University of Hawaii Press.
- Ryan, G., & Weisner, T. (1998). Content analysis of words in brief descriptions: How fathers and mothers describe their children. *Using methods in the field: A practical introduction and casebook*, 57-68.
- Schensul, J., & LeCompte, M. (2013). *Essential ethnographic methods a mixed methods approach* (2). Lanham, MD: AltaMira Press.
- Sustainable Organic Integrated Livelihoods (SOIL). (2011). *The SOIL Guide to Ecological Sanitation*. Retrieved from <https://www.oursoil.org/resources/the-soil-guide-to-ecosan/>
- Survey Fundamentals: A Guide to Designing and Implementing Surveys. (2010). Madison, WI: University of Wisconsin.

- Trueworthy, A., Jungbluth, A., Occidentale, A., Tom, B., Morgan, D., & Chant, E., Wang, Z. J. (2017). Fertilizers. Retrieved from <http://12.000.scripts.mit.edu/mission2017/fertilizers-2/>
- United States, Environmental Protection Agency, Office of Water. (1999). *Water Efficiency Technology Fact Sheet: Composting Toilets*. Washington, D.C.: United States Environmental Protection Agency, Office of Water.
- United Nations. (2018). *Water Facts*. United Nations. Retrieved from <http://www.unwater.org/water-facts/>.
- Viola, D. W. (2009). WATER CONSERVATION: REDUCING WASTE SAFELY. *Heating/Piping/Air Conditioning Engineering : HPAC*, , 16. Retrieved from <http://ezproxy.wpi.edu/login?url=https://search.proquest.com/docview/214409430?accountid=29120>
- Welch, J. C. (2008). Water Resources of the Upper Río Gaucimal Watershed: Summary, Analysis, and Recommendations. Retrieved from https://slideblast.com/water-resources-of-the-upper-rao-guacimal-monteverde-institute_59682a6e1723dde3a8950867.html
- Werner, C., Otterpohl, R., & Hakan, J. (2003) 10 Recommendations for action from the Lübeck symposium on ecological sanitation. Retrieved from: <https://waterfund.go.ke/watersource/Downloads/017.%20ecosan-Symposium-Luebeck-Recommendations.pdf>
- Winblad, U., & Simpson-Hebert, M. (Eds.). (2004). *Ecological sanitation*. EcoSanRes Programme. Retrieved from https://books.google.com/books?hl=en&lr=&id=nM6B_uMwU5MC&oi=fnd&pg=PR3&dq=ecological+sanitation&ots=AVO3EMMmbS&sig=82AUpYhVVOUQq0hx54AOBE1O9GE#v=onepage&q=ecological%20sanitation&f=false.

Appendices

Appendix A. Objective 1 Interview with Composting Toilet Owners

INTERVIEW QUESTIONS

GOAL: Learn about the current owners' personal experience to get a clearer understanding of how the composting toilets were built, how they are maintained, the origin of the design, the motivation behind its implementation, and factors that lead to both success and failure.

We are a group of students from Worcester Polytechnic Institute (WPI) in Massachusetts working with CORCLIMA to determine the best design options for composting toilets in Monteverde and promoting their use within the community. We are requesting your permission to interview you about your composting toilet experience and audio record your responses. This interview will take approximately 30-45 minutes. The purpose of this interview is to get a clearer understanding of your motivation for installing a composting toilet and your experience using it. No audio recording will occur without your prior knowledge and consent. If you have any questions prior, during, or after recording has finished, please feel free to ask. This is a collaborative effort between CORCLIMA and WPI, and your participation is greatly appreciated. If interested, a link to the video can be provided at the end of the project. Please feel free to contact us with any questions or concerns at gr-clima-mv19@wpi.edu. You may also contact our WPI project advisors, Melissa Belz and Courtney Kurlanska, at mbez@wpi.edu and cbkurlanska@wpi.edu. Sign Informed Consent Form if video recording. See Appendix H.

Introductory Questions

How did you learn about composting toilets?
What made you want to install a composting toilet?

¿Cómo aprendió sobre los inodoros secos?
¿Qué se hizo querer instalar un inodoro seco?

Habits

Do you have any other toilets?
How often do you and your family use your composting toilet?

¿Tiene algún otro inodoro?
¿Con qué frecuencia se utiliza su inodoro seco?

<p>Design</p>	<p>Did you install it by yourself or did you receive assistance from an organization? Was there more than one design option for you to choose from? Can you tell us about the design you choose and why?</p> <p>¿Lo instalo si mismo o recibió ayuda de una organización? ¿Hubo más de uno opción de diseño para que elija? ¿Puede hablar sobre el diseño que escogió y por qué?</p>
<p>Maintenance & Odor</p>	<p>What maintenance is required? What is the most difficult aspect of maintaining your composting toilet? Have you experienced any challenges with your composting toilet? Does your composting toilet require any additives? What kind? Have you used others? Is there a noticeable odor? Under what circumstances does it smell? Do odor problems occur more during certain times of the year?</p> <p>¿Qué mantenimiento se requiere? ¿Cuál es el aspecto más difícil de mantener su inodoro seco? ¿Ha experimentado algún problema con su inodoro seco? ¿Su inodoro de compostaje requiere aditivos? ¿Que tipo? ¿Ha usado otros? ¿Hay un olor notable? ¿En qué circunstancias huele? ¿Los problemas de olores ocurren más durante ciertas épocas del año?</p>
<p>Guest Interactions</p>	<p>Do guests use this composting toilet? How do guests react to the composting toilet?</p> <p>¿Los invitados usan este inodoro seco? ¿Cómo reaccionan los invitados al inodoro seco?</p>

<p>Compost Use</p>	<p>What do you do with the compost? ¿Qué hace con el compost?</p>
<p>Other Use</p>	<p>Have you ever used a composting toilet besides this one? Has your experience with this composting toilet been better, worse or the same as your experience with other composting toilets? Would you be willing to let us record the interview for our video?</p> <p>¿Ha usado un inodoro seco además de este? ¿Su experiencia con el otro inodoro seco fue mejor o peor que su experiencia con su inodoro seco? ¿Estaría dispuesto a dejarnos grabar una entrevista con usted para un video?</p>

Appendix B. Objective 1 Interview with Composting Toilet Builders

INTERVIEW QUESTIONS

GOAL: Learn about the builders' experience to get a clearer understanding of how the composting toilets were built, how they are maintained, the origin of the design, and factors that lead to both success and failure.

We are a group of students from Worcester Polytechnic Institute (WPI) in Massachusetts working with CORCLIMA to determine the best design options for composting toilets in Monteverde and promoting their use within the community. We are requesting your permission to interview you about your composting toilet experience and audio record your responses. This interview will take approximately 30-45 minutes. The purpose of this interview is to get a clearer understanding of your motivation for building a composting toilet. No audio recording will occur without your prior knowledge and consent. If you have any questions prior, during, or after recording has finished, please feel free to ask. This is a collaborative effort between CORCLIMA and WPI, and your participation is greatly appreciated. If interested, a link to the video can be provided at the end of the project. Please feel free to contact us with any questions or concerns at gr-clima-mv19@wpi.edu. You may also contact our WPI project advisors, Melissa Belz and Courtney Kurlanska, at mbez@wpi.edu and cbkurlanska@wpi.edu. Sign Informed Consent Form if video recording. See Appendix H.

Introductory Questions

How did you learn about composting toilets?

Do you own a composting toilet of your own?

What was your motivation to install a composting toilet?

How many composting toilets have you installed?

Who have you built them for? (self, friend, company, trail, etc.)

What kind of climate did you build them in? Was it similar to Monteverde's?

<p>Design</p>	<p>Did you design it from scratch or was it based off pre-existing designs? Was there more than one design option for you to choose from?</p> <p>Did you construct it by yourself or did you receive assistance from someone else?</p> <p>Is there a specific design that you think works better than others?</p> <p>Can you tell us about the design you choose and why? Does it include urine diversion?</p> <p>Are there any particular features in your composting toilet designs that differs from other composting toilet designs available? If so, what made you decide to incorporate them?</p> <p>Have you experienced any challenges installing composting toilets?</p>
<p>Maintenance & Odor</p>	<p>What maintenance is required?</p> <p>What is the most difficult aspect of maintaining a composting toilet?</p> <p>Does the composting toilet require any additives? What kind? Have you used others?</p> <p>Is there a noticeable odor? Under what circumstances does it smell?</p> <p>Do odor problems occur more during certain times of the year?</p>
<p>Compost Use</p>	<p>How long before you use the compost?</p> <p>What is the compost used for?</p>
<p>Miscellaneous</p>	<p>Is there any advice you have for first-time composting toilet builders?</p>

Appendix C. Objective 2 Field Observation

Composting Toilet	Electric or Non-electric	Ventilation type	Single story or Multi story	Separate or included	Type of seat	Additives
1	non-electric	Vent pipe	2	Separate	Flushable toilet with hole cut out	Sawdust, chemicals
2	non-electric	Vent pipe with elbow tube	2	Included	Oxfam modified seat	Leaves, sawdust, newspaper, drain powder
3	non-electric	Elbow tube	1	Separate	Wooden seat	Dirt, dry leaves
4	non-electric	No vent	2	Separate	Plastic lids	Sawdust, food scraps, ash or dirt, leaves
5	non-electric	Vent pipe	2	Separate	Plastic lids	None
6	non-electric	Chimney	2	Separate	Plastic seat	Fermented molasses, semolina, dry leaves
7	non-electric	N/A	2	Included	cement art, optional plastic seat	Leaves

Appendix C. Objective 2 Field Observation (continued)

Composting Toilet	Compost use	Urine diverting	Odor	Compost time	Base type	Vermin present
1	Nonedible plants	Y	4/5	2 years	Plastic bin	N
2	Fruit trees	Y; poor condition	4/5	2-3 years	Plastic bin	N
3	Banana trees for animal food	N; separate toilet	2/5	2 months + pile	Plastic bin	N
4	Fruit trees	N	4/5	2 years	Dirt floor	Y; pisotes
5	N/A	N	1/5	N/A	Cement floor	Y; flies
6	Fruit trees and nonedible plants	Y; tire	4/5	N/A	Cement floor	Y; rats
7	N/A	N	3/5	10+ years	Cement floor	N

Appendix D. Frequency of Design Aspect Mentions in Interviews

The following table summarizes how many times each design aspect was mentioned during all seven of our interviews with composting toilet owners, builders, and owner-builders.

Interview	Urine Diversion	Ventilation	Appearance	Distance from Waste	Maintenance
1	2	3	0	1	6
2	2	1	0	0	3
3	10	3	2	3	10
4	1	2	1	3	6
5	7	4	6	2	3
6	7	6	3	1	4
7	1	1	2	1	3
Total Mentions	30	20	14	11	35

Appendix E. Objective 3 Survey for Monteverde Institute

SURVEY QUESTIONS	
GOAL: To understand the experiences with the on-site composting toilet.	
Experience	<p>On a scale of 1 to 5 please rate your level of environmental consideration, with one equaling below average, three equaling average, and five equaling above average.</p> <p>Have you used the composting toilet before? Yes or No</p>
If yes...	<p>How often do you use the composting toilet?</p> <ul style="list-style-type: none"> -Rarely -Once every two weeks -Once a week -A few times every week -Every day <p>How would you rate your experience?</p> <ul style="list-style-type: none"> -Very Poor -Poor -Somewhat Poor -Neutral -Somewhat Good -Good -Very Good <p>Is there anything you would change about the experience?</p> <p>If you had a choice, would you still use the composting toilet? Yes or No</p> <p>Have you used any other composting toilets? Yes or No</p> <p>Was your experience with the other composting toilet better or worse than your experience with the one at [Insert Location Here]?</p> <ul style="list-style-type: none"> -Better -Somewhat Better

	<ul style="list-style-type: none"> -Same -Somewhat Worse -Worse <p>Why was your experience better or worse?</p>
If no...	<p>Why not? Please select all that apply.</p> <ul style="list-style-type: none"> -Bad Odor -Too Far Away -Lack of Cleanliness -I do not like the idea of them -I did not know we had one <p>What would encourage you to use it in the future?</p>
Demographics	<ul style="list-style-type: none"> Age Gender Country of Residence Association with location

Appendix F. Free Listing Data for First Prompt

Data from prompt “What do you think of when you hear the phrase *composting toilet*?”

	I don't know	Poor for your health	Doesn't have water	Miscellaneous
	I don't know	Very bad for health. Should be used with water	They don't use water	Public bathroom
	I don't know	Not hygienic without water	Uses no water	Uses water but goes to a different place with compost
	I don't understand. We have water so why not use it	Is it clean?	No water	Something artificial
	"That's just a hole right"	No water. It's dirty with bacteria	No water	"What I grew up with"
	Never used		Doesn't use water	A regular toilet with a hole in it
	I don't know			
	I don't know			
	Doesn't see connection between composting and toilet			
	Never heard of concept			
	I don't know			
	I don't know			
	I don't know			
	I don't know			

	I don't know, it's a bathroom?			
	What is that?			
	What is that?			
	Not sure, doesn't understand connection			
	Compost is for fruits, Doesn't know what exactly it is			
	Doesn't know			
	I don't know			
	I don't know			
	I don't know			
	I don't know			
	I don't know			
Total	24	4	5	5

Appendix F. Free Listing Data for First Prompt (continued)

	Conserves water	Composting	Negative Connotation
	Interesting, conserves water	Composting	It's weird. I don't like it. Normally needs water
	Little water, better less water	Something you use for trash	Not good
	Natural, better for the environment	One at MVI, reuses nutrients	
		We have one at farm, tourists don't like, uses waste as compost	
		Use organic waste	
		Recycles natural waste	
		Composting	
Total	3	7	2

Appendix G. Free Listing Data for Second Prompt

Data from prompt “From your perspective, what is the difference between a latrine and a composting toilet?”

Categories	Could Recognize Difference	Could Not Recognize Difference	Miscellaneous
	A latrine is a deep hole where waste goes/just sits. A composting toilet has more of a process	I don't know what a composting toilet is	Latrines are more common
	One manages compost, the other is a latrine	Not sure, never heard of it before	Latrine is a hole in the ground
	Doesn't know what a composting toilet is, but he knows that the compost process is using the waste	Not sure what a composting toilet is. Knows what a latrine is	Latrine is easier
	Composting toilet is more advanced. Privy versus actual toilet. Knows someone with one that never worked	I don't know	
	Latrines are old, composting toilets are newer	I only know what a latrine is	
	Composting Toilet is more hygienic, and latrine is bad	Doesn't know what they are	
	Latrine is unhygienic, and compost is natural	Doesn't know	
	You can see the waste in a latrine, and the composting toilet recycles waste.	Latrines are a normal thing, never heard of composting toilets	
	Many differences	Doesn't know	
	Latrines just keep filling, composting toilets are useful	They're the same	
	Composting toilets are better for the environment	I don't know	
	Composting flush & go to another place. Latrines are holes in the ground	I don't know	
	Only latrines smell & are bad for the environment	I don't know	
		I don't know	
Total	13	14	3

Appendix H. Informed Consent for Video Recording

We are a group of students from Worcester Polytechnic Institute (WPI) in Massachusetts working with CORCLIMA to determine the best design options for composting toilets in Monteverde and promoting their use within the community. We are requesting your permission to record our interview on video file(s) and include your name in our final video. This interview and recording will take approximately 30 minutes. The purpose of this recording is to create content for a promotional video for composting toilets to be posted on CORCLIMA's website. No recording will occur without your prior knowledge and consent. If you have any questions prior, during, or after recording has finished, please feel free to ask. This is a collaborative effort between CORCLIMA and WPI, and your participation is greatly appreciated. If interested, a link to the video can be provided at the end of the project. Please feel free to contact us with any questions or concerns at gr-clima-mv19@wpi.edu. You may also contact our WPI project advisors, Melissa Belz and Courtney Kurlanska, at mbez@wpi.edu and cbkurlanska@wpi.edu.

By signing below, I am stating that I have read and understood the Informed Consent for Video Recording and that I give my permission to video record our session(s) and use the file(s) in a promotional video for CORCLIMA.

Print Participant Name

Date

Participant Signature

COMPOSTING TOILET INSTRUCTIONAL MANUAL

A COMPREHENSIVE GUIDE FOR INSTALLING DRY
COMPOSTING TOILETS



TABLE OF CONTENTS

Introduction.....	3
How to Get Started.....	4
The Basics.....	5
How they work.....	5
Preparing your space.....	7
Obtaining materials.....	8
Design Option.....	9
Design: Compost Bin.....	11
Design: Ventilation System.....	13
How to Install a Composting Toilet.....	15
Pedestal.....	15
Ventilation System.....	16
Composting Bin.....	18
Putting it all together.....	19
How to Maintain a Composting Toilet.....	20
Additives.....	21
How to empty the bin.....	22
Compost Use.....	23
Trial and Error.....	24
Troubleshooting.....	26
Frequently Asked Questions.....	28
Resources.....	29

Introduction 🌞

Despite 70% of the Earth being covered in water, water scarcity is a global challenge. At the turn of the 21st century, nearly four billion people faced some degree of water scarcity. By 2025, it is estimated that 1.8 billion people will experience absolute water scarcity. In particular, Central America has experienced a steep increase in water scarcity since the 1960s largely due to sporadic weather caused by climate change.

When thinking about climate change, one's first thought is not the bathroom. It may not even be the tenth thought. However, using the bathroom has significant impacts on the planet. When a toilet is flushed, water is wasted in the transportation process as well as in the treatment and disposal of human waste. During this process, energy is also wasted transporting and treating the water. Instead of flushing human waste, what if it were reused?

Composting toilets are a sustainable solution to water scarcity. They save water, reduce pollution and energy consumption, and are easy to install in your home! You can be part of the solution to climate change! By installing a composting toilet, you can contribute to the trend of environmentally conscious decisions.



Examples of composting toilets already installed in Monteverde.

How to get started

Composting toilets have amazing environmental benefits over their septic system counterparts. These benefits however, require additional steps that conventional toilets do not need. Composting toilets must be maintained and updated as your needs change over time. These changes are easily achieved with only a small amount of ingenuity.

Before you decide that you're ready to own a composting toilet, there are three key things to keep in mind. Composting toilets require **PLANNING**. A proper space needs to be prepared! Adequate space must be present near your toilet for the composting bin. Composting toilets also require **BUILDING**. They can be installed by yourself or with the help of a hired professional. Lastly, composting toilets require **MAINTENANCE**. There is a certain amount of upkeep that your new system will require.

This manual will go into detail on all of these topics so you can have a better composting toilet experience!

PLAN	BUILD	MAINTAIN
Select a design and prepare your space for the composting toilet	Obtain the proper materials for the design Install the composting toilet system	Do the required upkeep to keep your toilet working properly Update your system as needed

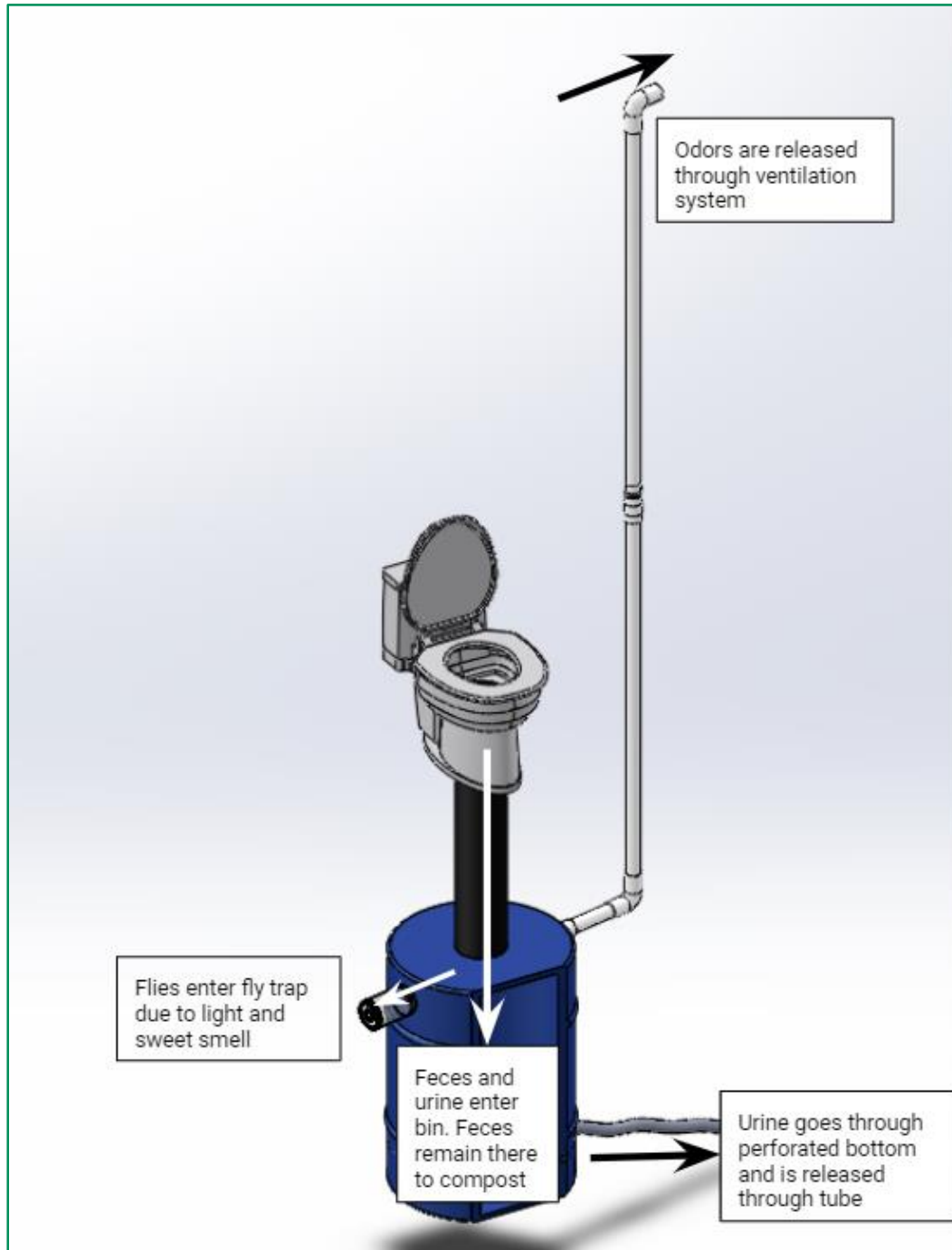
The Basics: How they work ☀️

A dry composting toilet is a type of toilet that treats both solid and liquid human waste through composting without the use of water.

- 🚽 Waste enters the dry composting toilet the same way as a flushing toilet. Since the designs require little to no water, it relies on gravity instead of water to move the waste.
- ♻️ The waste will break down within the tank. Additives, such as sawdust and leaves, aid the composting process.
- 🚲 After sitting for a minimum of six months, the compost can be used as fertilizer for vegetation.



How they Work: A System Diagram ☀️



The Basics: Preparing your space


You've decided you want a composting toilet...now what?

Composting toilets require a space beneath your toilet pedestal for the composting bin. Because it does not use water to flush, the system relies on gravity to move waste from the bowl to the bin.

A two-story house, one with a basement, or one with an elevation change is ideal for a composting toilet. However, even creating a small drop is sufficient for a system as long as you can fit a tank underneath.

Helpful tip:

Composting toilets are easily installed in a location that was planned for.

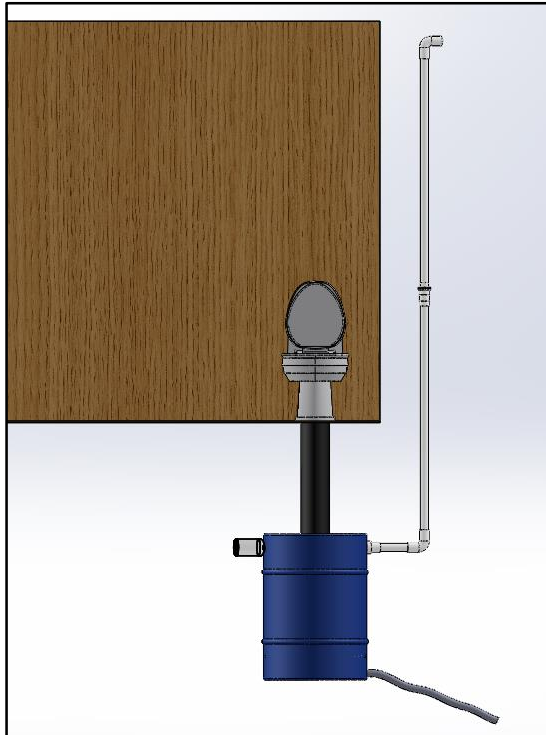
-  If you're in the middle of an addition or a renovation, think about creating a space underneath your bathroom to install the composting bin.

The Basics: Obtaining the materials

These materials can be obtained from local hardware stores. The tools required to cut these materials can also be found locally.

Quantity	Material
1	Toilet Pedestal
1	300 Kg Capacity Empty Plastic Barrel
1	Black Tube (Approximately 180mm in diameter)
1	Empty Clear Bottle (Any Size)
1	Long Plastic Tube (Small diameter)
1	2" PVC Male Adapter
1	2" PVC Pipe (Approximately 320mm in length)
2	2" PVC Elbow
2	2" PVC Pipe (Approximately 1,500mm in length)
2	2" PVC Square Housing (54mm x 54mm)
1	12V Battery-powered Computer Cooler Fan (52mm x 52mm x 15mm)
2	2" PVC Connector
1	Circular Mesh (2" Diameter)
4	2" PVC Pipe (Approximately 120mm in length)
1	Circular Mesh (640mm in Diameter)
1	Toilet Pedestal
1	300 Kg Capacity Empty Plastic Barrel
1	Black Tube (Approximately 180mm in diameter)
1	Empty Clear Bottle (Any Size)
1	Long Plastic Tube (Small diameter)
1	2" PVC Male Adapter
1	2" PVC Pipe (Approximately 320mm in length)
2	2" PVC Elbow

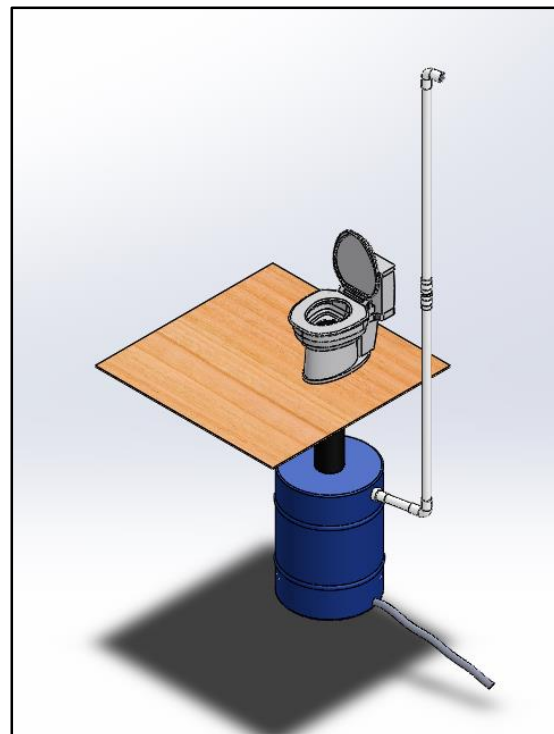
Design Option

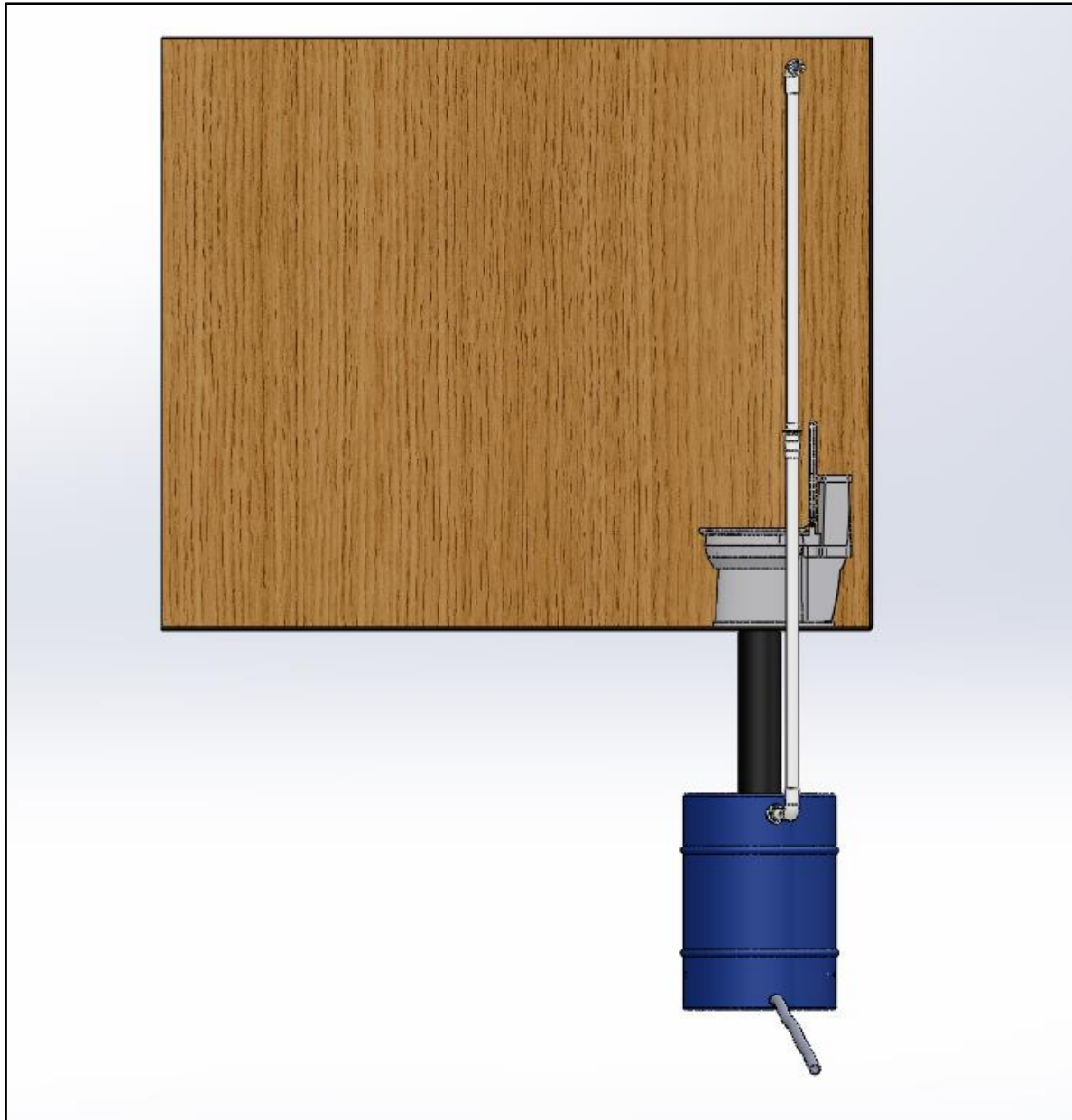


The design to the left depicts a multi-story composting toilet model. The toilet bowl shown on top is a recycled flushing toilet, but this could be swapped out with a variety of options, such as a wooden box with a toilet seat and lid on it. A hole of at least 120mm in diameter needs to be cut into both the toilet bowl and the floor below that it sits on.

Below the toilet bowl is a black plastic tube that will act as the chute. The diameter of it should be the same as the holes that were cut into the floor and bowl so that it can be placed inside them. It is recommended that a length of at least 800mm is used to help prevent users from seeing into the bin.

Attached to the black plastic tube is the composting bin, where the composting process takes place. This model has a composting bin with a perforated bottom, which catches the feces but allows the majority of the urine to pass through. Once the urine goes through the perforated bottom, it leaks out through a small tube that is attached lower than the perforated bottom on the bin. This helps to eliminate the smell.

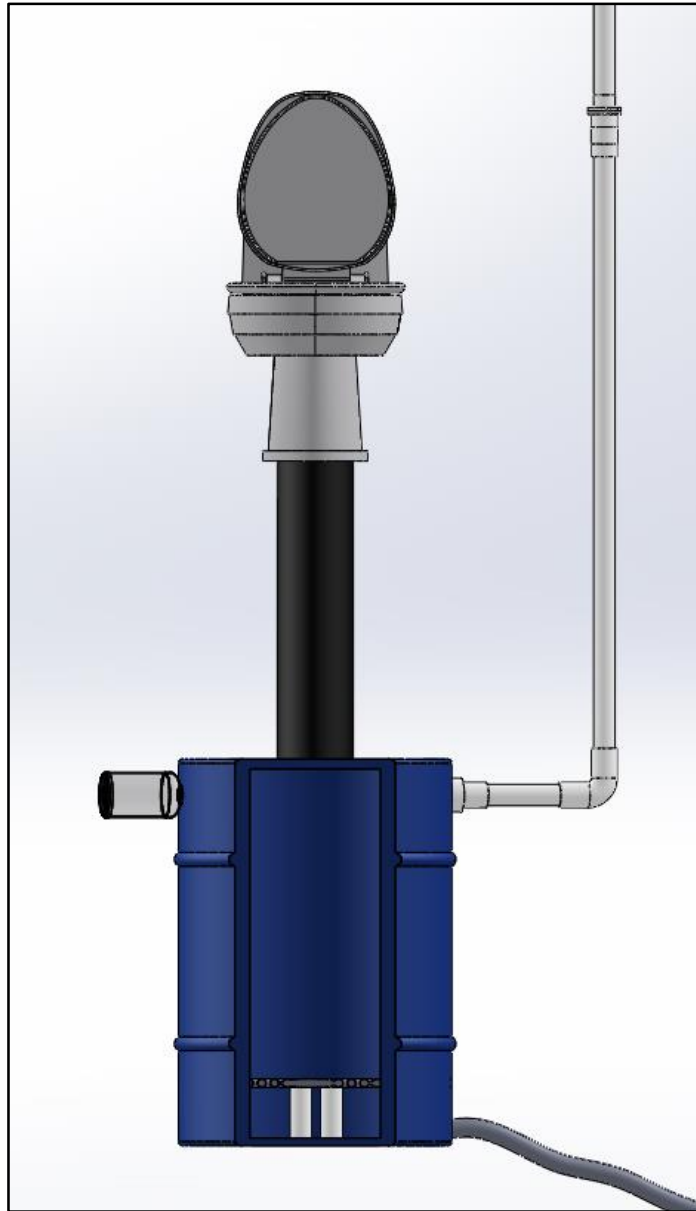




The ventilation system shown uses PVC pipes and a small computer fan. The ventilation system should be attached near the top of the composting bin. The ventilation system should extend out of the house, preferably above the level of the roof. It is recommended that a PVC elbow piece and mesh are added to the top of the system to prevent rain and bugs from entering the system.

A fly trap is also incorporated into the design. This can be made easily using some sort of clear plastic container with a sweet smelling substance in it. The plastic container should then be attached near the top of the composting barrel where the light and smell will attract and trap flies.

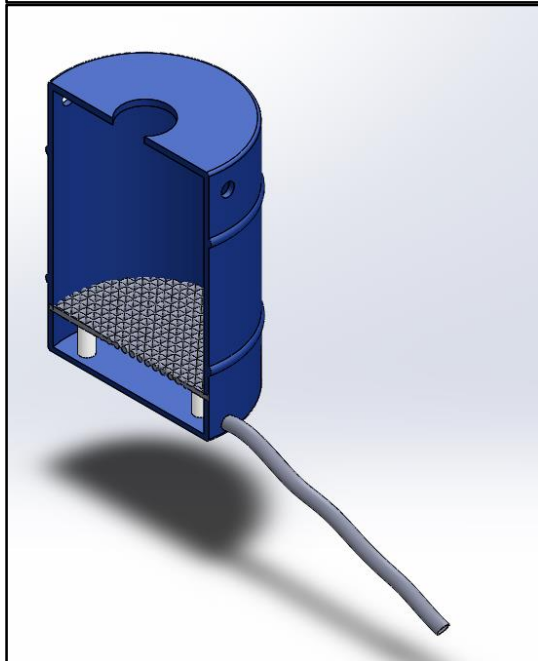
Design: Composting Bin ☀️



For this portion of the design, we created a gap using PVC pipes and a metal mesh to allow for liquids to drain out the bottom through a perforated tube. This gap also aids in the ventilation process due to the different densities of dry and moist air.

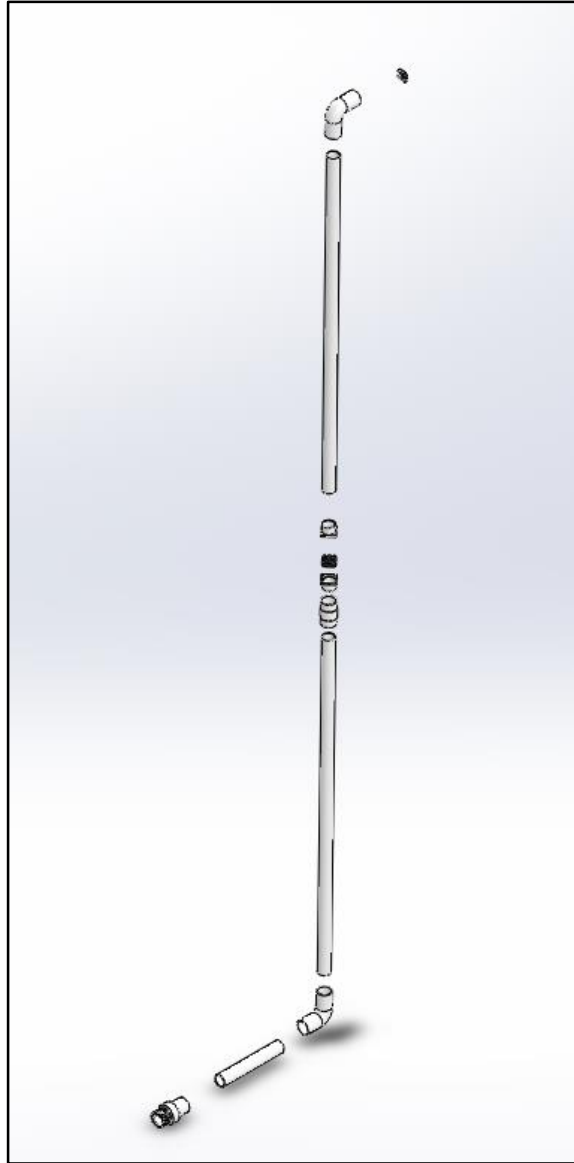
*It is important to not damage the ventilation pipes when emptying the bin.

Cross-sectional View of the Composting Bin



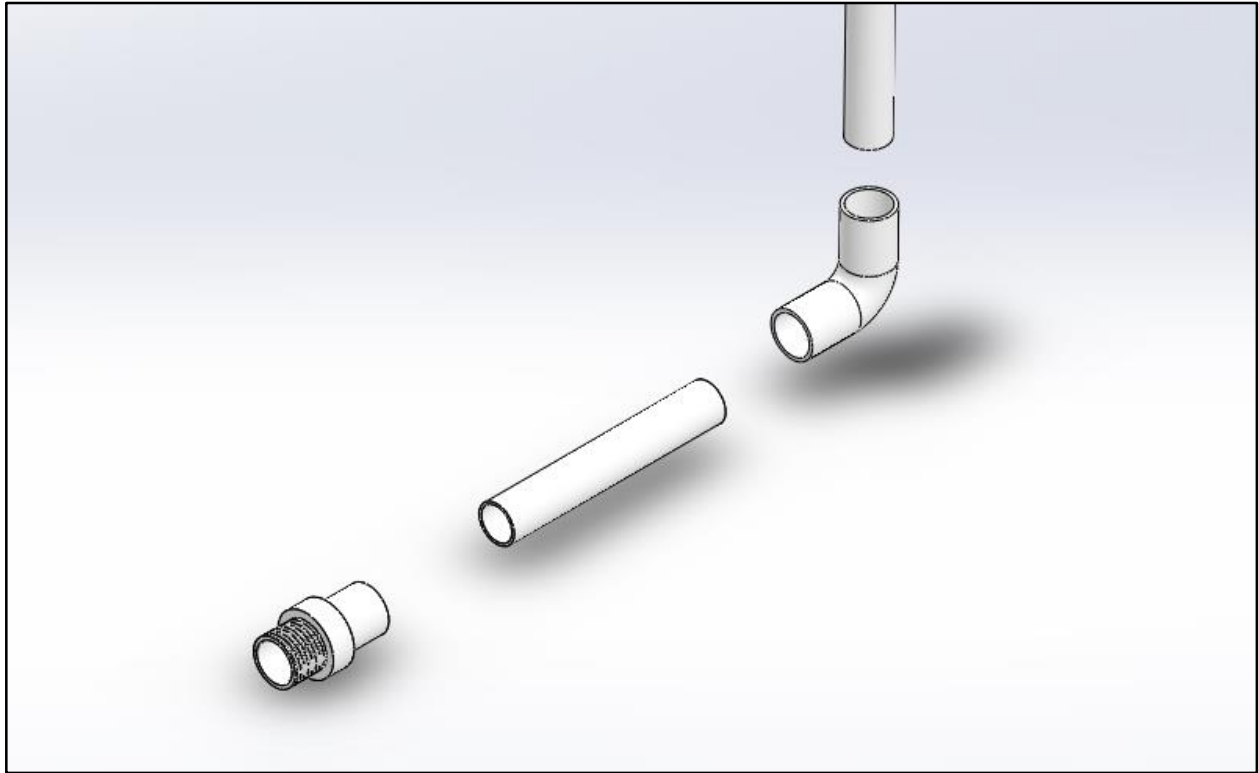
Alternate View of
the Composting Bin

Design: Ventilation System ☀



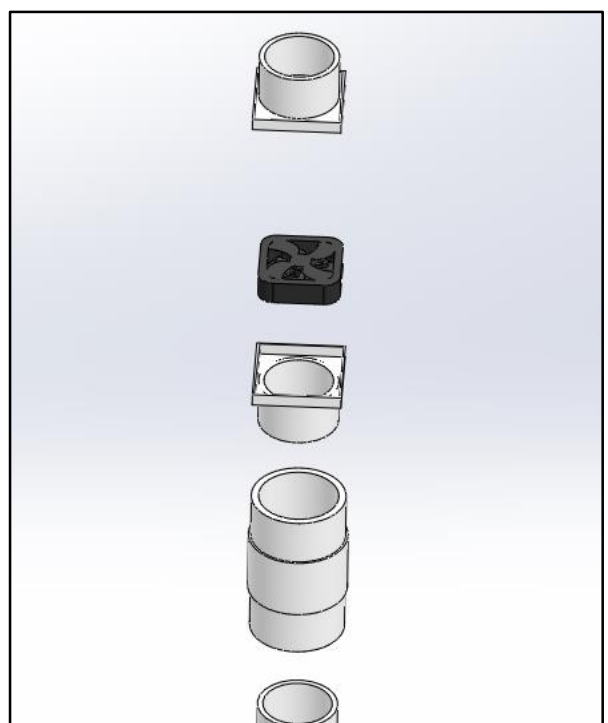
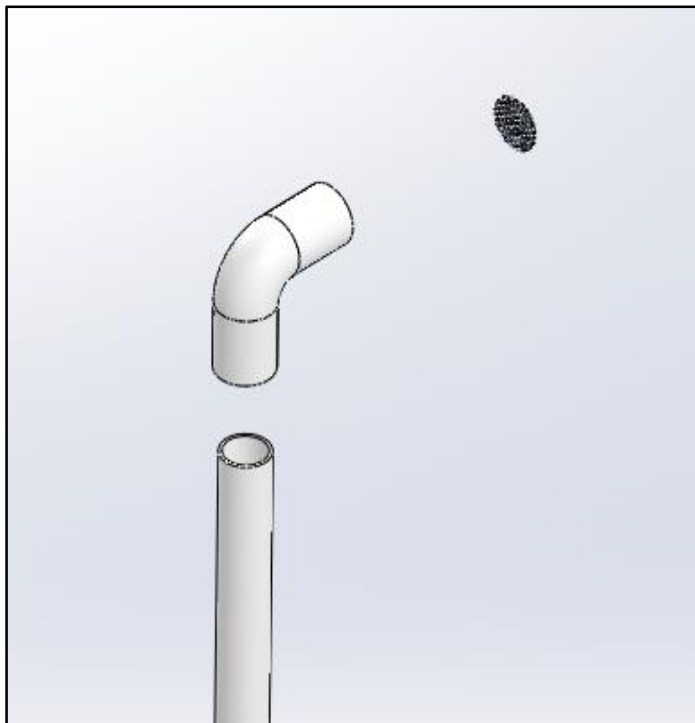
PVC pipes work well as the main component of the system. The PVC pipe should stem out horizontally from the composting tank before using an elbow piece to turn the PVC pipe vertically upward, ideally above the level of the house's roof to prevent any odor from venting near windows. The top of the PVC pipe should have both a metal mesh sheet cover to keep out vermin and a metal roof or elbow piece to keep out rainwater. To optimize the ventilation system, a small fan, such as one from a computer, can be utilized inside the PVC pipe to help circulate air.

Elbow and Connector Portion of the Ventilation System



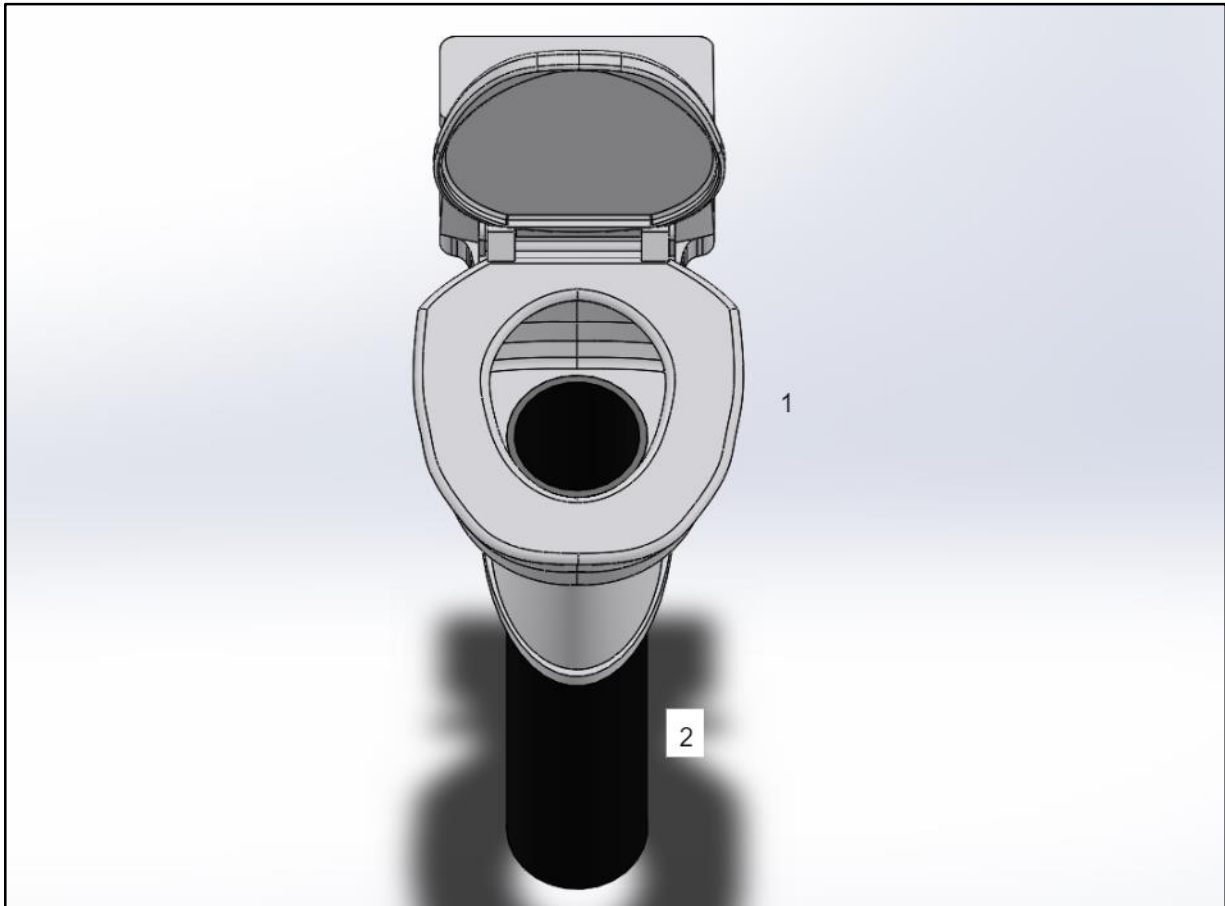
Top part with mesh segment

Fan segment



How to Install a Composting Toilet 🌞

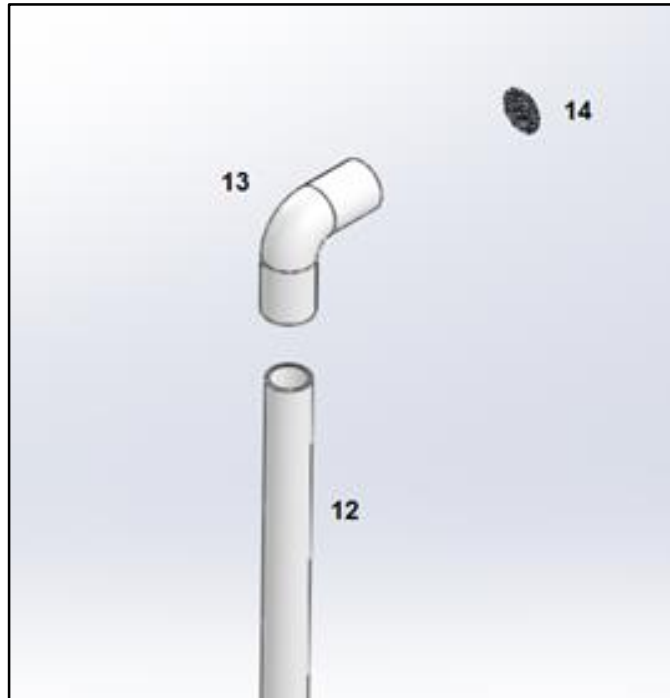
Set up the pedestal



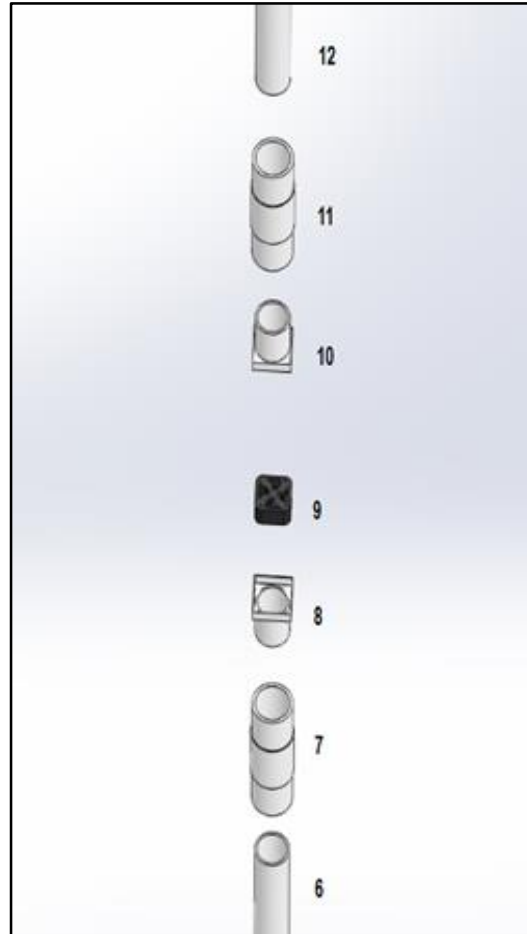
1. Find an old ceramic toilet [1] that is no longer in use.
2. Use a glass cutter to drill a hole with a 180mm diameter into the bottom of the bowl.
3. Insert the 1,000mm black plastic tubing [2] through the newly cut hole.
4. Secure the black tube [2] and the toilet bowl with a water-proof sealant.

Set up the ventilation system

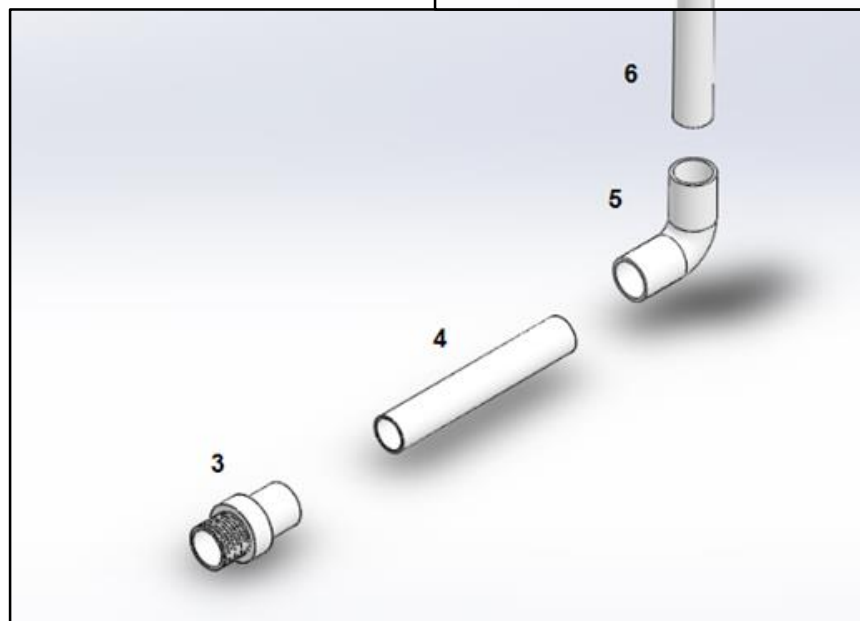
Top



Middle



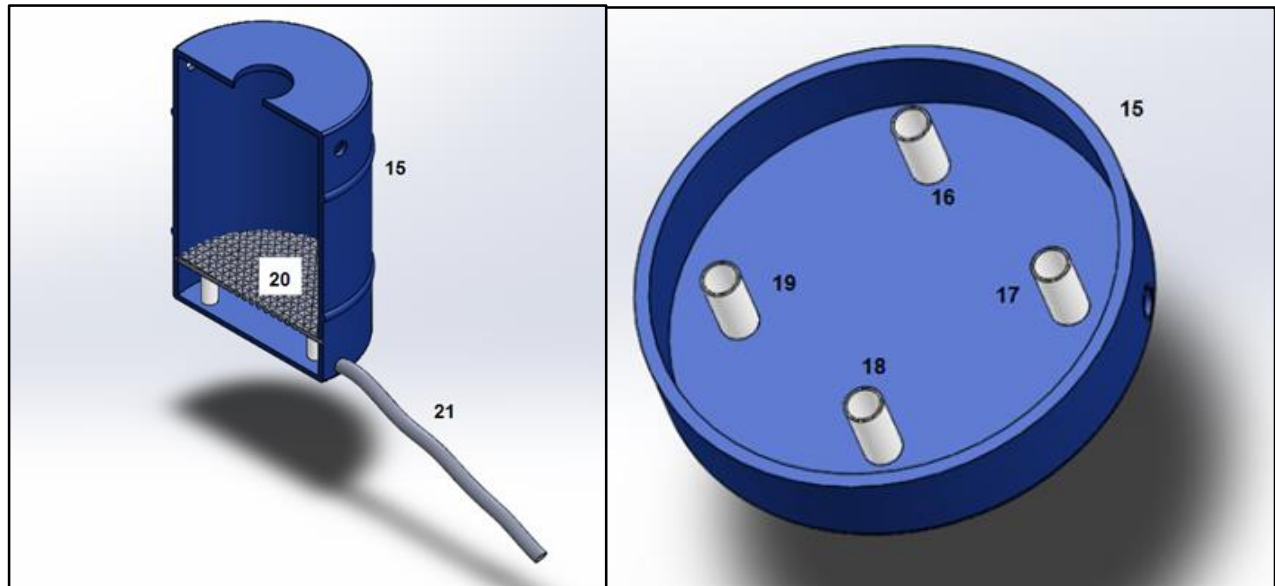
Bottom



Set up the ventilation system (continued)

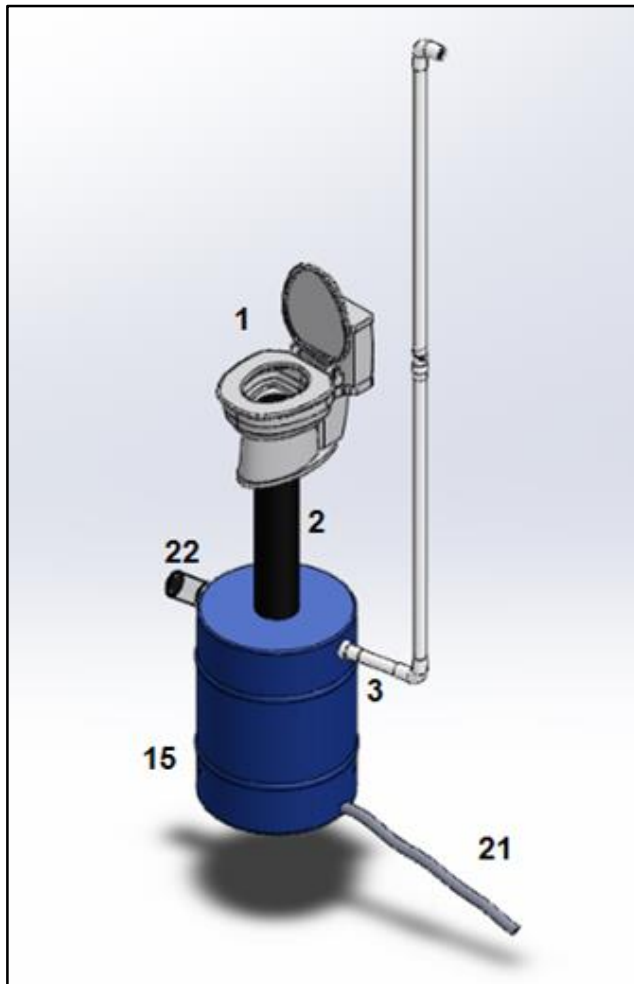
1. Attach the PVC Male Adapter [3] to one of the 320mm PVC pipe [4].
2. Attach the 320mm PVC pipe [4] to one of the PVC elbows [5].
3. Attach the previous PVC elbow [5] to one of the 1,500mm PVC pipes [6].
4. Attach the previous 1,500mm PVC pipe [6] to the PVC connector [7].
5. Attach the previous PVC connector [7] to the PVC square housing [8].
6. Insert the fan into computer fan [9] into the PVC square housing [8].
7. Attach the second PVC square housing [10] on top of the computer fan [9].
8. Attach the second PVC connector [11] to the second PVC square housing [10].
9. Attach the second 1,500mm PVC pipe [12] to the second PVC connector [11].
10. Attach the second PVC elbow [13] to the second 1,500mm PVC pipe [12].
11. Insert the 2" diameter circular mesh [14] inside of the second PVC elbow [13].

Set up the composting bin



1. Drill a 180mm diameter hole into the center of the composting bin [15] lid
2. Remove the lid of the composting bin [15]
3. Using water-proof sealant, attach the four 120mm PVC Pipes [16-19] equal distance from each other around the bottom of the bin [15]
4. Insert the 640mm diameter mesh circle [20] into the composting bin [15] so it is resting on top of the four PVC pipes [16-19] on the bottom
5. Drill one hole with a 2" diameter 60mm from the bottom of the composting bin [15]
6. Attach the long plastic tube [21] to the 2" hole
7. Drill another 2" hole directly above the previous 2" hole approximately 120mm from the top of the bin [15]
8. Drill a third 2" directly across from the second hole so that it is located 120mm below the lid on the opposite side of the composting bin [15]

Putting it all together



1. Put some sugar and water into the clear empty bottle [22] and attach it to the third hole that was drilled into the bin
2. Attach the whole composting bin system [15] to the 1,000mm black plastic tube [2] (Place the composting bin on an elevated object if it will not reach it standing alone)
3. Attach the whole ventilation system [3] to the second hole that was drilled in the composting bin [15], so that it is going vertically upwards the long way

How to Maintain a Composting Toilet

Composting toilets require different maintenance than flushing toilets that the owner must acclimate to. Composting, updating, additives, and emptying the bin are all pieces of the composting toilet puzzle!

Like any toilet, a composting toilet will get dirty. When it's time to clean it, be sure to use a biodegradable detergent so you don't hinder the composting process.

Composting

Compost can be used in any garden or yard after it has sat for at least 6 months!

System updates

As your needs change, your toilet can too! Design features can be added or adapted

Additives

Organic materials need to be added in order for the waste to be break down properly.

Emptying the bin

The composting bin needs to be emptied every 6 months.

Additives

Due to the high nitrogen content of human excreta, you must add supplemental materials to aid the composting process.

A 1:30 nitrogen to carbon ratio is needed for good compost. However, a 1:8 nitrogen to carbon ratio is reached from solely feces.

In order to achieve a good ratio, you must include additives to homogenize your compost. These additives also create air pockets in the human waste in order to ease aerobic decomposition. Additives can be any somewhat dry plant material, as long as it is ground into the appropriate consistency, such as coco coir, paper products, or cardboard. Below are our recommended additives.

Recommended Additives:

- **Sawdust**
 - Sawdust is the most popular additive for composting toilets. It has a nitrogen to carbon ratio of 1:60, so just a handful will bring the ratio to where it needs to be.
- **Dry leaves**
 - Dry leaves are also a popular option since they are extremely inexpensive and easy to find.
- **Wood or Bark Chips**
 - Wood and bark chips also soak up moisture during the composting process, helping to mitigate odor.

Disclaimer:

There are some additives that we advise against including in your compost.

- **Lime**
 - Lime often kills all important microorganisms that allow the composting process to occur.
- **Food Waste**
 - You should only include food waste in your compost if you feel comfortable with potentially attracting animals.

How to Empty the Bin

1. Prepare a space for the compost to be dumped out.
2. Unscrew the leach tube from the bin.
3. Unhook the ventilation pipes from the bin.
4. Unhook the chute from the composting bin.
5. Bring the composting bin to where the compost pile will be.
6. Be sure to not damage the perforated bottom.
7. Open the lid of the bin and turn it on its side.
8. Dump all the contents from the bin into the pile.
9. Add some compost to the bottom of the empty bin to provide a base for new composting to happen.
10. Screw on the leeching tube.
11. Hook up the chute to the composting bin.
12. Reattach the ventilation pipes.

Helpful Tips:

- **Don't reattach a completely empty compost bin. Your compost needs microorganisms and organic material to get started again.**
- **Always detach the ventilation pipes, leaching tubes, and chute before trying to move the compost bin!**

Compost Use 🌞

The compost from your toilet can be used like any other compost! Make sure you let your compost completely break down (at least 6 months, but we recommend a year) before you disperse it. Otherwise, there is a risk of spreading harmful bacteria. If you are concerned that the compost has not finished breaking down, you can add organisms such as worms to the mix to help the process along. But once it's fully composted, feel free to spread it wherever you want!

Here's a few ideas to get you started:

1. Mix it with other compost
2. Topsoil
3. Lawn
4. Around fruit trees
5. Scatter it in the forest
6. Indoor plants
7. Flower Garden
8. Vegetable Garden*

*While fully composted human waste is safe, many people prefer to avoid using the compost on food crops.



Trial and Error

This is by no means a perfect design. When building your own composting toilet, there can be some growing pains. While this is the design we think is easiest to build, install, and maintain, feel free to make your own modifications!

Vermicomposting

Vermicomposting is composting with the use of earthworms to aid in the composting process. If you want to speed up your composting add a few handfuls of earthworms to your composting bin.

Urine diverter in the seat

People have had varying degrees of success adding a urine diverter to the seat. If the urine diverter is too large, solids will get caught. However, if the diverter is too small, it can be difficult to use. Depending on the needs of your household, you could add a urine diverter to the toilet seat to collect the urine in a separate bin. This urine can be diluted with water and used as a fertilizer (approximately 1:50 ratio).

A resident in Monteverde has seen success using a car tire to divert urine in his system. Another has a modified toilet seat with hole in the front of their toilet with a pipe to collect urine.

Compost stirrer

Some composting toilet systems have a stirrer to stir the compost in the bin. Depending how your compost is forming, you can stir your compost every few weeks. This is entirely up to your preferences.

Multiple Bins

Constructing a second or third composting bin eliminates the need for open compost piles. You can put your bins on a rotation so when one is full and the compost is forming, another one can be attached to your system.

Troubleshooting

My composting toilet smells bad!

1. Make sure the lid is closed when not in use.
2. Make sure the lid is tightly fitted to the opening to stop any odor from escaping.
3. Try a different additive. Depending on your system, different additives may work better at absorbing liquids or masking the smell.
4. Check your ventilation system, make sure it isn't clogged and your fan is still functioning.

There are flies.

1. Make sure the lid is closed when not in use.
2. Check the fly trap, it might be full.
3. Add more additives after every use, the ratio may be off which results in a bad odor that can attract flies.
4. Get an additional fly trap.

My fan broke.

1. Replace it with a solar-powered fan you can buy from a local electronics store.
2. Remove the fan completely. While it is a helpful addition to the ventilation system, they aren't necessary.

This can happen because there's too much condensation in your ventilation pipe due to Monteverde's climate.

There's too much liquid in my compost.

1. Add more additives! They improve your compost by absorbing excess liquid.
2. If your regular additives are not working, try adding soil to add more solids to your system.
3. Check your drainage system and urine diverter, one or more may be clogged.

FAQs

What if my composting toilet smells?

Composting toilets require the use of additives, such as sawdust or dry leaves, in order to adjust the carbon to nitrogen ratio. Adjustment of this ratio also results in a significant reduction in odor.

Will it be more expensive?

The upfront cost of installing a composting toilet is greater than that of installing a flushing toilet if you already have the infrastructure to accommodate them. However, owning a composting toilet saves money over time.

Will it require more maintenance than my flushing toilet?

You can design your composting toilet with maintenance requirements in mind. Larger tanks are often tied to a much lower necessary emptying frequency. As long as you continue including additives, the waste will naturally detoxify and become compost on its own.

Are composting toilets sanitary?

Any potentially dangerous bacteria is destroyed in the composting process. As long as the waste has time to rest and enough additives are included, humanure compost is just as sanitary as any other type of compost.

FAQs

Can I put toilet paper in?

Adding toilet paper to your compost bin is completely fine. In fact, it's better for your compost! It aids in balancing the carbon to nitrogen ratio. Higher ply toilet paper will take longer to compost but will break down eventually.

How long will it take to fill the barrel?

For an average family of four, the composting bin will take approximately six months to fill. Depending on how often it is used and how much additives you are using, the bin could fill faster. If you find your bin is filling up too quickly, you can upgrade to a larger bin.

How does the composting process work?

The waste that you produce is 70-90% water. During the composting process, this water evaporates and exits the composting bin through the ventilation system. The compost pile reduces to 10-30% of its original volume. Any pathogens present in the compost pile is destroyed by the aerobic breakdown.

How do I know when the compost is ready to use?

You know your compost is ready to use when it looks and smells like very dark, rich soil.

Resources

- *The Humanure Handbook* by Joseph C. Jenkins
- *The Composting Toilet System Book: A Practical Guide to Choosing, Planning and Maintaining Composting Toilet Systems, an Alternative to Sewer and Septic Systems Book* by David Del Porto and Carol Steinfeld
- *“Do It Yourself” DIY Compost Toilet Manual* by Nature Loo
- Blog Post about Composting Toilets on corclima.org

Special thanks to the members of the Monteverde community who shared their knowledge with us.



Fact vs. Fiction

Disposing of waste through sewage systems is a lost opportunity to reuse a valuable resource for agriculture. Society's common misconceptions about dry composting toilets serve as one of the greatest obstacles for their widespread use.

Fiction: Human waste is unsafe to use as compost.

Fact: When given the proper amount of time to compost, all the harmful bacteria in human waste is killed.

Fiction: Because there is no water, dry composting toilets are bad for your health.

Fact: There is no scientific evidence supporting that the use of water is more sanitary.

Fiction: Dry composting toilets are just latrines.

Fact: Dry composting toilets are more advanced than latrines and require more maintenance.

Fiction: Dry composting toilets smell bad.

Fact: When owners maintain their toilet properly and have adequate ventilation, composting toilets have no more odor than a flushing toilet.



How to get started

For more information about dry composting toilets and how to install them, checkout CORCLIMA's blog post and their manual to have your own composting toilet.

Blog Post: [link](#)

Manual: [link](#)

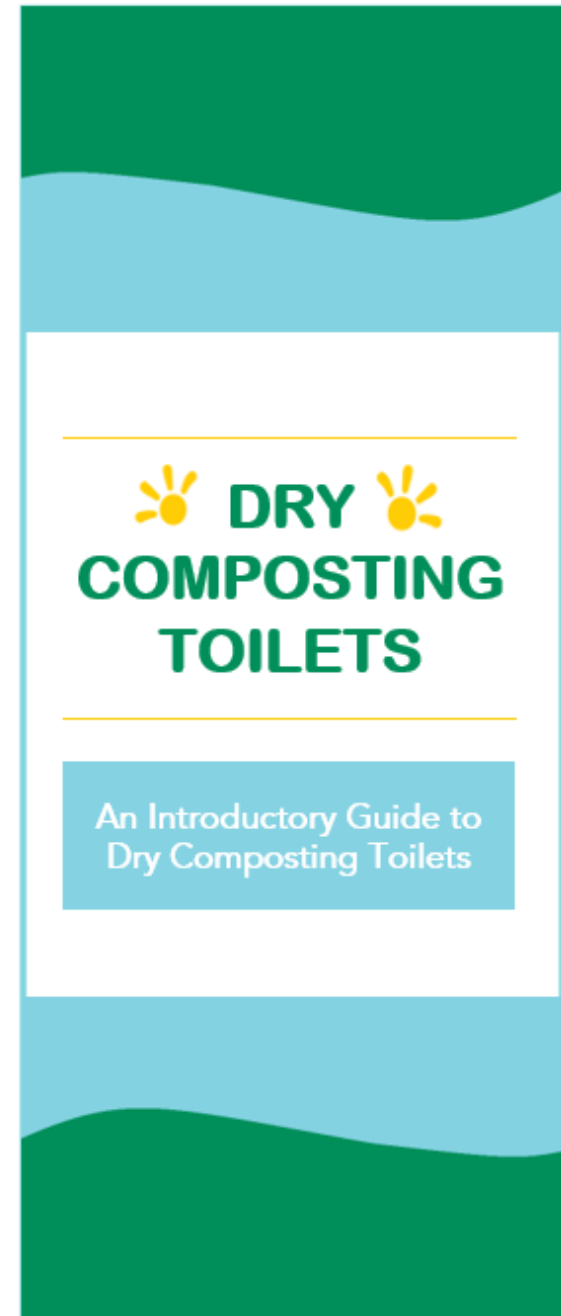
About Us

We are the Monteverde Commission on Resilience to Climate Change (CORCLIMA). Our mission is to unite efforts in Monteverde to lower emissions, capture carbon and adapt to climate change.

Contact Us

CORCLIMA email:
climaticamonteverde@gmail.com

Web: corclima.org



What is a dry composting toilet?

A dry composting toilet is a type of toilet that treats both solid and liquid human waste through composting without the use of water.

In the dry season, a lot of springs will dry up, so we've had to have water rationing ... people are not aware of how important it is to save water in Monteverde."

- a Monteverde resident



[Picture of a dry composting toilet]

COMPOSTING TOILETS

An eco-friendly alternative to flushing toilets

FLUSHING TOILETS WASTE WATER

For a family of five, the average amount of water wasted from flushing toilets is:



28% OF TOTAL WATER USE IS FROM FLUSHING TOILETS

(EPA, 2015)

Composting Toilets reduce toilet water usage by

100%

What could you do with 72,000 litres of water?

90 YEARS of adequate drinking water for the average female

480 SHOWERS per 150 litre shower

(EPA, 1991) (EPA, 2015)

COMPOSTING TOILETS PROTECT THE ENVIRONMENT

97.5%

OF MONTEVERDE RESIDENTS HAVE SEPTIC SYSTEMS

97.8%

DISCHARGE GREYWATER DIRECTLY INTO THE ENVIRONMENT, DESPITE LAWS

(Green, King, Papp, Sullivan & Swanson, 2015)

Composting Toilets SAFELY and NATURALLY treat waste!






Nutrients from waste are returned to the soil



[A representation of a composting toilet system]

How do they work?

-  Waste enters the dry composting toilet the same way as a flushing toilet. Since the designs require little to no water, it relies on gravity instead of water to move the waste.
-  The waste will break down within the tank. Additives, such as sawdust and leaves, aid the composting process.
-  After sitting for a minimum of six months, the compost can be used as fertilizer for vegetation.

Appendix K. Blog Post

What is a dry composting toilet?

A dry composting toilet is not a latrine. It is a toilet that treats human waste through composting without the use of water.

Why are they better than flushable toilets?

- With more than half the people in the world affected by water scarcity, conserving water is essential. In Costa Rica, a family of five will use an average of 24,000 litres of water every month. Flushing toilets contributes to 28% of this monthly consumption. This means that on average, a family of five will flush approximately 197 litres of potable water down their toilets every day. Flushable toilets use an average of 9 liters of water per flush, depending on the type of toilet. On the other hand, dry composting toilets use no water.
- The waste is transformed into a resource for agriculture through the composting process.
- Dry composting toilets also eliminate the need for a septic tank.



What's the difference between septic tanks and dry composting toilets?

- Septic tanks hold dangerous bacteria and toxic waste that can leak, while the composting process destroys any dangerous bacteria.
- Unlike toilets connected to septic tanks, this process is aerobic (which means it uses oxygen) and emits carbon dioxide. Septic tanks emit methane which is about 23 times stronger than carbon dioxide in warming the atmosphere.
- Septic tank waste can pollute rivers when not disposed of properly, while compost can safely be returned to the environment once it is fully broken down.



How do they work?

Waste enters the dry composting toilet the same way as a flushing toilet. Since the designs require little to no water, it relies on gravity instead of water to move the waste. The waste will break down within the tank. Additives, such as sawdust and leaves, aid the composting process. After sitting for a minimum of one year, the compost can be used as fertilizer for vegetation.

What are some common misconceptions about composting toilets?

Disposing of waste through sewage systems is a lost opportunity to reuse a valuable resource. Society's misconceptions serve as one of the greatest obstacles for widespread use of dry composting toilets.

Fiction: Human waste is unsafe to use as compost.

Fact: When given the proper amount of time to compost, all the harmful bacteria in human waste is killed.

Fiction: Because there is no water, dry composting toilets are unhygienic.

Fact: There is no scientific evidence supporting that the use of water is more sanitary.

Fiction: Dry composting toilets are just latrines.

Fact: Dry composting toilets are more technologically advanced than latrines and can be installed indoors.

Fiction: Dry composting toilets can't be inside.

Fact: They can be built outside in free-standing structures or installed inside a home or other building.

Fiction: Dry composting toilets smell bad.

Fact: When ventilated and maintained properly, composting toilets have no more odor than a flushable toilet.

COMPOSTING TOILETS

An eco-friendly alternative to flushing toilets

FLUSHING TOILETS WASTE WATER

For a family of five, the average amount of water wasted from flushing toilets is:



28% OF TOTAL WATER USE IS FROM FLUSHING TOILETS

(Rico, 2015)

Composting Toilets reduce toilet water usage by

100%

What could you do with 72,000 litres of water?



(Kleiner, 1999) (Rico, 2015)

COMPOSTING TOILETS PROTECT THE ENVIRONMENT

97.5%

OF MONTEVERDE RESIDENTS HAVE SEPTIC SYSTEMS

97.8%

DISCHARGE GREYWATER DIRECTLY INTO THE ENVIRONMENT, DESPITE LAWS

(Brown, King, Papa, Seillac, & Syvertsen, 2008)

Composting Toilets SAFELY and NATURALLY treat waste!



Nutrients from waste are returned to the soil

How do I get started?

You can be part of the solution to climate change! By installing a composting toilet, you can contribute to the trend of environmentally conscious decisions. For more information about dry composting toilets, check out the composting toilet instructional manual.

Sources

- Eisner, S., Florke, M., Guillaume, J., Kummu, M., Moel, H., Porkka, M., Siebert, S., Veldkamp, T., Ward, P. (2016). The world's road to water scarcity: shortage and stress in the 20th century and pathways towards sustainability. Bethesda, MD: National Center for Biotechnology Information. Retrieved from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5146931/>.
- Gato-Trinidad, S., Jayasuriya, N., & Roberts, P. (2011). Understanding urban residential end uses of water. *Water Science and Technology*, 64(1), 36-42. Retrieved from <http://dx.doi.org/10.2166/Wst.2011.436>
- Jenkins, J. C. (1999). *The humanure handbook: A guide to composting human manure* (2nd ed.). Grove City, PA: Joseph Jenkins, Incorporated. Retrieved from <https://humanurehandbook.com/downloads/H2.pdf>
- Rico. (2015). *How Much Water Do You Use Daily?* Costa Rica: The Q Media. Retrieved from <https://qcostarica.com/how-much-water-do-you-use-daily>