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Sustainability of the Composting Toilet

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SUSTAINABILITY OF THE COMPOSTING TOILET

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Introduction.

Composting toilet, dry toilet, waterless sanitation, aerobic sanitation, earth closet, evaporating vault latrine, ecotoilets: if you were to have dropped any of these names three or four years ago, very few people would have known what you were talking about. And even fewer would stick around to listen to your explanation. Unfortunately, in the twentieth and twenty-first centuries, alternative waste treatments have generally been considered a “hippie” or “tree-hugging” technology. While the environmental activist community is happy to claim them for their own, these systems have sadly been relegated to just another product of the “green-wash” movement, and a dysfunctional one at that.

In very recent years, however, the composting toilet and its alternative counterparts have risen to a new level of fame. With sustainable development becoming such an integral part of foreign policy and first world benevolence, the products that were green-washed in the last few decades have been introduced to the global spotlight. And, consequently, to a whole new level of scrutiny.

Most notably, alternative toilets have been a large focus of the Bill and Melinda Gates Foundation’s “Reinvent the Toilet” campaign and their quest for safe sanitation. The Gates Foundation claims that four out of ten people globally do not have “a safe way to poop,” and while some might argue that even fewer dispose of their wastes in an environmentally safe manner, the truth is that the developing world suffers extreme economic, social, and environmental disadvantages when it comes to safe elimination and treatment of wastes (Bill & Melinda Gates Foundation, 2011). Their goal is to approach the concept of waste management from a completely new perspective: seeing the toilet as not just a way to remove wastes and their accompanying contamination from the immediate

community, but as a system that can sustainably produce energy, fertilizer, and even clean drinking water (Bill & Melinda Gates Foundation, 2011). To jumpstart this revolution, they asked the world's top engineers to participate in a contest to see who could design and build the most innovative new toilet. The winner created a solar powered toilet that generates both hydrogen and electricity (Bill & Melinda Gates Foundation, 2011). Hundreds of companies and universities, including the University of Colorado, also participated and designed systems that sanitized water, produced fertilizer, improved decomposition efficiency, and even produced charcoal-like fuel (Bill & Melinda Gates Foundation, 2011).

The technology itself, however, isn't even half the battle. In fact, it is probably closer to a third. When developing a truly sustainable system, it has to be designed for environmental, economic, and social success. Though many of these systems are technologically and environmentally sound, it will be a long time before they are economically feasible and before they are socially appropriate. This is where one of these technologies, the composting toilet, has the most opportunity for success.

The composting toilet is a cost-efficient waterless sanitation system that uses aerobic decomposition to remove pathogens from human waste (Jenkins, 2005). The technology aims to combine the effects of the proper amount of heat and moisture with naturally occurring microbes to decompose waste materials into safe, usable fertilizer.

The idea behind the composting toilet is based on a relatively simple ecological principle; that if food begets waste, waste should also beget food. This principle is a large part of the global movement towards sustainability and can also be called a 'closed-loop cycle' (Vega, 2010). The composting toilet is designed to close the loop between food and

waste in a sustainable manner and also without the addition of a large amount of other inputs.

The composting toilet is also a notable part of modern sustainability because of its ability to operate without water. This function is not only an attractive option for developing communities, but for developed communities as well, as water is becoming a scarce resource worldwide (Seckler et al. 1998). By decreasing the possibility of water pollution and contamination, the composting toilet not only conserves, but also works to protect global water sources.

While the composting toilet is sustainable in theory, however, it is increasingly obvious that in practice, it is rarely so efficient. And while the toilet suffers serious technological flaws and many environmental challenges, overcoming these would only be addressing part of the issue. In addition to exploring the biological sustainability of the composting toilet, my thesis paper will address the little-explored social, cultural and psychological issues surrounding the proper use of the composting toilet. I will use this joint approach of a technological evaluation paired with a cultural analysis to examine the reasons behind the low success rate of the composting toilet as a global waste management technology. I will also use the conclusions I draw from this analysis to provide a set of recommendations for the design and implementation of future composting toilets and other alternative waste treatments in an effort to contribute to a greater body of knowledge on global water and waste issues as related to the communities they affect.

History of the Toilet

Sanitation itself is a relatively new player in the arena of human history. For the majority of our recorded history, human waste has been disposed of rather carelessly and with little regard to sanitation and safety. Practices such as open defecation are still in use in many developing areas of the world despite our knowledge of the incredible dangers they pose to human health. Open defecation, or relieving oneself in a public, unregulated space, was the primary method of “waste management” in most of the world until the 1500’s (Schladweiler, 2011).

While open defecation began to raise eyebrows (and noses) in the late 1500’s, it was not yet out of concern for human health, but mostly in an effort to increase convenience and pleasantness. Etiquette books from the 16th and 17th centuries prescribed rules for how to handle encounters with people who were relieving themselves in public, though the rules go no further than to advise not to greet a person while they are in the process of defecating, or if you happened to stumble upon them, to pretend as if it hadn’t happened (Shladweiler, 2011).

Chamber pots (small buckets often stored in velvet covered closets) did evolve during this time period, but were only used by higher-class citizens (Schladweiler, 2011). Their effects, however, were experienced by all as the maintenance of chamber pots often involved throwing their contents off of balconies into the street. This habit persevered through the late 18th century and contributed to etiquette that has lasted until modern times, including the custom of men walking nearer to the street to shelter women from potential waste overhead (Shladweiler, 2011). In certain households, mostly those that housed royalty, some latrine-type structures were used that dumped wastes into cesspools

located directly beneath the house (Shladweiler, 2011). This system proved very dangerous, however, as weak floorboards often gave way and led to drowned guests.

Water and sanitation related disease ran rampant in these times, especially in heavily populated urban areas. Fleas from the rats who thrived in the waste material were the main carriers of disease in cities (Shladweiler, 2011). They transmitted diseases such as cholera and typhoid that could easily wipe out an entire village. These epidemics sometimes spread beyond the local context, however. In 1817, a huge cholera epidemic broke out in Calcutta, India. By 1832, it had reached New York City, resulting in a widespread panic that nearly shut the city down (Grondzik et al, 2010). A similar incident occurred in 1961 in Indonesia and spread to Latin America by 1991 (Grondzik et al, 2010).

In 1878, Louis Pasteur made the most significant contribution to sanitation in its history by linking disease with microbes occurring in 'septic fluids,' as he termed them (Pasteur, 1878). This discovery led to a movement known as Germ Theory that began to link many diseases with bacteria and microbes occurring naturally in 'unsanitary' conditions. Making this important link between sanitation and health led to a complete cultural revolution and a desperate movement to remove bodily wastes from developed areas.

The first "sewer" systems were developed in Paris in the 1300's. They were initially open-air waterways, but covered sewer systems, such as the Menilmontant, also developed and were known as the "Great Drain" of Paris (Schladweiler, 2011). These systems were primarily used to direct storm water out of city streets, and also inadvertently carried away the wastes "disposed" there (Schladweiler, 2011). While cesspits (cesspools that allow

percolation into the soil) and cesspools were still widely used, city officials began to notice that they compromised the subsoil and were too difficult to maintain (Schladweiler, 2011).

Another innovative program that developed during this period was the use of human wastes as fertilizer for gardens and agricultural areas. This was known as “Nite Soil” and initially also included hauling away collected human excrement and dumping it in nearby rivers or community cesspools (Schladweiler, 2011). The practice of using human wastes on farms, however, had been in practice in Asia for thousands of years (King, 1911). Night soil applications were used as fertilizer for all crops, including staples such as rice and wheat (Ellis, 2012).

To create this fertilizer, solid and liquid human wastes were collected and stored (sometimes separately) in slate lined tanks (Ellis, 2012). Pig manure and urine might also be added to the mixture, which was allowed to settle and then applied directly to fields (Ellis, 2012). It’s application is still considered more successful than some chemical fertilizers because it is so heavy that it does not often wash or blow away from the area it was applied to (Ellis, 2012). Night soil also does not contribute to the runoff of high concentrations of nitrogen and phosphorus (though it is a very good source of both) into nearby waterways, which could potentially cause algal blooms and depleted oxygen content for marine ecosystems (Ellis, 2012).

Obviously, the night soil program did not come without its flaws. The raw application of sewage to food crops clearly presents an environment for the spread of disease such as intestinal parasites, hepatitis, cholera, and typhoid (Jenkins, 2005). Raw sewage used in Berlin in 1949 was said to be the cause of an outbreak of a worm-related diseases and in the 1980’s it was blamed for a bout of typhoid in Santiago (Jenkins, 2005).

Night soil was also thought to be the cause of a cholera epidemic in Jerusalem and South America in the 1970's and 1990's (Jenkins, 2005). But the program did lead to an important connection between "waste" and food. In areas where it is still used, such as Shanghai, which has a population of over 14 million, produce is so plentiful that an exportable surplus is harvested every year (Jenkins, 2005). In its earliest years, however, the nite soil program was so expensive that few people could afford it and it was eventually dismissed (Schladweiler, 2011).

After the cholera outbreak in the early 1800's, Paris began to construct a more complex sewer system designed by Eugene Belguard that became one of the city's greatest prides (Evans, 2009). They were so popular, in fact, that it became a tourist event to take a boat ride through the canals (Evans, 2009). These sewer systems initially only properly served the wealthy communities and left many poor without access to running water (Evans, 2009), but by 1930, the sewers were 6 ft. high, regularly maintained, and ran under every street in the city (Schladweiler, 2011).

London began constructing sewers around the same time after many occurrences of cholera, typhoid, and, of course, the Great Plague of 1665 (Schladweiler, 2011). London was unique, however, in the fact that the main drainage outflow, the Thames River, was 30 feet higher in elevation than the city itself (Schladweiler 2011). What waste that did flow into the Thames, mixed with the same source of water used to extract drinking water for the city and contributed heavily to disease (Daunton, 2012). The Metropolitan Commission of Sewers was given the responsibility of regulating sewer usage, but was not supplied with adequate power or funds to improve the conditions (Daunton, 2012).

In 1858, however, the filth of the Thames reached an all time high (Daunton, 2012). Because Parliament was located downstream from most of the households where waste was being added to the river, they had very extreme experiences with the odors from the Thames, especially in summertime months (Daunton, 2012). Because of the height of the city in relation to the river, the Thames became an open-air cesspool when flows were not strong enough to carry wastes away (Schladweiler, 2011). In order to combat strong odors, large amounts of lime were added to the river and the drapes of the House of Parliament were soaked in chloride to help reduce the smell, but it rarely worked (Schladweiler, 2011). Shortly after realizing that the odor would not be masked, Parliament granted the Metropolitan Commission of Sewers adequate funding and power to redesign their sewer system (Daunton, 2012). The last cholera outbreak in London ended in 1866 (Schladweiler, 2011).

There was, however, a period of history where the uses of water-intensive sanitation measures were questioned. In 1859, the first “composting toilet” was invented by Reverend Henry Moule who believed that dumping human excrement into rivers was a waste of God’s nutrients and polluted His rivers (BBC, 2012). He developed a system that mechanically deposited earth material or ash into a bucket after a person was finished relieving his/herself (BBC, 2012). This combined material was then taken out into a garden and dug into the ground (BBC, 2012). This system was not the first of its kind, but it was the first to receive a patent in 1873 and it was sold in Army and Navy stores for about 30 shillings (BBC, 2012).

The Creation of a Sustainable System

With the compelling ease and relative safety of water-based waste removal, though, the flush toilet became a staple in the developed world early in the 20th century.

Today, the conventional toilet is the largest consumer of domestic, potable water in the developed world. It is also the largest polluter. With a “typical” flush toilet system (one that uses 5-7 gallons per flush), one person will use around 7,300 gallons of potable water per year. The Environmental Protection Agency (EPA) recently started a program designed to encourage water conservation in the home called Water Sense. This program certifies toilet models that consume 20% less water per flush (the average being around 1.6 gallons per flush). On average, the EPA estimates that switching to a Water Sense model can save a family of four 4,000 gallons of water per year and over \$2,000 over the lifetime of the product (EPA, 2012). While water-saving toilets are only a short-term solution to a much greater issue, they are also an important step in the right direction.

The Water Sense program supports not only the conservation of water, but also a greater theme of sustainability. The most common definition of sustainability is ‘meeting the needs of today’s generation without compromising the ability of future generations to meet their own needs’. This broad definition of sustainability can and should be divided into smaller pieces, though. For modern environmental scientists, the theme of sustainability is often subdivided into three pillars: environmental sustainability, economic sustainability, and social sustainability. The idea is that these three pillars work to hold up a greater ideal of sustainable development, but if any one of them falters, the whole system collapses. Some people prefer to think of the three pillars as two subsets of a greater goal of

environmental sustainability, but the concept is the same in either case. Without the cooperation of all parts at all levels, nothing can be truly sustainable.

This three-part system is an effective way to evaluate both the sustainability of composting toilets and other waterless treatment systems and will be integral to the both the technological and cultural analysis of different systems. The overarching theme of environmental or ecological sustainability is the focus of these pillars. The importance of environmental health for global development was recognized at the 1992 Earth Summit in Rio de Janeiro, but more explicitly developed at the 2002 Summit in Johannesburg (United Nations, 2012). Without a healthy environment to supply adequate food, water, and raw materials for development, a community cannot successfully develop and sustain itself. The summit also called attention to how much we depend on the natural environment to dispose of and clean up our wastes, highlighting both our high contributions of carbon dioxide and other greenhouse gases to the atmosphere and the scarcity of fresh water for drinking and sanitation (United Nations, 1997).

A healthy environment provides us not only with a hospitable home and materials for development, but is the sole provider of life-sustaining necessities such as food, minerals, fuels for energy, and even the air we breathe and thus should be a major factor in daily practices, including business and development. The harsh reality, however, is that the health of the environment is not often considered as an important contributor to human wellbeing. We are far more comfortable addressing the economic pillar as it relates to our daily activities and overall life-satisfaction.

And the economic pillar does deserve a fair amount of our attention, as it has become the primary motivation for change in the last few centuries. It is evident, when

looking at successful development in recent years, that a technology that cannot be economically supported will not continue. This is especially true for (but certainly not limited to) developing communities. While practices of earlier generations supposed that charity from wealthier countries would rescue impoverished nations, it is becoming increasingly apparent that these countries must be able to economically support themselves and participate in the global market in order to relieve poverty and improve the human condition. Especially as the increasing gap between the wealthy and the poor exacerbates economic dependency, it is important that new developments be self-sustained and, more importantly self-motivated.

This motivation and the methods used to derive it fall under the social pillar. This pillar incorporates the idea of community and culture in development. The development in a region must be organic and must directly benefit those living in the community. It also must incorporate their own cultural nuances if it is to be accepted and continued- and it must not have the values of another culture forced upon it unwillingly. This is often one of the hardest pillars to address, as it is difficult to understand what motivates a community when you are an outsider. It is also, the pillar that presents the greatest opportunity for global cooperation, for if we learn to listen to and understand each other, we drastically increase our chances of avoiding unnecessary conflict.

Though the challenge may seem insurmountable, it is possible to create a system of sustainable development that supports all three pillars. Success is most often achieved not through a centralized method, but through the decentralization of responsibility, decision-making, and enforcement. And though the regulation is local, it requires a global commitment and a global investment to ensure the longevity of a project. The composting

toilet, because of its simplicity in design and application, and because of an increasing necessity for a sustainable system, has potential to satisfy the demands of some pillars, but the question that begs to be asked is can it support the greater weight of sustainability?

Waste Management Today

Our current system of waste management and treatment, unfortunately, often falters under the weight of sustainability. According to Duncan Mara Sanitation, a sanitation system is considered sustainable when:

- It functions properly and is used
- It provides the services for which it was planned including: delivering the required quantity and quality of water; providing easy access to the service; providing service continuity and reliability; providing health and economic benefits; and providing adequate sanitation access.
- It functions over a prolonged period of time, according to the design life-cycle of the equipment.
- The management of the service involves the community; adopts a perspective that is sensitive to gender issues; establishes partnerships with local authorities; and involves the private sector as required.
- Its operation, maintenance, rehabilitation, replacement and administrative costs are covered at the local level through user fees, or through alternative sustainable financial mechanisms.
- It can be operated and maintained at the local level with limited, but feasible, external support.
- It has no harmful effects on the environment. (Mara, 2012)

In the developed world, wastewater treatment consists mainly of sewage lines that direct wastewater from flush toilets to a publicly owned treatment works (POTW) or wastewater is collected in on-site septic tanks (Center For Sustainable Systems, 2010). The

POTW systems that treat nearly 74% of all wastewater in the United States, however, still allow pollutants into the water system contaminating rivers, shorelines, lakes and estuaries. The treatment plants in the United States alone produce nearly 8 million tons of dry sludge each year. While 60% of the sludge is currently being put to beneficial use (including agriculture and energy production), it must undergo an exorbitant amount of energy intensive treatment before it is safe to use. In some cases, the waste is treated using ultraviolet radiation, but most of the treatment is chemically based, usually involving a chlorination process immediately followed by a de-chlorination process to ensure the health of the receiving body of water (Center for Sustainable Systems, 2010). The energy and chemical waste of treating sewage topples the environmental pillar of sustainability.

On-site septic tanks also contribute to environmental degradation if they are not properly monitored. During heavy rains or in areas with high water tables, untreated effluent can be leaked from the system and is one of the largest contributors to contaminated groundwater (Jenkins, 2005). To avoid these leaks, septic tanks must be pumped regularly (costing their owners between \$150 and \$500) and if they are not properly maintained, repair costs can range between \$1,000 and \$10,000, depending on the size of the tank. These costs are much too high for low-income families, thus toppling the economic pillar of sustainability.

As urban sprawl spreads, sewage lines will have to be extended to include these remote locations. With the addition of more sewage lines, comes a higher cost of maintenance (which, according to the American Society of Civil Engineers, should occur every 15-20 years). Both the cost of renovation and the potential hazards associated with delaying renovations due to shortage of funds would then fall on the taxpayers, disrupting

the social pillar of sustainability (Center for Sustainable Systems, 2010). Conversely, as urban areas become more densely populated, and the land they span becomes more impermeable, the sewer systems that are already in place will be taxed with additional storm water runoff that should have been absorbed by the land (Grondzik et al, 2010). Eventually the current systems will be overwhelmed and will either have to be remodeled or completely replaced.

While the sustainability of current systems of waste treatment in developed countries is questionable at best, the sad truth is that most of the sewage in developing countries enters rivers, oceans, and groundwater completely untreated. In some Latin American countries, such as Peru, more than 85% of sewage runs off into bodies of water without any treatment (Bourke, 2010). Untreated sewage not only contaminates aquatic habitats, but is also one of the major contributors to diarrheal illnesses, which are responsible for 80% of the deaths in children every year (UN Water, 2008). Many of these developing areas lack adequate sanitation because of costs or feasibility of existing technologies. Some simply lack demand for a better system. It is in these areas that the composting toilet could be of great use. The question remains, however, is the technology of the composting toilet able to reduce the amount of pathogens in human waste to safe levels? I will explore this question in my research methods section.

The composting toilet, however, offers more to the realm of global sustainability than simply preventing the spread of waterborne disease. In fact, one of its most significant contributions to sustainability is the fact that the composting toilet is a waterless system. Of all of the water that covers nearly 75% of the Earth's surface, only 0.3% is accessible, fresh water (Klees, 2011). In addition to satisfying the needs of all other life on land, this

water is needed for human agriculture, drinking water, steam generation for turbines, construction, and hygiene.

It came as little surprise to me to discover that a number of composting toilets exist in the Boulder area, seeing as Colorado is known for its progressiveness in the area of sustainability. Yet, being an area so affected by water supply issues, I honestly expected to see more. The front range of Colorado currently operates under the Colorado Water for the 21st Century Act. This is a negotiating process that has been in place since 2004 that works to allocate water from the Rocky Mountain runoff to all areas of the Front Range and further south (Sibley, 2009). The legislation is constantly challenged by the constant increase in population along the Front Range, especially in areas where water is most scarce.

Recently a proposal drafted by the Interbasin Compact Committee addressed the reality of Colorado's water supply. The committee came to the conclusion that water shortages are a reality in the West and that these shortages will cause crisis and conflict in the future if not managed properly (Klees, 2011).

The composting toilet works to help reduce the demand on scarce freshwater resources by supplying a sanitation system that operates entirely without the use of water. In addition, composting toilets provide valuable fertilizer that has particularly high nitrogen content due to the variety in human diet (Jenkins, 2005). This technology, however, is only sustainable if it can efficiently treat human waste and if it can be tailored to a variety of communities.

The Science Behind the Composting Toilet

The composting toilet is a system designed primarily to contain and destroy pathogenic material in human excrement and secondly to compost the excrement with additional material such as toilet paper, natural carbon matter, and sometimes, household food 'waste' (Del Porto et al., 1999). Waste is placed in quotations here because one of the most important ideas behind the composting toilet is that no part of the process can be considered waste. Instead, all inputs and outputs are part of a closed-loop sustainable system where all nutrients and materials produced from the earth (our food) are also returned.

To better understand how a composting toilet operates, one must first have a clear understanding of the composting process in general. The term "composting" means to biologically decompose moist, organic (containing naturally produced carbon) solid matter in an oxygen rich environment (Del Porto et al., 1999). To be considered composting, rather than simply decomposition, the process must occur in a controlled environment where the end product is soil humus rich in nutrients (Del Porto et al., 1999). The composting process requires the presence of certain microorganisms such as bacteria, actinomycetes, fungi, algae, mixomycetes, lichens, microplasms, and can even include soil animals like earthworms, arthropods, protozoa and nemotodes (Del Porto et al., 1999). These microorganisms produce enzymes that break down the complex molecules of organic matter into their simpler parts (Del Porto et al. 1999).

This system, however, depends heavily on the coordination of a variety of factors. The rate and success of decomposition can be determined by a combination of environmental factors (heat, moisture, aeration, etc.), the makeup of the materials being

composted, the health of the microbial community in the compost material, and of course, the knowledge and skill of the person responsible for managing the compost (Del Porto et al. 1999). The most important factor, however, is that there is proper ventilation to ensure that the system remains aerobic. If the compost becomes too saturated with liquids, the entire system will collapse (Del Porto et al. 1999).

When composting is successful, the decomposing material can produce a significant amount of heat, decomposing most successfully at temperatures between 70° and 160° Fahrenheit (Smith et al., 2012). This heating process is caused by the workings of the aerobic bacteria present in the compost. As they digest the nitrogen present in compost matter, they oxidize the remaining organic matter (mostly carbon material) (Smith et al. 2012). If conditions are optimal, they can heat the pile to 100° F in a matter of a few days, but these organisms are especially sensitive to any change in their surroundings including, but not limited to, moisture, acidity, oxygen, and ambient temperature (Smith et al. 2012).

Another very important factor in the success of a compost pile is the balance between carbon and nitrogen material. A compost pile will be most efficient with a carbon-nitrogen balance of between 25:1 and 30:1 (Smith et al. 2012). Microorganisms require carbon material for energy and nitrogen material for protein to build mass and reproduce (Del Porto et al. 1999). If the balance is off, the microorganisms will not reproduce at a sustainable rate and the compost pile will not generate enough heat to decompose its organic material (Del Porto et al. 1999). For the compost overseer, this means that a great deal of attention must be paid to the “food” for the compost pile. In general, brown plant material (wood shavings, yard waste, hay, straw, paper products) provides an excellent source of carbon (Jenkins, 2005). Other compostable material, such as kitchen scraps, are

generally already carbon-nitrogen balanced, but can provide enough excess nitrogen to support some decomposition (Jenkins, 2005). Composting piles with an added source of nitrogen, however, can compost at a more sustainable rate (Jenkins, 2005).

If this information were to be applied to a composting toilet directly, the composting toilet would seem like the best version of a compost pile that could exist. Human waste is exceptionally high in nitrogen, providing a perfect source of protein for aerobic bacteria. In addition, the moisture content in human excrements, especially when combined with urine, is high enough to ensure optimal conditions for composting if managed properly (Jenkins, 2005). This combination allows for rapid reproduction of aerobic bacteria in the compost pile, ensuring the pile will reach a point within the desired temperature range. This temperature range is also optimal for the destruction of harmful pathogens present in human waste.

Pathogens found in human excrement are responsible for a wide variety of illnesses, some of which can be fatal, which creates a sensitive situation with composting toilets. Some of the most common illnesses associated with poor excreta management include amebiasis, cholera, cryptosporidiosis, gastroenteritis, hepatitis, parasites, salmonellosis, shigelosis, typhoid fever, E. Coli, and a variety of other diarrheal illnesses (Del Porto et al. 1999). While these pathogens can't survive for extremely long periods of time once they have left the body, if improperly decomposed, they pose a serious threat to those coming into contact with compost from a composting toilet or even a crop that has been fertilized with composting toilet material (Del Porto et al. 1999).

Heat is not the only part of the compost pile that destroys pathogens, however. In fact, if a composting pile gets too hot, it can destroy its own community of microorganisms,

completely stopping the composting process. Luckily, pathogens are also competing with compost microorganisms for food and air (Jenkins, 2005).

Despite relative success in all of these areas, however, the composting toilet is not a foolproof technology. In fact, in the state of Colorado, composting toilets have gained little popularity, even though it is a generally environmentally progressive state. A good example of the shortcomings of the composting system is found in an experimental waste management trial in Jefferson County, Colorado.

CASE STUDIES

Jefferson County Open Space

Matthew Cox, a man exceptionally enthusiastic about waste management, has been overseeing maintenance operations in Jefferson County Open Space for over two decades. And, as he is happy to tell anyone interested in hearing, he has had his experience with the flaws in composting toilet technology. Jefferson County installed their first composting toilet, a Clivus Multrum model, in 1985. They had heard rumors that the septic tank was soon to become a thing of the past and wanted to get on board with a more sustainable technology. They were also excited to have a toilet that wouldn't have so many deterrents for their patrons. The style of toilets they had been using was similar to that of a porter-potty and had to be filled with fluid and pumped regularly. Because the majority of their toilets were located in remote areas, it was difficult to get a pumping truck out to them. When the season was in full swing, the toilets would fill up especially fast and begin to emit a foul odor. Many people, offended by the smell, would instead use the trails as a bathroom. This is dangerous because human waste contains a large amount of material that will not biodegrade, as wild animal excrements will, including antibiotics and hormones present in the meat and dairy we consume. The pathogens are also more likely to enter water sources and contribute to pollution if the patrons are not careful about where they deposit their waste.

The composting toilet provided an attractive alternative for Cox and the rest of the Jefferson County maintenance team. In fact, they were so excited about the technology, they started a vegetable garden on open space property in hopes of using the compost to fertilize it. By the late 1990's, they had installed 21 Clivus Multrum composting tanks but it

was hard to determine whether or not most of the composting toilets were working properly. In most cases, the tanks were holding too much liquid (mostly from urine) to allow the composting process to continue. The maintenance team worked hard to try and correct any errors by adding more sawdust to the piles and turning them more often. Cox, after speaking to one of four Clivus Multrum representatives, even tried adding more microorganisms to the compost piles. This was especially complicated, though, because the microorganisms had to be introduced through warm water, which is not available at any of the campsites where the toilets were located. So Cox was forced to drive to friends' houses daily to borrow warm water as he made his rounds through the park to distribute the microorganism solution.

As complicated as this is, it is only the surface of the issues that the maintenance department had to deal with. Just to work with the composting toilet in the vault, the employees all had to get special Hepatitis A and B shots and, as Cox is quick to remind, hand sanitizer was applied in copious amounts. These were just precautions, though, and the staff had no recorded cases of illness related to the compost material during this time.

They did, however, have to remove some of the compost material themselves as it was almost impossible to find a company to do it for them. The material they removed was considered hazardous material and had to be triple bagged and taken to an approved site, and most certainly not spread anywhere. Clivus Multrum offered a few suggestions for solutions such as adding a pump to remove excess fluid (which would also require the addition of a leach field) or installing a fan or a heat lamp to encourage evaporation and decomposition, but these would require power, which in this case would require large batteries that would need to be replaced frequently.

In 2002, Jefferson County decided to discontinue their use of composting toilets in their open space. This presented a problem all in its own, though. How were they to remove all of the partially composted material in the bottom of the vaults? For this, they had to hire a company that specializes in cleaning out manholes. The waste had to be transported with a special permit to a pre-approved location in the eastern plains of Colorado.

Today, Jefferson County uses the old Clivus Multrum structures, but have developed their own system of vault toilet with an added evaporation system. This system allows for less frequent pumping of the facilities, but because the service doors on the original composting toilet model were located so low to the ground, they must be pumped before they breach the doors so that the pump can access the vaults without leaking any of the material. These new systems are generally pumped twice per year and seem to be working well for the maintenance department.

Analysis of Jefferson County Open Space: Environmental Failure

The composting toilets that were installed in Jefferson County Open Space failed for a number of reasons, among those was a poor design for the location. But another major factor that contributed to their malfunction was the environment in which they were located. As mentioned earlier, the composting process is very sensitive to a variety of climactic factors such as external temperature and humidity (Jenkins, 2005). It also depends heavily on what organic material is being added to the composting pile. Because we live in such a globalized world, diets are generally similar in most developed countries, but may be very different in rural developing areas around the world. What we eat has a direct influence on the quality and type of composting that will occur in a composting toilet.

The quality of compost also depends on what is added as dry or carbon material. If compost is being managed with sawdust, results will be influenced by whether the sawdust is from a hardwood or softwood and these types of trees grow in different geographical areas (Jenkins, 2005). Different regions also have differing variations in temperature. Some stay at a relatively constant temperature throughout the day while the temperature of desert areas can fluctuate between -18°C and 49°C in a short period of time (UC Berkeley, 2012). Some regions will maintain warm temperatures for a few months of the year and then stay well below freezing for the remainder of the year while others are relatively consistent. Jefferson County is located in an area where temperatures do not fluctuate quite so dramatically on a daily basis, but over the course of a year can reach similar extremes. The Clivus Multrum model was not equipped to handle extended periods of such low temperatures, which could have contributed to the failure of the toilets in Jefferson County.

What this all points to is that the composting toilet must be designed to the local environment it will inhabit. While companies such as Clivus Multrum design composting toilets that can function well in most environments, they are not geographically suited to every area. Little research, for example, has been done on the effect of altitude on the effectiveness of composting toilets.

Some environments, though, have been found to be almost perfectly suited for the composting toilet. Among these are warm, humid climates such as those found near the equator. One such success story is the installation of a number of EcoSan Latrines in the village of San Juan Bautista, Peru.

Case Study: EcoSan Latrine Project, San Juan Bautista, Peru

In May of 2011, three graduate students from the University of Colorado traveled to San Juan Bautista, Peru to the city of Iquitos to conduct an evaluation of the EcoSan Latrines, a model of double-vault composting toilets, which had been installed there the previous year. For their evaluation, Josh Armstrong, Jeff Walters, and Jami Nelson-Nunez spent their time conducting surveys of households where the latrines had been installed and testing the compost that these latrines produced.

Iquitos was chosen as the location for their project in part because of its warm, humid climate, but also because much of the area lacks access to improved sanitation and could benefit from an evaluation of the effectiveness of their new technology on the prevention of the spread of sanitation-related disease. Most families in the city of Iquitos have latrines that are constructed above and over the stream that runs through town and all of their waste is dumped in the river. This method of waste disposal is not at all unique to this area, but is how much of the developing world deals with waste management. This type of waste disposal not only promotes the spread of pathogens and related diseases, but also contributes to the contamination of global water sources and can severely affect the health of aquatic ecosystems.

The design of the EcoSan Latrine was a basic building over two vaults that were each about half a meter cubed and, once full, designed to decompose material within twelve months. Because they were designed for individual families and not as community toilets, the maximum amount of users allowed for each toilet was 5.

The household surveys were conducted in 205 households with just 106 of those households containing EcoSan Latrines (and only a handful of those toilets having been in

operation for over a year). The surveys were designed to get an idea of the demographics, feelings of responsibility, sanitation of the toilet, satisfaction with the program, views on composting, and how the latrines were being maintained. A compost test was also performed that measured the following qualities:

- Microbiology: total coliforms, thermo-tolerant coliforms, *E. coli*, Ascaris eggs (round worm)
- Physical Properties: water content, pH
- Nutrients: Carbon, Nitrogen, Phosphorus, Potassium, and Sulfur.

According to the responses from most users, the composting toilets that were installed in the Iquitos area were considered successful. Some participants in the survey did mention that there were times when their latrine was not functioning but in most cases this was because they had run out of drying material such as sawdust or plant material. While this shows that there might not be an adequate source of this material in the vicinity, the students also noted that by not using the latrine when they did not have sufficient drying material, the owners are showing a good understanding of how the latrine functions. In general, users thought that the toilet functioned well to very well and that it did not emit any unpleasant odors and that they would feel comfortable handling the compost produced by these latrines. One interesting result the survey showed was that people that had neighbors with EcoSan latrines installed often showed a higher satisfaction. This could mean that social networks involving composting can help improve their success rate.

While the EcoSan enjoyed relative social success in the city of Iquitos, it was not an overall success biologically. While some compost piles were successful in removing pathogens, there was a good amount of compost that would not be considered safe to use on food crops, which many participants claimed to be their planned use for the compost.

Remarkably, though, the success of the toilets was not at all correlated with the amount of time that the latrines had been composting. This means that other factors were in play. Because the toilets were all located in nearly the same environment, it can be assumed that it was probably the management of the latrine that contributed either to its success or its failure. One potential issue might be that, even though the toilet was only designed to handle the waste of a family of five, other community members may have wanted to use the facilities because they did not have access to proper sanitation themselves. This, if it is a factor, could potentially compromise the proper functioning of the toilet, and thus decrease its ability to break down and destroy pathogens.

Analysis of EcoSan Latrine Project: Environmental Success

Overall, the EcoSan Latrine project in Iquitos was considered a success, which shows promise for the composting toilet as a technology in some areas. It's primary reason for success was a design well suited to the environment. San Juan Batista has a much warmer and less variable climate than Colorado and is also relatively humid. These conditions are well suited to a healthy microbial community, and thus, efficient decomposition of human excreta. The absence of large fluctuations allowed a microbial community to establish itself without having to repopulate on such a frequent basis, also contributing to the health of the system.

Another cause of success was that it seemed as though all of the users were well educated on how to maintain their facility properly. In the Jefferson County case, most users were completely unaware that they were using a composting toilet and behaved as if it were a common pit latrine or porter potty. This left it up to the maintenance staff to correct any user errors and try to manage the balance of materials in the pile. Perhaps if users had been educated on how the composting toilet operates, as the community members of San Juan Batista were, they would have taken more responsibility for the upkeep of the system and managed their disposal more carefully.

Another important factor in this situation, however, was that the latrines were a socially accepted method of waste management in the local community. Cultural and social perceptions of new technology have a large influence on its acceptance and eventual implementation, but surprisingly this area has been given little attention in regards to composting toilets despite their obvious potential to offend or surprise a potential user.

Our current system of waste management, unfortunately, can be partly to blame for this. Because it is a process that is almost entirely hidden from the average citizen, most people tend to ignore the harmful environmental effects and the costs of treating and disposing of our waste.

Cultural and Psychological Sensitivity

Our perceptions of and relationships with our waste are a surprisingly clear reflection of our cultural values. Take the United States, for example. Here, unless you are talking with a physician or your uncle is telling a bad joke, defecation is not an ordinary topic of conversation. Even reading this paper would make most Americans uncomfortable. This is not without cause, though. We are fundamentally repulsed by our excrement for good reason- it can be dangerous! We have learned hard lessons throughout history about what happens when you get too close to your poop and the discovery of links between feces and disease have turned us off of any technology that forces us to become more intimate with it.

And the composting toilet is just that sort of technology. Instead of employing an “out of sight, out of mind” attitude about our waste, it forces us to acknowledge the link between what we eat and what our bodies discard and challenges us to sanctify that relationship to a point where we are willing to keep this “waste” around. But we cannot expect that transition to be an easy one. It took decades for germ theory to catch on and for people to recognize the risks that exposure to untreated feces posed to their health. And in order to protect us from the kind of epidemics that wiped our ancestors out our culture has developed in a way that reemphasizes these fears. Instead of recognizing the power that natural processes might hold for disinfecting our excrement, we throw chemicals and radiation at it and send it as far away from us as we can, because we have learned that this will keep us safe. And Americans are not alone.

Japanese culture has had a particular interest in toilets and waste disposal methods for many centuries, perhaps as a result of their sensitivity to concepts of ‘clean’ and ‘unclean,’ which dictate practices from washing your hands to coming in the front door

(Magnier, 1999). Most toilets in Japan are accompanied by bidets that are much more effective and sanitary than toilet paper, but also contribute to higher energy costs and more water waste (Magnier, 1999). But their reverence of the toilet runs much deeper than simple sanitation. The director of Aomori University's Modern Social Studies Institute, Takahiko Furata, says that the Shinto religion places traditional emphasis on physical and spiritual cleanliness (Magnier, 1999). "Japanese hate impurities and think it's important to have a place to remove them," says Furata, "That place is the toilet. Japanese toilet culture is based on this idea." The Japanese are so sensitive to toilet culture that they have developed pills to reduce any odor that might be produced during defecation and special slippers that are only worn while in the toilet room. Because women are especially sensitive to sounds made while using the toilet, the Japanese also have machines that imitate flushing noises to mask any embarrassing noises (Magnier, 1999).

Introducing a composting toilet, or any waterless system for that matter, to a country like Japan would involve overcoming serious cultural and religious obstacles, but it is not just the developed world that has such high sanitation standards. For some developing areas including parts of Mexico and India, the flush toilet is seen as a symbol of social status. In these areas where water is scarce and private access to sewer systems very limited, having a flush toilet implies that you are among the wealthy few who can afford the luxury of sanitation (Epps, 2012). In areas where this system has become so idealized, it would be even more challenging to promote a less technological alternative, especially one that resembles the latrines constructed in poorer areas (Epps, 2012).

Harder yet would be introducing the system to the extremely rural communities in undeveloped areas that have had little to no exposure to germ theory or its effects on

human health. According to Dr. Anne Ruch of SewHope, many people in these types of communities do not understand the need for toilets and find them to be an added burden compared to relieving themselves in public (Ruch, 2010). Her organization has attempted to show them the pathogenic organisms that flourish in their waste and how they can compromise the health of the community, but the villagers simply don't understand. They have been defecating openly in their community for as long as they can remember and are not ready to accept science as a reason to change. Composting toilets have been constructed in a Guatemalan village the program supports, but have all failed. Their lack of success is not a result of improper management or design, but because they were never used.

These cultural nuances may ultimately be a larger factor in the success of the composting toilet than design or economics because they are so difficult to predict and understand. How can the technology be altered to accommodate both the wealthy families who won't even be bothered to change their cleaning solution and the village women who associate public restrooms with violence and sexual assault? How do we simultaneously cultivate a need for change in the tech savvy cities of Japan and the primitive Guatemalan villages? The answer may be that we can't.

Introducing New Technology

The advent of the composting toilet has met with both a limited amount of success and widespread failure and mistrust. These are symptoms of the greater problem of the cultural and environmental ignorance of introducing new technologies. Current systems of technological advancement, both those in the field of sustainability and others, carry great potential for alleviating suffering and granting access into a global market that has become vital to success. These technologies, however, are often geared toward the wealthy population designing and backing them and fail to include input from the people interacting with the technology on a daily basis. To create successful technologies, we must ensure that they are locally appropriate and involve diversity of design (Practical Action, 2012).

As has been discussed in great length, the composting toilet, along with many modern sustainable products, is especially sensitive to local climate, culture and psychological dispositions. It must be introduced to areas in a manner that acknowledges these sensitivities and allows for the participation of locals and their community leaders if it has any hope of being successful.

This method of introducing new sanitation tools has already begun to have an impact in developing nations such as Indonesia, Bangladesh, Vietnam, and some African countries. One of the most common approaches to improving rural sanitation is through a method known as Community-Led Total Sanitation (CLTS) pioneered by Kamal Kar and the Village Education Resource Centre (Kar, 2005). CLTS is a process designed to self-motivate rural communities to completely rid themselves of open defecation within their boundaries (Kar, 2005). CLTS is based on the belief that peoples in these communities will feel

shameful and embarrassed when they see the conditions that they are living in through the eyes of an outsider and will be inspired to build latrines or develop other methods of containing their waste (Kar, 2005). This method was first implemented in 1999 in Bangladesh and has met with a great deal of success since then.

To trigger a reaction from a community that practices open defecation, a facilitator of the CLTS program usually begins by taking a tour of the community with as many members and political leaders as they can get in attendance and simply asks questions such as: who's shit is this? Who has openly defecated today and where? Do you think it is still there? If not, where did it go? The general idea of this 'transect walk' is to get community members to realize that they are ingesting each other's feces when they practice open defecation. Kar encourages using shocking and vulgar terminology for feces (such as the local term for 'shit') not only to grab attention, but to help convey an association with sensations of disgust and degradation. It is important that the facilitator not lecture community members on their means of sanitation, nor provide them with directions to build a certain model of latrine or other device. The members must come up with their own motivators and solutions organically or the process will have a much lower success rate (Kar, 2005).

Different communities, depending on variations in location, religion, culture, etc. can differ greatly in motivators for improved sanitation. Some of these might include homeowners who realize that they are just as exposed to contaminants as those without access to toilets, or women who know that they are the most disadvantaged by a lack of privacy in defecation. These motivators, biased as they are by certain factors, are encouraged so that different groups might form to help ignite change (Kar, 2005).

One of the most important aspects of CLTS is that it is a subsidy-free program. Researchers in the program have found that subsidies are actually a hindrance to sanitation efforts because they increase dependence on outside aid and influence to ignite and continuously fuel change. If these funds decrease or run out, the chances that the community will resort back to open defecation are very high. When a community is self-funded or only receives subsidies from local governments or organizations that are closely involved in the sanitation effort, they are much more likely to remain open defecation free and to have reduced dependence on a constant stream of funding (Mukherjee, 2011).

Some communities that have experimented with CLTS, though, have ultimately failed in their attempt to provide improved sanitation, not because of a lack of motivation, but because of a lack of supplies. An important part of CLTS is that a community chooses what method is appropriate for them and is not persuaded by facilitators to adopt a certain model. Local entrepreneurs and governments play a large role in the next step of the program by providing the raw materials or manufactured systems to supply to the community (Bill & Melinda Gates Foundation, 2012). If they are not adequately prepared to provide these materials, though, the system is at risk of total collapse.

A study was conducted of East Java communities that had participated in CLTS to see what factors influenced the sustainability of open defecation free (ODF) communities (Mukherjee, 2011). The study found that communities that achieved ODF status quickly (within two months of starting the program) remained ODF more often than communities that took many months to achieve their status (Mukherjee, 2011). These communities also had the highest success rate of behavior monitoring, but often had the lowest quality sanitation facilities (though they all met the “improved sanitation” standards) (Mukherjee,

2011). Late ODF communities only had an 80% rate of remaining ODF because sanctions against rule-breakers were rarely enforced and ownership was given higher priority (Mukherjee, 2011). Non-ODF communities were also usually located closer to a body of water (Mukherjee, 2011). But the most important factor in the success rate of ODF communities was the ability of local markets to meet the needs of poor consumers (Mukherjee, 2011). Especially in a program that discourages subsidies and dependence on foreign aid, cost is a big factor (Mukherjee, 2011). For many communities, the cost of the latrines that they really wanted were just too high and the local markets were unable to offer and less expensive solutions (Mukherjee, 2011). These communities were forced to invest in technology that did not work as well and often produced odors that lowered their appeal (Mukherjee, 2011).

A variety of solutions have been proposed, though. One of the most effective solutions is to prepare local builders, engineers, and entrepreneurs before CLTS is in effect in an area (Mukherjee, 2011). Most of the communities that failed to sustain ODF had not had proper exposure to the *Informed Choice Catalogue* that presented low cost options for various projects nor had they been properly trained (Mukherjee, 2011). Most of these missteps were a result of the over two-year delay in delivering the marketing aspect of the program to target communities (Mukherjee, 2011). While demand for the sanitation products was great, local markets simply couldn't increase their capacity for supply fast enough to keep up. If the program were tailored so that the local markets were supplied with materials and access to training first, the program may have a better chance of reaching ODF more quickly and sustaining ODF longer as a result (Mukherjee, 2011).

Conclusions

We live in a critical time in human history: a critical time for democracy, for medicine, for culture, but foremost, for sustainability. The realm of sustainability has spread from the protection of species, to land, air, and water, and important connections have been made between a healthy environment and improved quality of life. This juncture is especially important for sustainable sanitation and as awareness grows, so do new opportunities for improvement. The composting toilet is a forerunner in this arena, but it is not alone.

The composting toilet excels in a variety of areas. One is in its ability to recycle nutrients. As the literature review proved, the composting toilet has the ability to provide safe, healthy, and incredibly nutrient dense fertilizer. More importantly, it accomplishes this with a very limited amount of additional inputs, just some sort of carbon material, a handful of microbe-rich soil to start the process, and plenty of oxygen. The catch is that these processes require a design precisely tailored to a local climate and careful management or they will not work. As we saw with the example from Jefferson County Open Space, one-size-fits-all models simply do not fit all climates. At best, they fit one or two. While these systems may be mechanically altered to fit an environment, this often requires chemical inputs, such as the liquid needed to transform Jefferson County Open Space's composting toilets to latrines or access to electricity-dependent systems such as fans for ventilation or heat for aid in decomposition.

The composting toilet is also a successful technology because it can operate without connection to a water or sewage system. In some cases, a composting toilet with urine diversion and a leach field can drain and purify water and send it back into natural systems.

Unfortunately, we have found through CLTS programs that a waterless feature is not unique to the composting toilet and the added construction cost is often an incentive for communities to choose latrines over composting systems.

Composting toilets, however, are especially attractive because they do not pollute like a latrine can. Because all excrement is given time to decompose independently of the surrounding soil and water, it does not leach pollutants or pathogens into surrounding habitats or water sources. But there are alternative waste treatment systems that go beyond preventing pollution and reduce pollution from other areas of human life, including anaerobically creating methane gas for electricity or charcoal-like products for cooking and heating (Bill & Melinda Gates Foundation, 2012). The world needs more than sound technology, though, and luckily, the composting toilet is able to deliver.

One of the largest cultural and psychological burdens our generation will be forced to overcome is acknowledging the existence of the abundance of our excrement and consenting to become involved in the process of treating and recycling it. The composting toilet forces an intimate understanding of and involvement in this process, which, as has been discussed, can be both a cultural barrier and blessing. But because it can be designed in so many different ways and the user's participation can be shaped by this design, the composting toilet has great potential for helping communities overcome cultural hurdles.

Recommendations

CLTS and its principles of local responsibility and motivation have made great strides in improving sanitation in developing areas, but there is still an incredible amount of work to be done. For one, CLTS needs to work more closely with local governments to provide resources and training to the community and to facilitate the training of trainers (TOT) (Rosensweig et al, 2010). This process involves the theory of decentralization, one of the most promising developments in the field of sustainability. Decentralization is the redistribution of authority to lower levels of government or administration and has had a profound effect on sustainable development in many communities. Decentralization of power allows local authorities to make decisions for their own communities under the assumption that they know the needs of their constituents better than a more centralized power would. This allows them to tailor local policy and enforcement to the specific needs of their community, increasing both its effectiveness and its importance to local residents.

Decentralization in CLTS allows local governments to design a program and approach that is best suited to their community without having to work through a bureaucracy to make changes. Local governments also often have the proper infrastructure to serve as leaders in sustainable development (Rosensweig et al, 2010). Decentralization would allow communities to independently evaluate their environmental, economic, and social barriers to success and develop a specific program to overcome them.

Another concern associated with CLTS is that most of the systems installed in developing communities are simple latrine models. While they are a vast improvement from a system of open defecation, a latrine still contributes to health and environmental issues through the possible contamination of groundwater sources. Latrines also must be

sealed off and rebuilt periodically, posing an additional economic burden in the future. Finally, latrines represent a critical missed opportunity to reclaim important nutrients and a potential energy source from human waste. If we are presented with an occasion to create a better system of waste management than the ones we have in place, we are doing both ourselves and the planet a severe injustice by not demanding more of it. While CLTS prides itself on letting communities choose their own method of sanitation, it also must be conscious to provide them with the best options at the best price. The composting toilet and its nutrient-recovering counterparts must be developed in a way that will make them an attractive CLTS option. They must be able to be tailored to fit different environments and communities and also must be cost effective and safe. Most importantly, they must be open to future improvements. In such an ever-changing world, it would be naïve to think that a solution will be permanent, but instead must be flexible enough to meet any future needs.

Finally, CLTS and the improved sanitation movement cannot be restricted to the developing world. Sanitation reform needs to be a global movement if we are committed to creating a sustainable future. The composting toilet and other alternative sanitation technologies have been looked at through various lenses, but they have mostly been through the lenses of radical environmentalism or poverty alleviation. The true aim of this thesis is to synthesize materials from both outliers and determine whether or not the composting toilet is appropriate for those in the middle. Or are we forever stuck in a water-based sanitation system? The principles of CLTS can apply to the developed world as well. Our desire for sanitation reform must be organic. We must take a “transect walk” through our own culture of sanitation and ask the dirty questions: who’s shit is this? Where is it

going? How long can we keep sending it there? How much more efficient could this system be? We too can cultivate a sense of shame and disgust with our current system, and we should! Our system of waste management is a gross misuse of valuable resources and a deplorable misunderstanding of our potential for sustainability. But are we ready for change? Eventually, yes. But it will take a great deal of work.

Drastic improvements must be made in the design of the composting toilet in order to make it a viable alternative to water-based sanitation. It must be made more functional and operable within a residential or commercial setting. Its products must be held to a very high standard and systems must be put into place for testing and regulating both the system and its products. There must also be an efficient and sustainable system in place for large-scale removal of its byproducts and safe application of the resulting fertilizer. Various factors must be considered for specific locations: should the products be kept on site? Should they be applied locally or distributed? What are the risks associated with these decisions?

More importantly, though, our culture is not ready for the composting toilet. Our country must take great measures to improve our psychological preparedness before a composting toilet can be successful. We must cultivate a greater need and a greater sense of urgency in its defense. Currently, citizens of the developed world are becoming acclimated to the principles of conservation and efficiency, but they are not ready, nor will they accept a radical overhaul of the systems they are accustomed to. And the scope of the changes they are willing to make are directly dependent on the economic benefits they stand to gain from them and how little they will be inconvenienced in the process.

Right now, the composting system fails on both accounts. It is still priced at an unsustainably high cost for the level of comfort desired by developed countries and its placement in the greater system of waste management makes it inconvenient almost to a point of infeasibility. Our society is simply psychologically unfit for a change of this magnitude. But it need not always be this way. Just as CLTS appeals to a sense of shame, we must cultivate a similar, organic feeling. Environmental exposure and education must be increased and a sense of leadership and ingenuity must be developed so that people recognize flaws in the current system and want to take responsibility for change.

We must also be keenly aware of how our collective psyche is perceived throughout the world. In an age of globalization, standards and practices of one country quickly become standards and practices for all, as seen in the example of the toilet as a status symbol. But, with the proper preparation and introduction, why couldn't the composting toilet be a symbol of prosperity too? All it needs is a proper plan. It cannot haphazardly be thrown into the mix of our current cultural practices, but must be the right solution for a right and ready world. Is the composting toilet a sustainable solution for today's sanitation crisis? The short answer is, no. But is it a step in the right direction? Yes.

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