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## Composting Toilets: Safe and Sustainable Technology

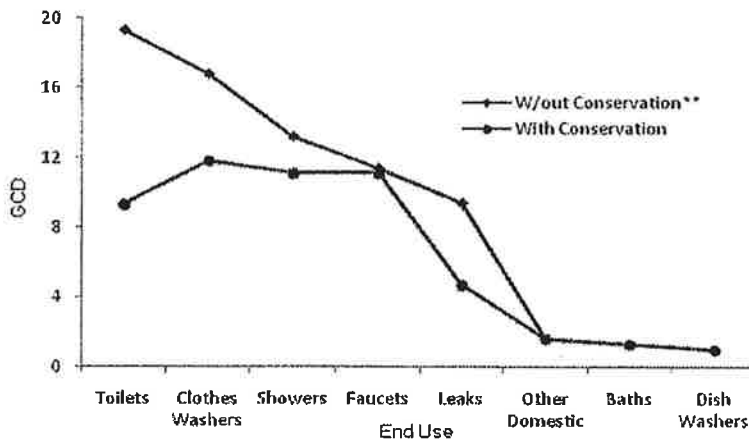
The average American uses 3.3 gallons of water treated to drinkable standards for a single flush of a toilet. At an average of 5.2 flushes per day, average American water use is over 6,260 gallons annually per person just for flushing toilets.<sup>1</sup> Depending on the waste treatment program, it takes an average of 1,000 to 2,000 tons of water to process one ton of human waste.<sup>2</sup> In a world where over 1.7 billion people lack access to clean water, the American sanitation system can hardly be argued to be just or sustainable. In addition, over 3.3 billion people are without proper sanitation facilities and more than 2.2 million people die each year from preventable diseases related to inadequate water and sanitation conditions.<sup>3</sup> When considering development options for these communities, sanitation facilities similar to those used in the United States and many other parts of the western developed world are simply not feasible. The amount of water needed to treat the waste of every person on the planet is unobtainable, especially when billions already lack the clean water necessary for drinking and cleaning. Current waste treatment programs utilized in much of the developed world are unsustainable and different approaches must be taken to ensure proper waste and wastewater management in communities in all degrees of development. A component of a feasible solution to this problem of waste treatment in both developed and undeveloped areas is the use of composting toilets.

Composting toilet systems contain and control the composting of human waste, toilet paper, and an organic carbon additive (such as peat moss or woodchips which absorbs liquid and controls odor). The contents of a common household compost bin, such as food waste, can also be added to most composting toilets. Depending on the model (a variety of which will be discussed later), these toilets use little or no water because the waste is not being flushed away. Instead, aerobic bacteria and fungi in the composting chamber break down waste to between ten and thirty percent of its initial volume, resulting in a soil-like material called humus. Depending on the location and regulations, humus must be buried or removed (most regions in the United States have laws requiring this) or can be used as fertilizer on crops.<sup>1</sup>

The objectives of composting toilet systems are to recycle human waste back into the soil, to operate with minimum maintenance and energy use, to destroy pathogens causing human disease, and to conserve water. Composting toilets are a natural way of treating human waste which, unlike many sewer and septic systems that pollute the environment (especially water sources) by leaking both human waste and large amounts of the chemicals conventionally used to treat it, do not contaminate the local or more distant environments. Some estimates state that the use of composting toilets alone can reduce a household's water consumption by 40,000 gallons per year.<sup>1,2</sup> In addition, composting toilet systems are relatively easy to combine with greywater recycling systems because they eliminate the production of blackwater, the mixture of excrement and water created by sewage and septic systems. When this dangerous component of the material most commonly treated in conjunction with all of a

household's wastewater is removed, the rest of the water (which is 99 percent of what enters a wastewater treatment plant<sup>2</sup>) can be safely reused for needs like irrigation after a much simpler on-site treatment process. Figure 1 and illustrates average difference in quantity of water use before and after the use of conservation measures. As the figure and table indicate, toilets are the major consumer of water in the home, meaning a more efficient water toilet (as shown in the data) or waterless composting system will save considerable amounts of water. Wash water from laundry and showers also use considerable amounts of water that when managed using a greywater treatment system can be utilized in other ways in a home.

A major concern regarding composting toilets is the safety of handling and reusing the humus. This is a legitimate concern because human excrement can contain pathogens which cause many dangerous diseases such as amebiasis, cholera, infectious hepatitis, typhoid fever, salmonellosis and other intestinal and diarrheal diseases. However, these bacteria, viruses, amoebae or protozoa, and parasites such as worms that cause these diseases have a very short lifespan outside a human or animal host unless put in an aqueous environment. While this is exactly what conventional sewer and septic systems do which results in the need to use large amounts of chemicals or



\*GCD= gallons per capita per average day of the year

\*\*Based on the average inside uses measured in 1,188 home in 12 North American cities including an additional 6% to account for estimated "in place" savings due to existing conservation.

SOURCE: For WaterWiser by John Olaf Nelson Water Resources Management cited on pg. 170 of the Composting Toilet System Book

Figure 1. Household End Use of Water (GCD) With and Without Conservation

thermal disinfection to reduce pathogens, composting toilet systems kill pathogens through containment, competition, antagonism and adverse environmental factors.<sup>1</sup> (In fact, septic systems are not generally designed to kill pathogens that enter the septic tank. These systems settle out the solids and then leach the effluent into the ground. In places where the septic effluent interacts with shallow aquifers or water tables, they can be highly pathogenic. In the United States, septic systems are the most commonly reported source of groundwater contamination.<sup>2</sup>)

Because pathogens generally cannot live for long periods of time outside the human host, containing the waste for an extended period of time kills the pathogens and reduces the risk of the infection of a new host. In addition to containment, composting toilet systems introduce competition for available carbon and nutrients from aerobic soil organisms which feed on the pathogens. When these organisms consume the available nutrients they begin to feed on their own protoplasm for energy. These organisms will die and then be digested by other organisms. If no additional nutrient sources are provided, all of the energy from this process will be released and the compost will be fully oxidized. This results in safe and stable humus. Some of these aerobic organisms also produce substances toxic to other organisms. These substances, such as the common antibiotic streptomycin produced by *Streptomyces griseus*, inhibit or kill pathogens but are not harmful to humans. Environmental factors such as temperature, moisture, pH, and ammonia also play roles in eliminating pathogens in composting toilet systems.<sup>1</sup>

Temperatures over 149°F will destroy pathogens in a matter of minutes, however most composting toilet systems require artificial warming to reach these heats. Total pathogen elimination is reached by heating the compost to 143.6°F for one hour, 122°F for one day, 114.8°F for one week, or 109.4°F for one month. Depending on the location and climate, some composting toilet systems use heaters and fans to achieve higher temperatures in the compost. There are also several models utilizing solar heating energy, however most compost piles can reach acceptable heats solely through the decomposition processes provided by a diversity of thermophilic microorganisms.

The most difficult pathogen to eliminate seems to be *Ascaris lumbricoides*, the roundworm. Roundworm eggs are particularly challenging to destroy because they have a protective outer coating which allows them to survive through some adverse environmental conditions. Though readily destroyed through thermophilic composting, in some cooler soils they are able to survive for up to ten years. For this reason, compost from low-temperature toilets should not be used for food crops unless it is first added to a larger, hotter compost pile.<sup>2</sup>

Composting toilets have been particularly popular in the developing world where access to the water and infrastructure needed for conventional western methods of sanitation treatment is not possible. Composting toilets were also a viable method for waste management before contemporary technology was available. The people of Asia are often credited for having composted and fertilized crops with their waste for centuries, and composting toilets were first introduced systematically in China in the 1930s and then on a wide scale in Vietnam beginning in 1956. The basic model for the composting toilets most commonly use in the developing world is based on the waterless double-chamber ventilated systems developed and used in India and Vietnam in the mid-twentieth century. This system consists of two side-by-side composting chambers; when the first chamber is filled it is sealed to compost while the other chamber is in use. Depending on the size of the composting chambers and the number of people using the toilet, it usually takes between one and five years to fill one of the chambers. Prior to use, each chamber must be filled with large amounts of organic bulking material such as straw, sawdust or peat moss. This helps to absorb liquid and prevent odor. In addition, after every use the new excrement should be covered with

more of this material. Because it is being used in smaller quantities a variety of organic household waste can be used for this purpose, such as stove ash or dry food waste that is often already composted. There are many variations on this basic model in order to adapt to specific environmental factors such as temperature, humidity, topography of the site, and cultural beliefs and expectations of the users. However, all toilets based on this model are waterless and produce usable compost.<sup>1,2</sup>

While composting toilets may be a necessity for sustainable sanitation in many parts of the developing world, they are also a viable alternative to flush toilets in areas where conventional sanitation systems have been established. Hundreds of site-built designs and manufactured models of composting toilets are currently available, and the general process has been used successfully in almost every environment. Figure 2 is an example of a site-built model called the Clivus Minimus, a variation on the Clivus Multrum which was the first large-capacity system introduced in the United States. Because these composting toilet systems are constructed at specific sites, numerous variations on this basic design exist to work with a site's size, climate, or structural needs. Common improvements on the model are a steeper and more lubricated grade so the composting excrement moves more smoothly down the

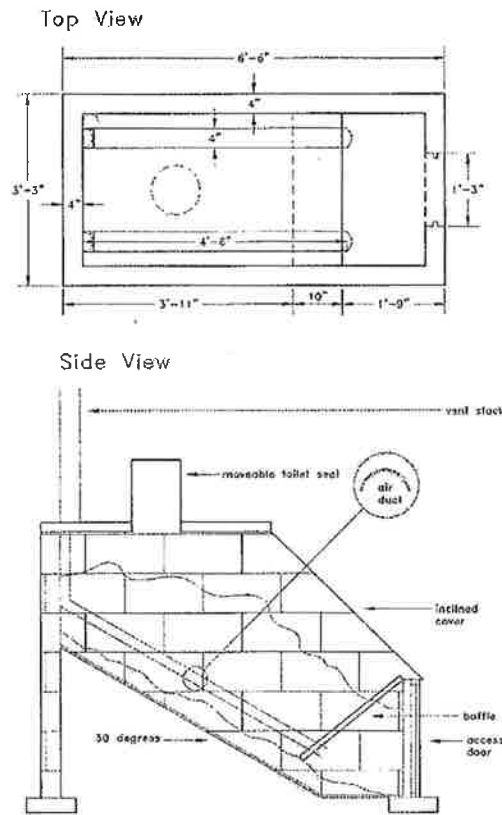


Figure 2. Top and Side Views of Clivus Minimus

slope, and baffle to keep the newly added excrement away from the humus that has been composting for a significant period of time so one part can be fully composted.<sup>1</sup>

Often the barrier to the widespread availability and use of composting toilet systems in developed regions with municipal sewage systems (especially in the United States) is regulation. Regulators are now slowly coming to see composting toilets as more than just "experimental," which allows for slow spread of less-restrictive building codes.<sup>4</sup> An additional barrier to the popular use of composting toilets in developed areas is a lack of commitment to personally managing one's waste. Combined with common misconceptions about safety and cleanliness, many people are unaware of the benefits of the compost generated by a toilet and are unwilling to handle the waste themselves. However, once people are informed of the realities of composting toilets (that they

don't smell if managed properly, the resulting compost can be easily and safely stored and reused, and they can work well in even an urban home setting) they are much more open to the possibility for personal use.<sup>4</sup> Technology has improved so much in this field over the last 20 years that there is a safe, odor-free option for nearly every location in the developed and developing world. As water becomes more of a scarce resource and space for the disposal of waste through traditional and conventional methods becomes more limited and therefore more damaging, the use of composting toilets can and most likely will be an important component of developing sustainable water and waste management in a variety of global settings.

#### References

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