SANITATION BY COMPOSTING

Sanitation developed in post-earthquake Haiti in 2010 and 2011 by GiveLove.org.

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ABSTRACT: Compost toilets can take many forms. One such toilet, the "humanure" toilet, is designed to simply collect and recycle human excreta, which includes fecal material, urine and toilet paper, along with a carbon-based cover material, via an odor-free, heat-producing organic mass. The organic compost mass is created away from the toilet in a separate compost bin, not in the toilet itself. The thermophilic and aging phases in the compost bin render the organic material hygienically safe by destroying pathogenic organisms. The final product, humus, is excellent for growing food. Because the toilets themselves are not utilized either for the composting process or for storage of toilet material, they are inexpensive and simple in design and implementation. They recycle organic materials and do not produce or dispose of waste. They create no environmental pollution when properly managed. They require no piped water, no electricity, no venting, no hole in the ground and no drain. When managed correctly, they do not breed flies or produce unpleasant odors and can therefore be located indoors, even in intimate settings. They can be used in almost any climate.

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INTRODUCTION: WHAT IS "COMPOST SANITATION"?

The World Health Organization (WHO) estimates that 88% of all diarrhea cases globally result from poor sanitation and polluted drinking water. The consequence is 1.7 million deaths annually, mostly of children under five years of age. The WHO states that fecal pathogens likely contaminate surface water and ground water through waterborne sewage systems, flush toilets and latrines. According to the WHO, "*Lack of sanitation is a serious health risk and an affront to human dignity. It affects billions of people around the world, particularly the poor and disadvantaged. If the trend continues as currently projected, by 2015 there will be 2.7 billion people without access to basic sanitation. Every US $1 invested in improved sanitation, translates into an average return of US $9.*"[1]

Sanitation systems that do not pollute water or soil are therefore crucial. A "*compost sanitation*" system collects human excreta before it comes into contact with either soil or water. The system is designed to promote hot composting of the collected human excrement, including fecal material and urine, which can and should be recycled for agricultural use. When properly used and managed, a compost toilet system, based on the "humanure" method, requires virtually no water, produces no waste, creates no environmental pollution, attracts no flies, costs very little, requires no urine diversion, and produces no odor. Instead of waste, the toilet system produces humus, a valuable resource that can safely be used to improve soils. The toilets can be constructed for very little money or no money at all if recycled materials are used. They can have a small footprint and can therefore be located virtually anywhere outdoors or indoors — in a bedroom, closet, porch, basement, dormitory, office, apartment or tent. When properly utilized, the toilet produces no unpleasant odor, so its presence inside a living area can remain unnoticed and discreet.

Compost sanitation also provides the basis for a complete composting system for either a home or community and allows for the recycling of food and other organic materials that are often discarded.

HOW DOES A COMPOST SANITATION SYSTEM WORK?

A compost sanitation system is based on the concepts and principles of thermophilic (hot) composting. The three basic components required for such a system to successfully operate are: 1) the toilet itself; 2) carbon-based cover materials; 3) compost bins.

Component #1 — The Toilet: The toilet is simply a collection receptacle. Its purpose is only to collect human excrement, both urine and feces, in a waterproof container or "toilet receptacle." The "toilet material" collects in the receptacle — human excrement does not contact soil or water. The toilet material is not referred to as "human waste" because nothing that goes into a humanure toilet is wasted, disposed of, or discarded. All components are constructively recycled and reused via composting. Hence, the word "humanure" has become popular when referring to human excrement that is recycled through composting systems. The term "waste" is not used, associated with, or appropriate when discussing humanure toilet systems. This sanitation system involves neither waste nor disposal.

The size and type of toilet receptacle can vary from place to place, depending on availability and application. Five-gallon (20 liter) plastic receptacles are commonly used and are attractive for a small-scale system because the receptacle can be easily carried and emptied by a single person. They can also be inexpensive or free, are water proof, have tight lids, and can last a long time. This system is not to be confused with a “bucket toilet" (Figure 1) which is human excrement deposited into a bucket without cover material, then discarded into the environment as waste. Bucket toilets, however, can easily be converted into humanure toilets by adding the other two components of the system (cover materials and compost bins).

Figure 1: A “bucket toilet” uses no cover material, is very odorous, breeds flies and pollutes the environment. This feces-caked bucket in Port au Prince is an example of unacceptable sanitation.

Larger toilet receptacles have also been utilized. In Haiti, both 20 liter and 60 liter receptacles are in use. The 60 liter receptacles require two persons to handle (although they can be slid out of a toilet and replaced by one person). Even larger receptacles such as a 55 gallon (208 liter) drum can be used. These may require machinery for efficient handling.

The purpose of the toilet is to collect feces, urine, toilet paper, and sawdust (or other cover material) so as to prevent unsanitary contact with the environment. The collection of toilet materials in this manner primes the human excrement for thermophilic composting because it is combined with a carbon-based organic material inside the toilet. Human excrement will not compost on its own because it’s too wet and too high in nitrogen. By adding a carbon-based material to the toilet after each use, the toilet contents can become balanced in carbon and nitrogen and the moisture level optimized for composting. The purpose of thermophilic composting is to subject the toilet materials to robust microbial activity which produces heat and bio-competition generated by compost microorganisms. This process has been scientifically proven to destroy human pathogens, rendering the toilet material hygienically safe and achieving the true essence of "sanitation."[2]

“Urine diversion,” the practice of diverting urine from the solids inside a toilet, can be counter-productive to compost sanitation because urine provides essential moisture and nitrogen required to offset the dryness and carbon of the cover materials. When urine is removed from the toilet contents, it creates a dry organic mass that is deficient in moisture and nitrogen. This can retard the important thermophilic phase of the compost.

The addition of paper products to the toilet is encouraged, such as toilet paper, toilet paper center cardboard rolls, etc. There is no reason to separate these when using a humanure toilet. Paper or cotton-based feminine hygiene products can also be added to humanure toilets. Plastic components of these products will have to be manually removed from the finished compost since they do not decompose.

Humanure toilets can be designed for household use indoors or outdoors, for single person or family use, and for group use where many people gather, such as refugee camps, villages, schools, orphanages, etc. They can also be used as backup or emergency toilets when flush toilets are not available due to electricity outages or disaster scenarios.

Figure 2 illustrates a 20-liter capacity humanure toilet manufactured in Haiti. Under the toilet seat is the toilet receptacle where urine and feces are collected and covered with amyris sawdust, sugar cane bagasse, or another locally available plant cellulose material. The cover material, when the texture and moisture content are correct and when it is used in adequate quantities, completely blocks odors and flies. When full, the toilet receptacle is removed from the toilet and set aside with a lid, to be collected and composted at a separate location.

Figure 2: Typical 20 liter capacity humanure toilet in Haiti made from plywood construction.

Figure 3 shows a 20-liter humanure toilet in use at a Haitian orphanage. The dark container to the left contains the carbon-based cover material.

Figure 3: Toilet contents are covered inside the receptacle with sawdust and/or bagasse. The 20-liter receptacle simply lifts out when full.

Figure 4 shows a humanure toilet with the receptacle completely exposed and ready for removal. When full, the receptacle is removed from the toilet, covered with a lid and set aside for collection and composting.

Component #2 — The Cover Material: Carbon-based cover materials are required for the humanure toilet system to function successfully. These materials cover the contents inside the toilets as well as the contents of the compost piles. Enough cover material of the correct consistency and moisture content is needed to totally and effectively eliminate odor and flies. The correct amount of cover material can be gauged by simply smelling the toilets or the compost piles. If there is an offensive odor, more cover materials must be used. Likewise, if flies can be seen accessing the contents of the toilet or the compost pile, more cover material must be used.

The cover materials must originate from "carbon based" plant cellulose material in order to promote thermophilic composting. Cover materials can be any somewhat dry plant material ground into the correct consistency, such as from coco coir, paper products, cardboard, even junk mail. One of the most widely used cover materials, for example, is sawdust from trees. Others include peat moss and rice hulls. Sugar cane bagasse, left over from the crushing and processing of sugar cane, is widely available in Haiti and useful for compost sanitation systems. Sawdust from the manufacturing of amyris oil is also being used as a cover material inside toilets in Haiti.

Availability of appropriate cover material is essential to the successful operation of a compost sanitation system. The cover material must not be too coarse. Wood chunks, for example, are inappropriate — even wood shavings are not ideal for use inside the toilets if they are airy and can allow odor to escape. Wood shavings can inhibit thermophilic composting because

Figure 4: The toilet receptacle is easily removable.

the carbon can be relatively inaccessible to compost microorganisms when the wood particles are too large, although wood shavings can be used successfully in larger compost piles.

Wood ashes should never be used as a cover material, nor should lime (ground agricultural limestone). These mineral materials can inhibit microbial activity, whereas compost sanitation is designed to *increase* microbial activity, not to inhibit it. Some believe that sanitation requires the killing of microorganisms because excrement can include pathogens. For this reason, they encourage the use of lime and wood ashes in toilets. Although such materials do inhibit bacterial growth, they do not eliminate pathogens. The best way to completely sanitize excrements is to *encourage* beneficial microbial populations, not discourage them. Increased microbial activity in a compost environment can fully sanitize human excrements. They eliminate pathogens through microbial competition and internal heat developed by thermophilic microorganisms. Therefore, the goal of compost sanitation is to encourage and support robust microbial populations in the composting matrix. *Sanitation* and *sterilization* are entirely different. Sterilization is the absence of anything living. Sanitation is the elimination of pathogenic organisms, or the reduction of their populations to the extent that they are not a threat to human health. Composting *sanitizes* toilet material, it does not sterilize anything.

When the cover material is from an appropriate source and of appropriate consistency for use in the toilet, the toilet contents can be covered such that no odor whatsoever escapes from the toilet. This enables the toilet to be located indoors, if desired. However, if appropriate cover materials are not available or are not utilized, the toilet will emit unpleasant odors and attract flies. It is imperative to understand that compost sanitation may not be appropriate for all people in all places and situations, any more than a flush toilet is. In woodland areas, tropical areas, or any location where sawdust and/or other similar plant materials are available, the toilet works very well. Compost sanitation may not work in the Gobi desert for example, without trucking in compostable cover materials. In areas where agricultural byproducts can be collected and stockpiled for use, such a sanitation system can also work well. The byproducts can include such things as grain chaff, pine needles, coffee grounds, distillery byproducts, cleanings from woolen mills, paper products ground to the right consistency, etc.

Cover materials are required for the compost bins as well as for the toilets. The compost bin cover materials can be drier and coarser than the toilet cover materials. They can include grasses, hay, straw, pine needles, weeds, leaves, sugar cane bagasse or many other organic plant materials that are odor-free and do not attract flies. Such cover materials allow for the collection of large quantities of toilet materials in above-ground compost bins without creating unpleasant odors or attracting flies. They also encourage an aerobic thermophilic microbial population by creating tiny interstitial air spaces in the compost piles. If appropriate cover materials are not available, a compost sanitation system is not recommended. If the cover materials are available in limited quantities, humanure toilets can be successfully used in limited numbers.

The carbon-based cover materials balance the moisture and nitrogen in human excrement. This creates a desired "carbon to nitrogen ratio" that encourages reproduction of beneficial heat-producing microorganisms. By using enough cover material of the correct consistency to prevent odors from escaping the humanure toilet system, the correct balance of carbon to nitrogen can automatically be achieved so long as urine is included. In addition, most food scraps and other organic materials available from human activity can be added to the humanure compost bins to achieve high-quality compost. Food scraps tend to already be carbon/nitrogen balanced, so they can be added to humanure compost piles with great benefit.

Cover materials must be kept dry in cold climates to prevent them from freezing.

Component #3 — The Compost Bins: All toilet materials that are collected must be composted in an aerobic, thermophilic manner in order to become sanitized. This requires the depositing of the materials into an above-ground compost bin. The purpose of the bin is to allow the piling of the collected material in such a manner that it is not accessible to children, animals or other vermin or insect vectors.

The bins contain and hold the compostable materials, effectively creating an “in-vessel” composting environment (Figure 5). This composting matrix is enveloped with clean cover materials on the top, bottom and sides.This enables the heat that the compost generates to be confined inside the mass and not dissipate into the air as in windrow composting. Temperature readings taken from various points throughout the bin at different depths can be remarkably uniform.

Windrows, on the other hand, are open piles of compost that have large surface to volume ratios (Figure 6). The surface area is so large that much of the compost is exposed to the air and does not contain heat. These piles must be stirred regularly in order for the entire compost mass to be subjected to the high internal temperatures. The stirring or turning is very labor intensive, releases gasses, molds, spores and odors into the air, dissipates heat into the environment, and causes the loss of organic matter.[3]

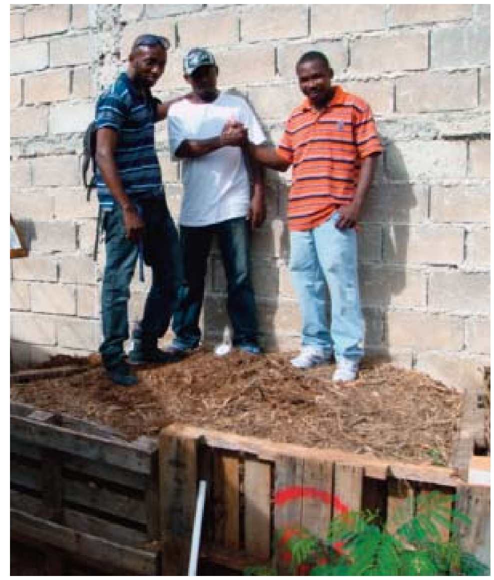

Figure 5: Compost bins enclose and contain the compost matrix, preventing the heat from dissipating.

Compost sanitation, therefore, is based on the bin method, not the windrow method. The compost inside the bins is never turned or stirred. Once the bin is filled, it is left alone to “cook” without disturbance, for approximately one year. This method is simple, inexpensive and effective.

Compost bins should have four walls or at least be completely surrounded in order to keep out dogs, goats, children, chickens, etc. One wall can be removable to allow for access to the finished compost. A piece of wire fencing laid over the top of the active compost pile will prevent animals from digging into the pile or scratching the cover material off the compost. Wire mesh around the sides and underneath the piles will prevent rats and other smaller vermin from entering the piles.

Figure 6: Compost windrows have large surface to volume ratios. The surfaces remain cool and the piles must be stirred regularly to subject all parts of the compost matrix to the hot internal temperatures.

The compost bin walls may be constructed of wood boards, masonry materials such as bricks, blocks or concrete; straw or hay bales, which can be reused as cover material after their function as side walls is completed; bamboo; poles or logs; wood shipping pallets turned on their sides, etc.

The bins are constructed with a "biological sponge" as the base layer. The biosponge consists of plant materials such as straw, hay, weeds, grasses, etc., piled on the soil in the bottom of the bin for the purpose of absorbing excess liquids that may collect when the pile is being constructed. The biosponge also creates a barrier between the soil and the compost. A biosponge should also be built on top of the compost pile to absorb excess rainfall and prevent waterlogging of the pile. The top biosponge also keeps the compost pile from drying out in arid climates and acts as a thermal insulator, holding in heat. It prevents the release of odors and does not attract flies. Cover materials should also be applied to the inside walls of the compost bins when toilet material is added in order to provide an insulating organic layer between the toilet material and the bin walls.

The bins can be located on bare soil with the base shaped into a slightly concave configuration, allowing any liquid to pool into the center of the bin, thereby preventing leaching out the bottom onto the soil surface should excess moisture be an issue. Sufficient dry material should be used in the biological sponge to absorb excess liquids.

Odorous organic materials should never be put “onto” a compost pile — they should always be put “into” the pile. “Into the pile” means moving the cover material aside using a designated compost tool, such as a hay fork or shovel, digging a depression into the top of the pile, and then adding the organic material, which may be toilet material, food scraps or even animal mortalities.

Cover materials are added to the bin when odorous materials are added. This layering effect suppresses odor and discourages flies when the bin is being filled while creating a mixed organic matrix. Once the thermophilic phase begins, liquid is rapidly absorbed by the extremely robust biological activity, hence the benefit of urine. In arid climates, rain water or graywater can be used to moisten the compost mass, if needed. The overall moisture content of the compost matrix is best controlled by adding a correct blend of materials. If wetter materials are being added, then more drier materials must be incorporated into the pile.

When these simple rules are followed, all food scraps can be added to the compost, including meat, bones, fat, oils and animal mortalities. Small dead animals such as chickens, ducks, etc. can be added directly. Larger animals may require special treatment prior to composting. There is absolutely no need to segregate meat or animal material from a humanure compost system.

Bins can be constructed on concrete or other hard surfaces, although a soil base encourages beneficial soil organisms, including earth worms, to migrate into the compost pile. Soil will absorb moisture whereas concrete will not. A drained base, such as a gravel bed or soakpit, is not recommended. The object is to keep all of the organic material, including liquids, contained in the compost matrix. Some moisture absorbing into the top couple inches of soil underneath a compost pile is not a problem, but draining liquid into the subsoil can allow it to enter ground water, which could be a source of pollution.

Proper management of the compost pile is very important, therefore experience and education are strongly recommended. Composting is as much an art as it is a science. The top of the compost pile must be kept covered at all times with clean cover materials of sufficient quantity such that all unpleasant odors are eliminated. It is essential that the cover material be appropriate in consistency so that flies cannot access the contents of the pile. For example, straw, grasses, leaves or hay scattered adequately over the compost pile work well for this purpose. Very coarse materials, such as pond reeds, may not.

Compost operations can be executed in two basic manners: “batch” compost or “continuous” compost. Batch compost occurs when an entire compost bin is filled in a short period of time — perhaps in a few days, in a week or two, or even a few months. Continuous compost is when a compost bin is added to continuously for a longer period of time, such as a year. In either case, <u>after</u> the bin is completely filled, the compost should be left adequately covered and <u>undisturbed</u> for approximately one year, or until the internal temperature is equivalent to the average outdoor ambient temperature.

HOW THERMOPHILIC COMPOSTING WORKS

Thermophilic composting is the managed aerobic decomposition of organic matter that includes a hot phase dominated by heat-producing bacteria. The hot phase may last days, weeks or months, depending on factors such as the organic ingredients, the size of the compost mass, ambient temperatures, geographic location and/or time of year, and moisture content, among others. Thermophilic temperatures are generally in the range of 45 degrees C (113F) or hotter.

Much scientific research has been conducted regarding the efficacy of thermophilic compost to destroy human pathogens such as viruses, protozoa, intestinal worms, and bacteria. Research has shown that human pathogens find the thermophilic environment hostile and that they will rapidly die off in such an environment. When Westerberg and Wiley composted sewage sludge which had been inoculated with polio virus, Salmonella, roundworm eggs, and Candida albicans, they found that a compost temperature of 47-55C (116-130F) maintained for three days killed all of these pathogens.[4] This research has been corroborated and expanded by teams of scientists over generations. Most notable among these include Gotass (1956) of the World Health Organization, Feachems et al. (1980) of the World Bank, Shuval et al. (1981) of the World Bank, and Franceys et al. (1992) of the World Health Organization.[2]

TABLE 1

PATHOGEN SURVIVAL BY COMPOSTING OR SOIL APPLICATION

Pathogen	Soil Application	Unheated Anaerobic Digestion	Composting Toilet (Three mo. min. retention time)	Thermophilic Composting
Enteric viruses	May survive 5 mo	Over 3 mo.	Probably elim.	Killed rapidly at 60C
Salmonellae	3 mo. to 1 yr.	Several wks.	Few may surv.	Dead in 20 hrs. at 60C
Shigellae	Up to 3 mo.	A few days	Prob. elim.	Killed in 1 hr. at 55C or in 10 days at 40C
E. coli	Several mo.	Several wks.	Prob. elim.	Killed rapidly above 60C
Cholera vibrio	1 wk. or less	1 or 2 wks.	Prob. elim.	Killed rapidly above 55C
Leptospires	Up to 15 days	2 days or less	Eliminated	Killed in 10 min. at 55C
Entamoeba histolytica cysts	1 wk. or less	3 wks or less	Eliminated	Killed in 5 min. at 50C or 1 day at 40° C
Hookworm eggs	20 weeks	Will survive	May survive	Killed in 5 min. at 50C or 1 hr. at 45C
Roundworm (*Ascaris*) eggs	Several yrs.	Many mo.	Survive well	Killed in 2 hrs. at 55C, 20 hrs. at 50C, 200 hrs. at 45°C
Schistosome eggs	One mo.	One mo.	Eliminated	Killed in 1 hr. at 50°C
Taenia eggs	Over 1 year	A few mo.	May survive	Killed in 10 min. at 59°C, over 4 hrs. at 45°C

Source: Feachem et al., 1980

Table 7.15

THERMAL DEATH POINTS FOR COMMON PARASITES AND PATHOGENS

PATHOGEN	THERMAL DEATH
Ascaris lumbricoides eggs	Within 1 hour at temps over 50°C
Brucella abortus or *B. suis*	Within 1 hour at 55°C
Corynebacterium diptheriae	Within 45 minutes at 55°C
Entamoeba histolytica cysts	Within a few minutes at 45°C
Escherichia coli	One hr at 55°C or 15-20 min. at 60°C
Micrococcus pyogenes var. *aureus*	Within 10 minutes at 50°C
Mycobacterium tuberculosis var. *hominis*	Within 15 to 20 minutes at 66°C
Necator americanus	Within 50 minutes at 45°C
Salmonella spp.	Within 1 hr at 55C; 15-20 min. at 60°C
Salmonella typhosa	No growth past 46C; death in 30 min. 55C
Shigella spp.	Within one hour at 55°C
Streptococcus pyogenes	Within 10 minutes at 54°C
Taenia saginata	Within a few minutes at 55°C
Trichinella spiralis larvae	Quickly killed at 55°C

Source: Gotaas, Harold B. (1956). Composting - Sanitary Disposal and Reclamation of Organic Wastes. p.81. World Health Organization, Monograph Series Number 31. Geneva.

The Humanure Handbook — Chapter 7: Worms and Disease 147

When processing sewage sludge, which is not the same as humanure, but it is similar in that it includes human excrement as a key ingredient, the United States Environmental Protection Agency (EPA) lists composting as one "Process to Further Reduce Pathogens" or PFRP. When this process is operated under specified conditions, "*pathogenic bacteria, enteric viruses, and viable helminth ova are reduced to below detectable levels.*" The specified conditions depend on whether the compost is made in vessels, static aerated piles, or windrows. According to the EPA, "*Using either the within-vessel composting method or the static aerated pile composting method, the temperature of the sewage sludge is maintained at 131F (55C) or higher for three consecutive days. Using the windrow composting method, the temperature of the sewage sludge is maintained at 55C (131F) or higher for fifteen consecutive days or longer. During the period when the compost is maintained at 55C (131F) or higher, there shall be a minimum of five turnings of the windrow*" for the compost to be considered hygienically safe.[5] Compost subjected to these conditions is considered "Class A" compost that can be used for any purpose and is often sold in bags of topsoil or potting soil in department stores in the US.[6]

When human excrement can be rendered hygienically safe through the elimination of pathogenic organisms, the true essence of sanitation can be achieved. Refer to Table 1 for a partial list of pathogen thermal death points.

Compost piles will undergo several stages of decomposition in addition to the thermophilic stage. After the hot phase has subsided, the organic material will continue the process of biological degradation and transformation into humus aided by non-thermophilic microorganisms, macroorganisms such as earthworms and other insects, and fungi. These additional stages allow for the further decomposition of the organic material to produce a plant-friendly, agriculturally beneficial final product. The composting process incorporates both the element of temperature and the element of time. Combined, they produce an end product that is safe, sanitary, pleasant-smelling, stable, storable and can be used for growing human food.

More information about this system is available via The Humanure Handbook, 3rd edition, which can be read free at HumanureHandbook.com. The same website has a number of instructional video clips showing humanure composting toilets and bins in use, both at a single family scale, larger scales and in Haiti. Video clips also show humanure toilet receptacles being emptied into a compost bin, humanure compost being used for gardening and planting trials, etc. There is also a public forum where people from around the world discuss issues and exchange information about compost sanitation systems.

SMALL-SCALE SYSTEMS

Many humanure toilet systems in the U.S., U.K, Australia and Canada utilize 20 liter toilet receptacles often made from nothing more than simple 5-gallon plastic buckets. The toilet cabinets are built to fit the receptacles. For convenience, several toilet receptacles should be available for use, one at a time. As each one fills with toilet material (fecal material, urine, toilet paper and cover material), it is set aside with a lid on it and an empty receptacle is put in its place. The set-aside receptacles, after they're removed from the toilet, can also be used for depositing food scraps. It is not advisable to add food scraps to a humanure toilet in use as it can promote the breeding of fruit flies. When enough full toilet receptacles have collected, they are taken to a compost site and the contents deposited into a compost bin. If the receptacles are being collected by a dedicated composting crew, which is recommended, then any number of full toilet receptacles may accumulate and be stored until collection time. Composting will not occur inside the toilets.

After emptying the receptacles, they are rinsed. A tiny amount of liquid soap and a long-handled toilet brush will aid in cleaning the receptacle. The rinse water can be used to clean other receptacles in order to conserve water. All rinse water is added to the compost pile, soap included. Alternatively, the receptacles can utilize "biodegradable plastic" bag liners, which will largely eliminate the need for cleaning inside the receptacle after emptying it.

In general, one 20-liter toilet receptacle can provide enough toilet capacity to service one adult for one week if the correct cover material is used. Bulky cover materials such as wood shavings do not mask odor effectively and a greater quantity may be needed, filling the toilet more rapidly. Excessive use of toilet paper will also cause the toilet to fill more rapidly. Sawdust has the ideal consistency for toilet cover material, although sawdust that is completely dry will benefit from moistening before use. Not only does a finer, slightly damp cover material mask odor effectively, but it also promotes better composting because the woody particles are smaller and easier to break down by microorganisms. In a family of four using appropriate cover materials, four 20-liter receptacles may be needed per week. If the compost bin is not inconveniently far from the toilet and the toilet receptacles are not allowed to freeze, the weekly emptying and cleaning of four receptacles takes about 20 minutes. Alternatively, the toilet receptacles may be filled, set aside with lids, then collected by a compost service and processed at a central location by trained composters. The author's humanure toilet system has been continually in use in the same location since 1979. During that time, all household toilet material, along with all kitchen scraps, garden weeds, yard materials, animal mortalities, meats, bones, fats, oils, liquids and other organic materials have been recycled through the compost sanitation system.

THE AMURT SCHOOL — PORT AU PRINCE, HAITI

The Amurt School in post-earthquake Port au Prince, Haiti (AmurtHaiti.org), offers a good example of a compost sanitation system in use. Amurt, a “green” school, consists of 11 pavilions and 22 classrooms, 8 composting toilets, 8 rainwater catchment systems, a reservoir, two composting sites, a tree nursery, a permaculture demonstration site and organic gardens. Two agronomists and three technicians provide classes and demonstrations of urban permaculture, focusing on the 820 children attending the preschool and after school programs, their parents, and the women’s and youth groups. Here, students utilize two toilet stalls, each with four toilets (Figure 7). The private toilet stalls have chutes through the floor (Figure 8). The receptacles, located underneath the floor, have a capacity of approximately 60 liters (Figure 9). They can easily be replaced with empty receptacles when full. Sugar cane bagasse and amyris wood sawdust are utilized as cover materials. The system produces approximately eight 60-liter containers of toilet material every three days. This volume fills a compost bin measuring 1.5 meters wide, 2.0 meters long and 1.0 meter high, every three months (Figure 10).

Figure 7 (above): A toilet stall at the Amurt school, located next to the compost bins.

Figure 8 (right): This lady keeps the toilets clean at the Amurt School. The toilet material enters the below-floor receptacle through the white chute.

Figure 9 (above): 60 liter receptacles slide out from underneath the toilet stalls.

Figure 10 (above): Each bin holds approximately three months’ worth of toilet and food material.

Food scraps are added to the compost bin twice a day. Temperatures in the nearly full active compost bin were measuring approximately 60C or 140F (Figure 11). A bin that had been aging for six months was still reading 55C (131F).

The compost bins are adjacent to the toilet stalls, allowing the contents to be conveniently composted without the need to transport the toilet material. The system is devoid of unpleasant odor and flies are not a problem. A hand washing station is conveniently located next to the toilet stall (Figure 12).

The self-managed compost sanitation system has a dedicated crew of three persons: one woman who cleans the compost receptacles and two men who manage the composting (Figure 13). They are paid by the school. In Figure 13, the nearer bin has reached maturity and is being used in the gardens. The far bin has been aging for 6 months and is still at approximately 55C. It will require months more to cool down and reach maturity.

Figure 11: Temperatures measured ranged from 46C (115F) to over 74C (165F). Fluctuations varied according to size of pile, age and contents.

Figure 12: Hand washing stations are an important part of the system.

Figure 13: Two men manage the compost sanitation system at the Amurt School.

When toilet receptacles are full, the contents are deposited into a compost bin. First, the cover material in the bin is raked back, then a depression is dug into the top of the compost pile (Figure 14). The toilet material is added into the depression (Figure 15) and the cover material is raked back over the fresh deposit (Figure 16).

Figure 14: The compost pile is opened before fresh toilet material is added.

Figure 15: The toilet material is emptied into the pile.

Figure 16: Cover material is raked back over the fresh deposit.

The toilet receptacle is rinsed with water (Figure 17) and the water is dumped into the compost pile (Figure 18). New cover material is added (Figure 19).


Figure 17: The receptacle is rinsed.


Figure 18: The rinse water is dumped into the pile.


Figure 19: Clean cover material is deposited over the top of the pile.

The compost must undergo a prolonged aging period of approximately a year after it is collected, otherwise the compost will be immature and phytotoxic (it will kill plants). Maturity is reached when the compost pile cools down and the internal temperature is approximately the same as average ambient (outdoor) temperature. At this point, the compost should be suitable for growing food. It can be tested by planting a seed, such as a squash or cucumber, in a sample of the compost.

Posters explaining the proper use of the toilets are displayed in the toilet stalls (Figure 20). Community training seminars are provided by GiveLove.org (Figure 21).

There is no waste in this system. Instead, where other sanitation systems produce sewage and pollution, compost sanitation produces fertile soil and food for humanity (Figure 22).

Figure 20: Posters describing the correct way to use the toilets are posted in every toilet stall.


Figure 21: Community training seminars that teach local residents about ecological sanitation are provided by GiveLove.org.


Figure 22: Mature compost is an excellent soil additive.

Figure 23: A typical Haitian pit latrine in Leogane at a Habitat for Humanity site is filthy and unpleasant. The toilet smells terrible, breeds maggots and flies, creates waste and pollutes ground water.

OTHER HAITIAN EXAMPLES

Many Haitians do not have the luxury of ecological sanitation systems and instead must use pit latrines. These are very odorous, fly infested, maggot-breeding holes in the ground which children can fall into. They're unpleasant to say the least, they pollute ground water, and the flies can spread disease. Figure 23 provides an example of a typical pit latrine in use at a Habitat for Humanity site in Leogane.

As an alternative to pit latrines, portable toilets are sometimes provided. However, these often fill up and remain unemptied. They then become very odorous and fly-infested and are shunned by the local population who would rather practice open defecation than walk into a stinky portable toilet. Figure 24 shows such a toilet in Cite Soleil. Feces are scattered on the ground around the toilet because the children would not go inside.

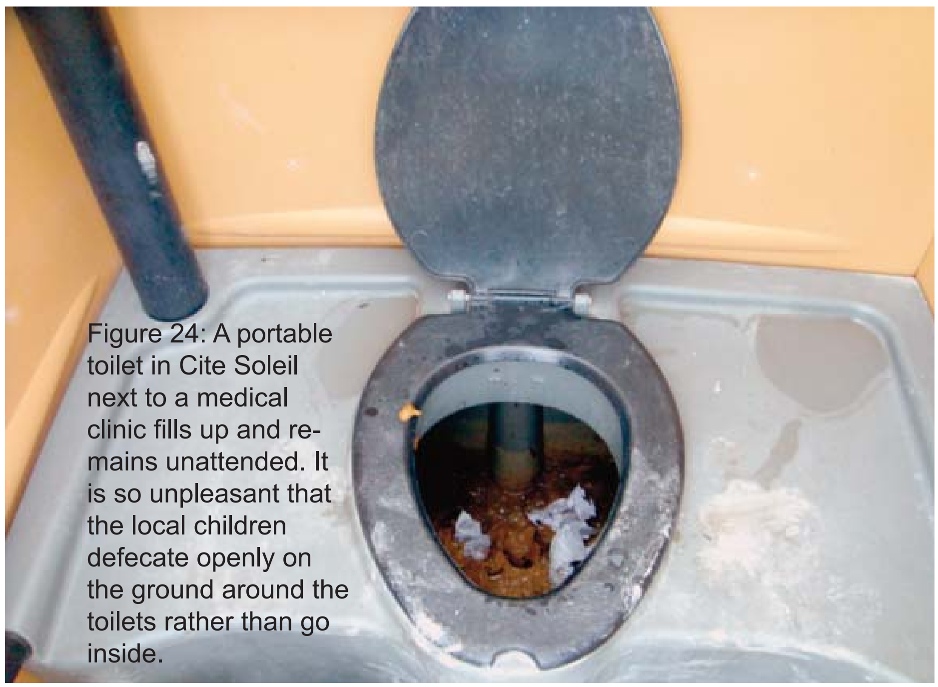

Figure 24: A portable toilet in Cite Soleil next to a medical clinic fills up and remains unattended. It is so unpleasant that the local children defecate openly on the ground around the toilets rather than go inside.

Figure 25: The toilets at the Matt Gunn orphanage site are located adjacent to the compost bins. There is no odor and no flies. A bagasse pile nearby provides the cover materials.

ORFELINAT ENFANT DE L'ESPOIR OR "CHILDREN OF HOPE" ORPHANAGE

The Orfelinat Enfant de L'Espoir or "Children of Hope" Orphanage in Leogane has a compost sanitation system very similar to the Amurt School. The stalls are located near the compost bins (Figure 25); inside each stall is a poster describing how to use the toilet. There is a rain water catchment system on the toilet building which provides water for washing toilet receptacles and for hand washing. Both 20 liter and 60 liter receptacles are used. The 20 liter toilets are meant for the smaller children while the 60 liter toilets are meant for the bigger children and adults. The toilet receptacles are located inside the toilet stalls, which are inside a small building adorned with a painting of the “human nutrient cycle” (Figure 26). The receptacles are removed from the inside. The 20 liter receptacle lifts out while the 60 liter receptacle slides out. Figure 27 illustrates the 60 liter toilet and Figure 28 illustrates the 20 liter toilet.

Figure 26 (above): The orphanage toilet is painted with a picture of the “human nutrient cycle” as well as a “GiveLove ecological sanitation” emblem. The rain water catchment system provides wash water for hands and toilet receptacles. GiveLove.org provided the setup and training for this self-managed compost sanitation system.

Figure 27: The Children of Hope toilets utilize 20 liter and 60 liter receptacles. This 60-liter receptacle simply slides out of the toilet when full, then a lid is placed on the receptacle until it is emptied.

Figure 28 (left): Twenty liter receptacles provide smaller toilets for young children.

THE SOPUDEP SCHOOL IN PETIONVILLE, HAITI

Harry Ha of Partners With Haiti and the Toronto Haiti Action Committee travelled to Haiti in February and March, 2011 to lead the installation of four composting toilets at the Sopudep School. GiveLove.org aided their endeavors. The sanitation system utilizes 20 liter receptacles and is self-managed by school personnel, serving 500 children when school is in session. The stall has a painting of the human nutrient cycle on the outer wall for educational purposes (Figure 29). The compost bins are immediately adjacent to the toilet building and the bagasse supply is nearby. Bagasse is also stored next to the toilets in wall-mounted dispensers (Figure 30). Rain water is collected and provided for hand washing (Figure 31).

Figure 29 (above): The toilet system at the Sopudep School utilizes the same procedures as Amurt and Matt Gunn.

Figure 30 (right): Sopudep uses 20 liter receptacles that lift out of the toilet when full. The bagasse is dispensed by hand from the green wall-mounted bin.

Figure 31 (above): Sopudep's toilet building includes a hand washing station supplied by rain water.

POTENTIAL PROBLEMS WITH COMPOST SANITATION SYSTEMS

Inadequate information, training, understanding and knowledge can make compost sanitation systems problematic. This is compounded by fear of fecal material. People who are not comfortable with alternative sanitation and who aren't serious and conscientious should not be managing humanure toilet systems. There should be a dedicated compost crew who understands and cares about what they're doing when compost sanitation is undertaken.

Correct and adequate cover materials must be used. Some people simply expect toilets to smell bad. They cannot imagine that a toilet can be odor-free — a result easily obtained by humanure toilets when correct cover materials are used in adequate quantities.

The basic management procedure is simple enough: if bad odors are smelled or flies are attracted to the toilet or the compost bins, then more cover material must be used. A conscientious compost sanitation manager will easily understand this and will be able to maintain an odor-free, sanitary system.

Figure 32 shows a mismanaged compost pile at an American relief agency site in Port au Prince. Note that the compost pile has inadequate cover material on top. There should

Figure 32: This compost is being mismanaged. There should be nothing visible but clean cover material on top. Instead, the compost was odorous and was breeding maggots. The few seconds it would have taken to throw clean cover material on the pile would have eliminated the odors and maggots.

be nothing visible but the cover material — no flies, no maggots, no food, no toilet material — and there should be no unpleasant odors. This pile was odorous and was breeding maggots when it could simply have been covered over adequately and these deficiencies avoided. The problem at this site was caused by a frequent turn-over of volunteers such that a dedicated compost crew was not available. Continuity of training was not maintained and the proper maintenance of the compost system fell to the wayside. Although GiveLove.org had set up this system, they had to remove their toilets from the site in 2012 due to mismanagement.

All toilet wash water must go into the compost piles and not be dumped anywhere else. The system is to be kept "closed" in order to keep human excrement from polluting the environment. It is important that humanure toilets be kept indoors in a heated area in cold climates; otherwise the contents of the receptacles can freeze and will not be able to be emptied. Frozen receptacles can also crack and leak. Compost bins can be located too far from the toilet area. This can make the job of emptying toilet receptacles burdensome and unpleasant if the toilet receptacles must be moved by hand, or expensive if otherwise transported. There is no reason to situate the compost bins far away. If they are adequately managed and covered, there is no odor. People who fear human excrement assume the compost bins will stink and will put them so far away from the toilet as to be impractical. This is a recipe for failure. The solution is to use enough cover material in the bins to prevent odors from escaping no matter where the bins are located.

CONCLUSION

Compost sanitation systems can provide safe and pleasant toilet alternatives in developing countries where electricity, water or money are in short supply, so long as carbon-based cover materials are available and compost sanitation personnel are conscientious and trainable. Compost sanitation systems are already in use in developed nations where users are motivated by the desire to prevent pollution and to produce compost for growing plants. The fact that compost sanitation systems are waste-free and instead produce compost suitable for growing human food should make this an attractive sanitation alternative anywhere in the world.

ABOUT

Joseph Jenkins is best known for authoring the Humanure Handbook — A Guide to Composting Human Manure — first published in 1995 and now in its 3rd edition. The book has been sold worldwide and published in foreign editions on four continents. He has been a compost practitioner in the United States since 1975 and has grown his family's food with humanure compost continually since 1979. His web site at HumanureHandbook.com offers videos, instructions and the complete Humanure Handbook free of charge. Jenkins also provides humanure sanitation consulting services internationally. More information about the author can be found at JosephJenkins.com. GiveLove.org was founded by Patricia Arquette and Rosetta Getty. Its project coordinator is Alisa Keesey and its primary educator in Haiti is Jean Lucho.

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