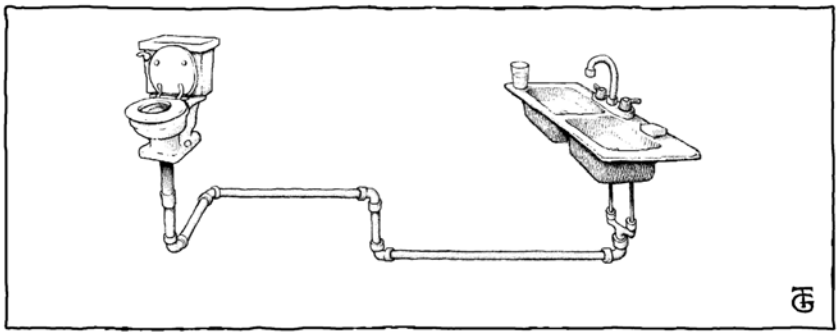


COMPOSTING TOILETS AND SYSTEMS

Technically, a "composting toilet" is a toilet in which composting takes place. Usually, the composting chamber is located under the toilet. Other toilets are simply collection devices in which humanure is deposited, then removed to a separate composting location away from the toilet area. These toilets are components of "composting toilet systems," rather than composting toilets, *per se*. They can also be called "compost toilets."

Humanure composting toilets and systems can generally be divided into two categories based on the composting temperatures they generate. Some toilet systems produce thermophilic (hot) compost; others produce low-temperature compost. Most commercial and homemade composting toilets are low-temperature composting toilets, sometimes called "mouldering toilets."

The most basic way to compost humanure is simply to collect it in a toilet receptacle and add it to a compost pile. The toilet acts only as a collection device, while the composting takes place at a separate location. Such a toilet requires little, if any, expense and can be constructed and operated by people of simple means in a wide range of cultures around the world. It is easy to create thermophilic (hot) compost with such a collection toilet. This type of toilet is discussed in detail in Chapter 8, "The Tao of Compost."

The toilets of the future will also be collection devices rather than waste disposal devices. The collected organic material will be hauled away from homes, like municipal garbage is today, and composted under the responsibility of municipal authorities, perhaps

under contract with private sector composting facilities. Currently, other recyclable materials such as bottles and cans are collected from homes by municipalities; in some areas organic food materials are also collected and composted at centralized composting facilities. The day will come when the collected organic materials will include toilet materials.

In the meantime, homeowners who want to make compost rather than sewage must do so independently by either constructing a composting toilet of their own, buying a commercial composting toilet, or using a simple collection toilet with a separate composting bin. The option one chooses depends upon how much money one wants to spend, where one lives, and how much involvement one wants in the compost-making process.

A simple collection toilet with a separate compost bin is the least expensive, but tends to be limited to homes where an outdoor compost bin can be utilized. Such a toilet is only attractive to people who don't mind the regular job of emptying containers of compost onto a compost pile, and who are willing to responsibly manage the compost to prevent odor and to ensure appropriate composting conditions.

Homemade composting toilets, on the other hand, generally include a compost bin underneath the toilet and do not involve transporting humanure to a separate composting area. They may be less expensive than commercial composting toilets and they can be built to whatever size and capacity a household requires, allowing for some creativity in their design. They are usually permanent structures located under the dwelling in a crawl space or basement, but they can also be free-standing outdoor structures. The walls are typically made of a concrete material, and the toilets are most successful when properly managed. Such management includes the regular addition to the toilet contents of sufficient carbon-based bulking material, such as sawdust, peat moss, straw, hay or weeds. Homemade composting toilets generally do not require water or electricity.

Commercial composting toilets come in all shapes, types, sizes, and price ranges. They're usually made of fiberglass or plastic and consist of a composting chamber underneath the toilet seat. Some of them use water and some of them require electricity. Some require neither.

COMPOSTING TOILETS MUST BE MANAGED

We have used flush toilets for so long that after we defecate we expect to simply pull a handle and walk away. Some think that composting toilets should behave in the same manner. However, flush toilets are *disposal* devices that create pollution and squander soil fertility. Composting toilets are recycling devices that should create no pollution and should recover the soil nutrients in human manure and urine. When you push a handle on a flush toilet, you're paying someone to dispose of your waste for you. Not only are you paying for the water, for the electricity and for the wastewater treatment costs, but you are also contributing to the environmental problems inherent in waste disposal. When you use a composting toilet, you are *getting* paid for the small amount of effort you expend in recycling your organic material. Your payment is in the form of compost. Composting toilets, therefore, require some management. You have to *do* something besides just pushing a handle and walking away.

The degree of your involvement will depend on the type of toilet you are using. In most cases, this involves simply adding some clean organic cover material such as peat moss, sawdust, rice hulls or leaf mould to the toilet after each use. Instead of flushing, you cover. Nevertheless, someone must take responsibility for the overall management of the toilet. This is usually the homeowner, or someone else who has volunteered for the task. Their job is simply to make sure sufficient cover materials are available and being used in the toilet. They must also add bulking materials to the toilet contents when needed, and make sure the toilet is not being used beyond its capacity, not becoming waterlogged, and not breeding flies. Remember that a composting toilet houses an organic mass with a high level of microscopic biodiversity. The contents are alive, and must be watched over and managed to ensure greatest success.

FECOPHOBIA AND THE PATHOGEN ISSUE

The belief that humanure is unsafe for agricultural use is called *fecophobia*. People who are fecophobic can suffer from severe fecophobia or a relatively mild fecophobia, the mildest form being little more than a healthy concern about personal hygiene. Severe fecophobics do not want to use humanure for food growing, composted or not. They believe that it's dangerous and unwise to use such a material in their garden. Milder fecophobics may, however, compost

humanure and use the finished compost in horticultural applications. People who are not fecophobic may compost humanure and utilize it in their food garden.

It is well known that humanure contains the *potential* to harbor disease-causing microorganisms or *pathogens*. This potential is directly related to the state of health of the population which is producing the excrement. If a family is composting its own humanure, for example, and it is a healthy family, the danger in the production and use of the compost will be very low. If one is composting the humanure from orphanages in Haiti where intestinal parasites are endemic, then extra precautions must be taken to ensure maximum pathogen death. Compost temperatures must rise significantly above the temperature of the human body (37^0C or 98.6^0F) in order to begin eliminating disease-causing organisms, as human pathogens thrive at temperatures similar to that of their hosts. On the other hand, most pathogens only have a limited viability outside the human body, and given enough time, will die even in low-temperature compost.

Humanure is best rendered hygienically safe by thermophilic composting. To achieve this, humanure can simply be collected and deposited on an outdoor compost pile like any other compost material. Open-air, outdoor compost piles with good access are easily managed and offer a no-cost, odorless method to achieve the thermophilic composting of humanure. However, such a system does require the regular collection and cartage of the organic material to the compost pile, making it relatively labor-intensive when compared to low-temperature, stationary, homemade and commercial composting toilets.

Many people will use a composting toilet only if they do not have to do anything in any way related to the toilet contents. Therefore, most homemade and commercial composting toilets are comprised of large composting chambers under the toilet seat. The organic material is deposited directly into a composting chamber, and the contents are emptied only very occasionally.

Thermophilic conditions do not seem to be common in these toilets, for several reasons. For one, many commercial composting toilets are designed to *dehydrate* the organic material deposited in them. This dehydration is achieved by electrical fans which rob the organic mass of moisture *and* heat. Commercial toilets also often strive to reduce the *volume* of material collecting in the composting chamber (mostly by dehydration), in order to limit the frequency of emptying for the sake of the convenience of the user. Bulky air-entrapping additions to the compost are not encouraged, although

these additions will encourage thermophilic composting. Yet, even passive, low-temperature composting will eventually yield a relatively pathogen-free compost after a period of time.

Low-temperature composting toilets include most commercial and many homemade units. According to current scientific evidence, a few months retention time in just about any composting toilet will result in the deaths of nearly all human pathogens (see Chapter 7). The most persistent pathogen seems to be the roundworm (*Ascaris lumbricoides*) and particularly the egg of the roundworm, which is protected by an outer covering which resists chemicals and adverse environmental conditions. Estimates of the survival time of *Ascaris* eggs in certain soil types under certain conditions are as high as ten years. Although the *Ascaris* eggs are readily destroyed by thermophilic composting, they may survive in conditions generated by a low-temperature toilet. This is why the compost resulting from such toilets is generally not recommended for garden use if it comes in contact with food crops.

People can become rather obsessive about this issue. One man who published a book on this topic wrote to me to say that a two year retention time in a low-temperature composting toilet is generally considered adequate for the destruction of *Ascaris* ova (eggs). He indicated that he would never consider using his own low-temperature compost until it had aged at least two years. I asked him if he was infected with roundworms. He said no. I asked him if anyone else was using his toilet. No. I asked him why he would think there could be roundworm eggs in his compost when he knew he didn't have roundworms in the first place? Sometimes common sense is not so common when issues of humanure are involved. This is similar to the phobic person who would never go to a movie theater because there may be someone in the theater who has tuberculosis and who may sneeze. Although this is a risk we all take, it's not likely to be a problem.

OWNER-BUILT COMPOSTING TOILETS

Owner-built composting toilets are in widespread use throughout the world since many people do not have the financial resources required to purchase commercially-produced toilets. Owner-built devices tend to be low-temperature composting toilets, although they can conceivably be thermophilic toilet systems if properly managed.

The objectives of any composting toilet should be to achieve

safe and sanitary treatment of fecal material, to conserve water, to function with a minimum of maintenance and energy consumption, to operate without unpleasant odors and to recycle humanure back to the soil.

The primary advantage of low-temperature toilets is the passive involvement of the user. The toilet collection area need not be entered into very often unless, perhaps, to rake the pile flat. The pile that collects in the chamber must be raked somewhat every few months, which can be done through a floor access door. The chamber is emptied only after nothing has been deposited in it for at least a year or two, although this time period may vary depending on the individual system used.

In order for this system to work well, each toilet must have a minimum of two chambers. Fecal material and urine are deposited into the first chamber until it's full, then the second chamber is used while the first ages. By the time the second side is full, the first should be ready to empty. It may take several years to fill a side, depending on its capacity and the number of users. In addition to feces, carbonaceous organic matter such as sawdust, as well as bulky vegetable matter such as straw and weeds, are regularly added to the chamber in use. A clean cover of such material is maintained over the compost at all times for odor prevention.

Some composting toilets involve the separation of urine from feces. This is done by urinating into a separate container or into a diversion device which causes the urine to collect separately from the feces. The reason for separating urine from feces is that the urine/feces blend contains too much nitrogen to allow for effective composting and the collected material can get too wet and odorous. Therefore, the urine is collected separately, reducing the nitrogen, the liquid content and the odor of the collected material.

An alternative method of achieving the same result which does not require the separation of urine from feces does exist. Organic material with too much nitrogen for effective composting (such as a urine/feces mixture) can be balanced by adding more carbon material such as sawdust, rather than by removing the urine. The added carbon material absorbs the excess liquid and will cover the refuse sufficiently to eliminate odor completely. This also sets the stage for thermophilic composting because of the carbon/nitrogen balancing.

One should first prime a composting toilet chamber before use by creating a "biological sponge," a thick layer of absorbent organ-

ic material in the bottom of the compost chamber to a depth of up to 50% of its capacity. Some suggest that the toilet can be filled to 100% of its capacity before beginning to be used, because if the material is loose (such as loose hay), it will compress under the weight of the added humanure. A bottom sponge may even consist of bales of hay or straw buried in sawdust. These materials absorb the excess urine as it is added to the toilet. Fecal material is covered after each use with materials such as sawdust, peat, leaf mould or rice hulls. A drain into a five gallon bucket (perhaps pre-filled with sawdust) will collect any leachate, which can simply be deposited back on the compost pile. Extra bulking materials such as straw, weeds, hay and food scraps are regularly added to the compost chamber to help oxygenate and feed the growing organic mass in order to promote thermophilic decomposition. Ventilation can be enhanced by utilizing a vertical pipe installed like a chimney, which will allow air to passively circulate into and out of the compost chamber.

Such systems will need to be custom-managed according to the circumstances of the individuals using them. Someone needs to keep an eye on the toilet chambers to make sure they're receiving enough bulking material. The deposits need to be flattened regularly so that they remain covered and odorless. Chutes that channel humanure from the toilet seat to the compost chamber must be cleaned regularly in order to prevent odors. When one compost chamber is filled, it must be rested while the other is filled. A close eye on the toilet contents will prevent waterlogging. Any leachate system must be monitored.

In short, any composting toilet will require some management. Remember that you are actively recycling organic material and that means you are doing something constructive. When you consider the value of the finished compost, you can also realize that every time you deposit into a composting toilet, it's as if you're putting money in the bank.

Homemade low-temperature composting toilets offer a method of composting humanure that is attractive to persons wanting a low-maintenance, low-cost, fairly passive approach to excrement recycling. Any effort which constructively returns organic refuse to the soil without polluting water or the environment certainly demands a high level of commendation.

ASIAN COMPOSTING

It is well known that Asians have recycled humanure for centuries, possibly millennia. How did they do it? Historical information concerning the composting of humanure in Asia seems difficult to find. Rybczynski et al. state that composting was only introduced to China in a systematic way in the 1930s and that it wasn't until 1956 that composting toilets were used on a wide scale in Vietnam.[1] On the other hand, Franceys et al. tell us that composting "has been practiced by farmers and gardeners throughout the world for many centuries." They add that, "In China, the practice of composting [humanure] with crop residues has enabled the soil to support high population densities without loss of fertility for more than 4000 years." [2]

However, a book published in 1978 and translated directly from the original Chinese indicates that composting has not been a cultural practice in China until only recently. An agricultural report from the Province of Hopei, for example, states that the standardized management and hygienic disposal (i.e., composting) of excreta and urine was only initiated there in 1964. The composting techniques being developed at that time included the segregation of feces and urine, which were later "poured into a mixing tank and mixed well to form a dense fecal liquid" before piling on a compost heap. The compost was made of 25% human feces and urine, 25% livestock manure, 25% miscellaneous organic refuse and 25% soil.[3]

Two aerobic methods of composting were reported to be in widespread use in China, according to the 1978 report. The two methods are described as: 1) surface aerobic continuous composting; and 2) pit aerobic continuous composting. The surface method involves constructing a compost pile around an internal framework of bamboo, approximately nine feet by nine feet by three feet high (3m x 3m x 1m). Compost ingredients include fecal material (both human and non-human), organic refuse and soil. The bamboo poles are removed after the compost pile has been constructed — the resultant holes allowing for the penetration of air into this rather large pile of refuse. The pile is then covered with earth or an earth/horse manure mix, and left to decompose for 20 to 30 days, after which the composted material is used in agriculture.

The pit method involves constructing compost pits five feet wide and four feet deep by various lengths, and digging channels in the floor of the pits. The channels (one lengthwise and two widthwise) are covered with coarse organic material such as millet stalks.

A bamboo pole is then placed vertically along the walls of the pit at the end of each channel. The pit is then filled with organic refuse and covered with earth, and the bamboo poles are removed to allow for air circulation.[4]

A report from a hygienic committee of the Province of Shantung provides us with additional information on Chinese composting.[5] The report lists three traditional methods used in that province for the recycling of humanure:

1) Drying — "Drying has been the most common method of treating human excrement and urine for years." It is a method that causes a significant loss of nitrogen;

2) Using it raw, a method that is known to allow pathogen transmission; and

3) "Connecting the household pit privy to the pig pen . . . a method that has been used for centuries." This is an unsanitary method in which the excrement was simply eaten by a pig.

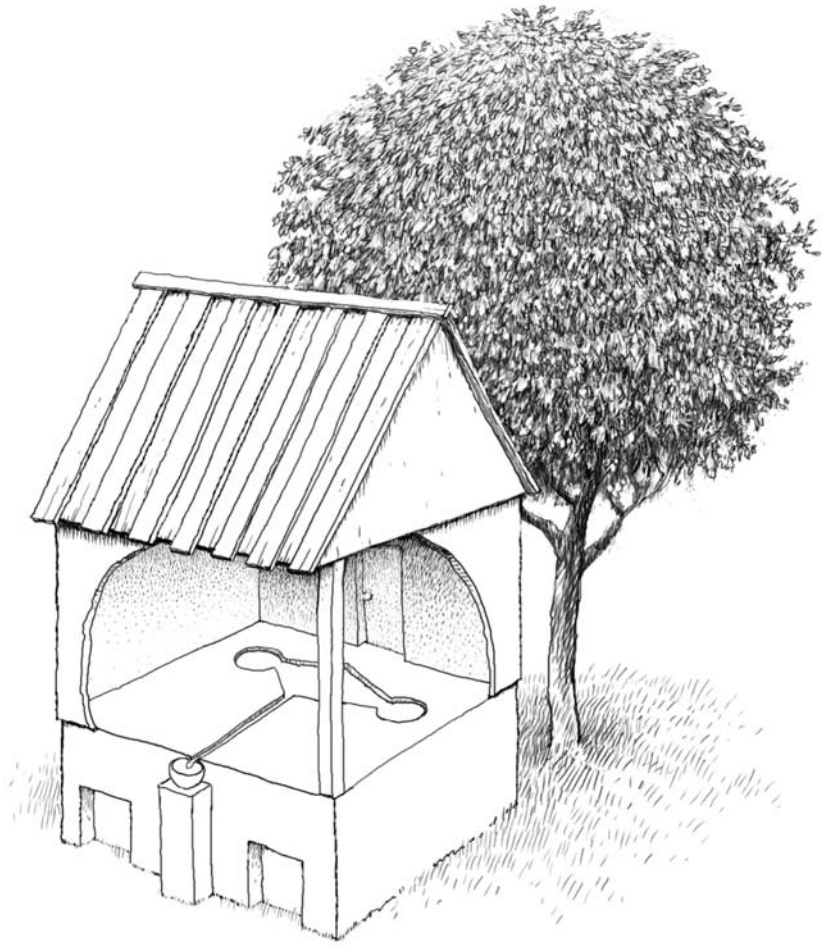
No mention is made whatsoever of composting being a traditional method used by the Chinese for recycling humanure. On the contrary, all indications were that the Chinese government in the 1960s was, at that time, attempting to establish composting as preferable to the three traditional recycling methods listed above, mainly because the three methods were hygienically unsafe, while composting, when properly managed, would destroy pathogens in humanure while preserving agriculturally valuable nutrients. This report also indicated that soil was being used as an ingredient in the compost, or, to quote directly, "Generally, it is adequate to combine 40-50% of excreta and urine with 50-60% of polluted soil and weeds."

For further information on Asian composting, I must defer to Rybczynski et al., whose World Bank research on low-cost options for sanitation considered over 20,000 references and reviewed approximately 1,200 documents. Their review of Asian composting is brief, but includes the following information, which I have condensed:

There are no reports of composting privys or toilets being used on a wide scale until the 1950s, when the Democratic Republic of Vietnam initiated a five-year plan of rural hygiene and a large number of anaerobic composting toilets were built. These toilets, known as the Vietnamese Double Vault, consisted of two above ground water-tight tanks, or vaults, for the collection of humanure. For a family of five to ten people, each vault was required to be 1.2 m wide, 0.7 m high and 1.7 m long (approximately 4 feet wide by 28 inches high and 5 feet, 7 inches long). One tank is used until full and

left to decompose while the other tank is used. The use of this sort of composting toilet requires the segregation of urine, which is diverted to a separate receptacle through a groove on the floor of the toilet. Fecal material is collected in the tank and covered with soil, where it anaerobically decomposes. Kitchen ashes are added to the fecal material for the purpose of reducing odor.

Eighty-five percent of intestinal worm eggs, one of the most persistently viable forms of human pathogens, were found to be destroyed after a two-month composting period in this system. However, according to Vietnamese health authorities, forty-five days



Vietnamese Double Vault

in a sealed vault is adequate for the complete destruction of all bacteria and intestinal parasites (presumably they mean pathogenic bacteria). Compost from such latrines is reported to increase crop yields by 10-25% in comparison to the use of raw humanure. The success of the Vietnamese Double Vault required "long and persistent health education programs." [6]

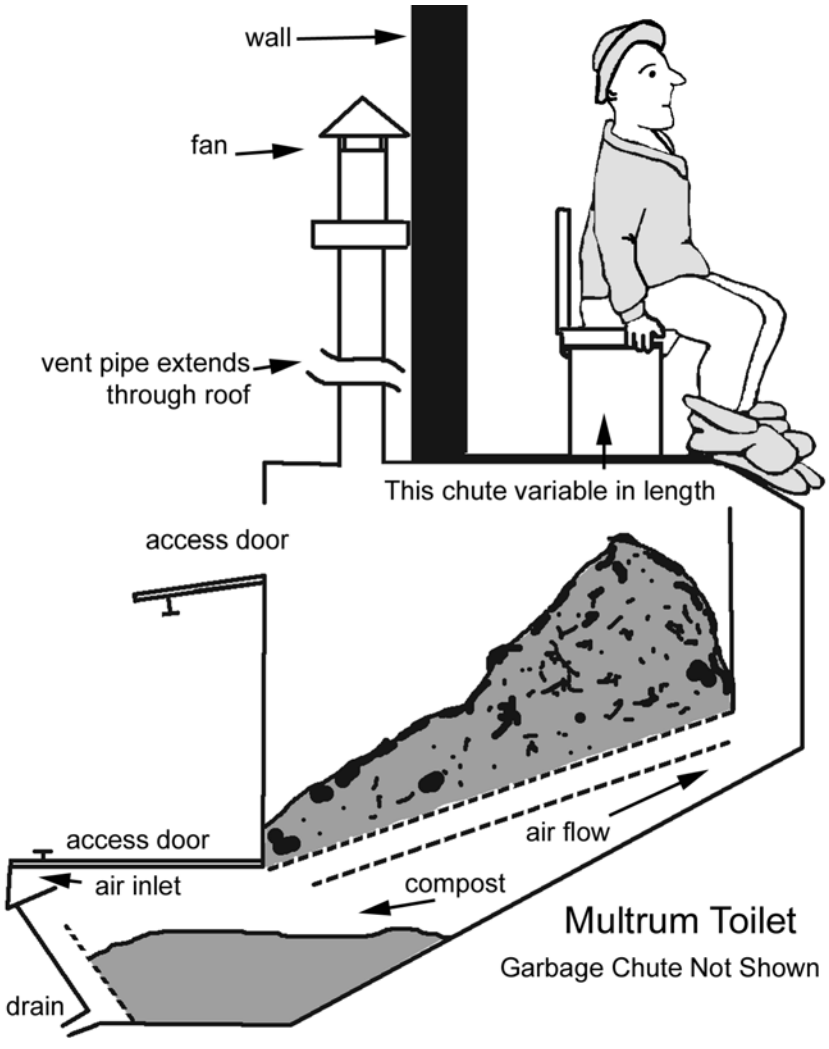
When the Vietnamese Double Vault composting toilet system was exported to Mexico and Central America, the result was "overwhelmingly positive," according to one source, who adds, "*Properly managed, there is no smell and no fly breeding in these toilets. They seem to work particularly well in the dry climate of the Mexican highlands. Where the system has failed because of wetness in the processing chamber, odours, and/or fly breeding, it was usually due to non-existent, weak, or bungled information, training and follow-up.*" [7] A lack of training and a poor understanding of the composting processes can cause any humanure composting system to become problematic. Conversely, complete information and an educated interest can ensure the success of humanure composting systems.

Another anaerobic double-vault composting toilet used in Vietnam includes using both fecal material and urine. In this system, the bottoms of the vaults are perforated to allow drainage, and urine is filtered through limestone to neutralize acidity. Other organic refuse is also added to the vaults, and ventilation is provided via a pipe.

In India, the composting of organic refuse and humanure is advocated by the government. A study of such compost prepared in pits in the 1950s showed that intestinal worm parasites and pathogenic bacteria were completely eliminated in three months. The destruction of pathogens in the compost was attributed to the maintenance of a temperature of about 40^{0}C (104^{0}F) for a period of 10-15 days. However, it was also concluded that the compost pits had to be properly constructed and managed, and the compost not removed until fully "ripe," in order to achieve the satisfactory destruction of human pathogens. If done properly, it is reported that "there is very little hygienic risk involved in the use and handling of [humanure] compost for agricultural purposes." [8]

COMMERCIAL COMPOSTING TOILETS

Commercial composting toilets have been popular in Scandinavia for some time; at least twenty-one different composting toilets were on the market in Norway alone in 1975.[9] One of the most popular types of commercially available composting toilets in the United States today is the multrum toilet, invented by a Swedish engineer and first put into production in 1964. Fecal material and urine are deposited together into a single chamber with a double bottom. The decomposition takes place over a period of years, and the finished compost gradually falls down to the very bottom of the toilet



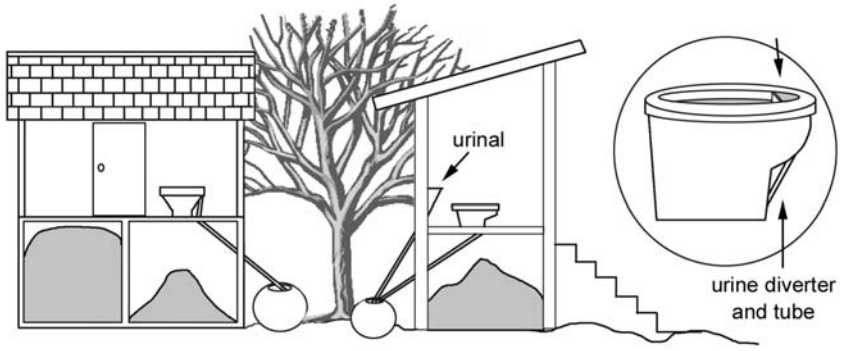
chamber where it can be removed. Again, the decomposition temperatures remain cool, not usually climbing above 32°C (90°F). Therefore, it is recommended that the finished compost be buried under one foot of soil or used in an ornamental garden.[10]

Because no water is used or required during the operation of this toilet, human excrement is kept out of water supplies. According to one report, a single person using a Clivus (pronounced Clee-vus) Multrum will produce 40 kg (88 lbs) of compost per year while refraining from polluting 25,000 liters (6,604 gallons) of water annually.[11] The finished compost can be used as a soil additive where the compost will not come in contact with food crops.

A 1977 report, issued by Clivus Multrum USA, analyzed the nutrient content in finished compost from seven Clivus Multrum toilets which had been in use for 4 to 14 years. The compost averaged 58% organic matter, with 2.4% nitrogen, 3.6% phosphorous, and 3.9% potassium, reportedly higher than composted sewage sludge, municipal compost or ordinary garden compost. Suitable concentrations of trace nutrients were also found. Toxic metals were found to exist in concentrations far below recommended safe levels.[12]

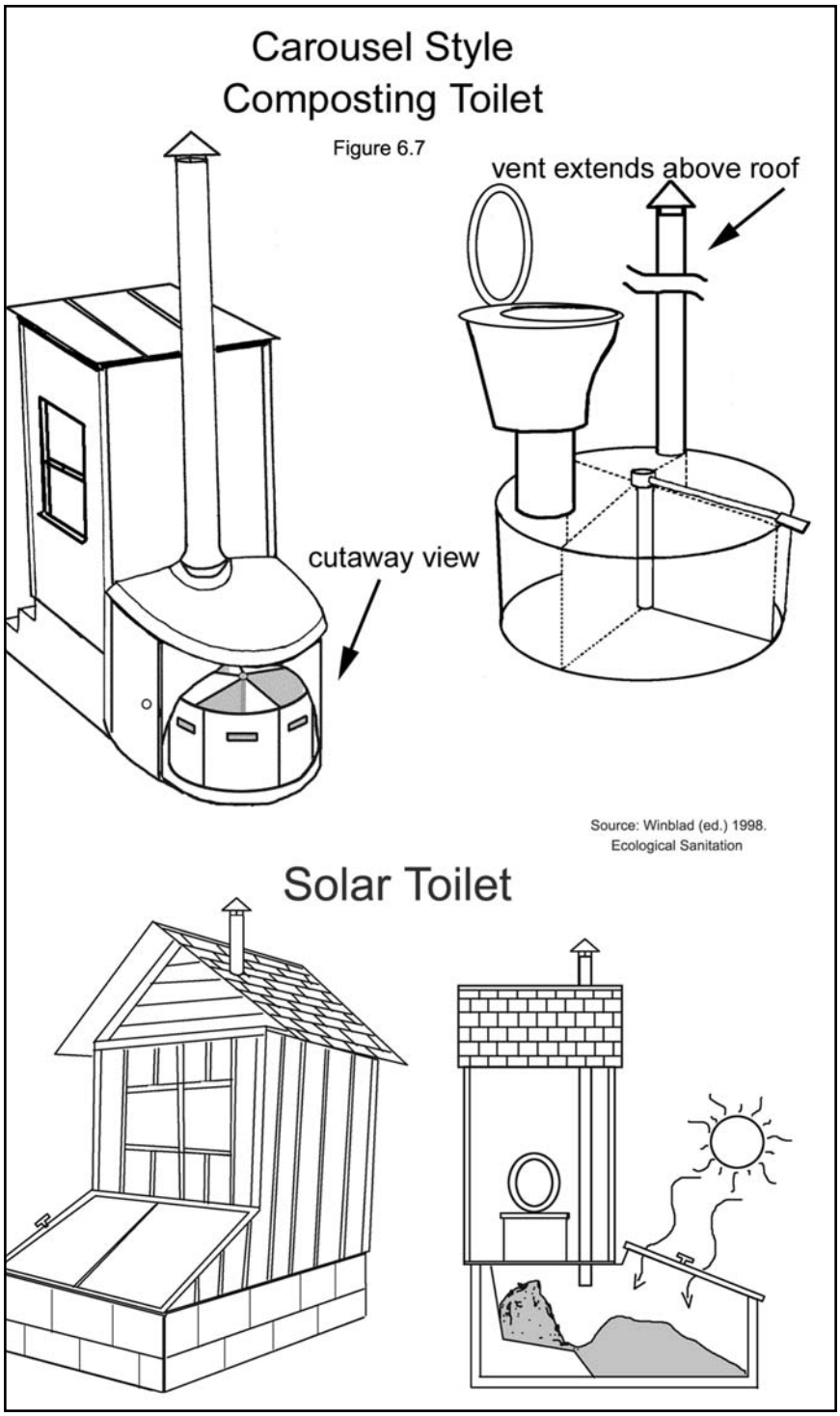
If a multrum toilet is managed properly, it should be odor and worry-free. As always, a good understanding of the basic concepts of composting helps anyone who wishes to use a composting toilet. Nevertheless, the multrum toilets, when used properly, should provide a suitable alternative to flush toilets for people who want to stop defecating in their drinking water. You can probably grow a heck of a rose garden with the compost, too.

Inexpensive versions of multrum toilets were introduced into



Guatemalan Composting Toilet

Source: Schiere, Jacobo (1989). LASF Una Letrina Para la Familia. Cornite Central Menonita, Technologia Apropriada, Santa Maria Cauque, Sacatepequez, Apartado Postal 1779, Guatemala Cuidad, Guatemala.


Carousel Style
Composting Toilet
Figure 6.7
vent extends above roof
cutaway view
Source: Winblad (ed.) 1998.
Ecological Sanitation
Solar Toilet

the Philippines, Argentina, Botswana and Tanzania, but were not successful. According to one source, "*Compost units I inspected in Africa were the most unpleasant and foul-smelling household latrines I have experienced. The trouble was that the mixture of excreta and vegetable matter was too wet, and insufficient vegetable matter was added, especially during the dry season.*" [13] Poor management and a lack of understanding of how composting works may create problems with any compost toilet. Too much liquid will create anaerobic conditions with consequent odors. The aerobic nature of the organic mass can be improved by the regular addition of carbonaceous bulking materials. Compost toilets are not pit latrines. You cannot just defecate in a hole and walk away. If you do, your nose will soon let you know that you're doing something wrong.

Besides the Scandinavian multrum toilets, a variety of other composting toilets are available on the market today. Some cost upwards of $10,000 or more and can be equipped with insulated tanks, conveyers, motor-driven agitators, pumps, sprayers, and exhaust fans.[15]

According to a composting toilet manufacturer, waterless composting toilets can reduce household water consumption by 40,000 gallons (151,423 liters) per year.[16] This is significant when one considers that only 3% of the Earth's water is not salt water, and two-thirds of the freshwater is locked up in ice. That means that less than one percent of the Earth's water is available as drinking water. Why shit in it?

Back to Chapter 5 Go to next chapter.

COMPOST TESTING LABS

WOODS END AGRICULTURAL INSTITUTE, INC. — PO Box 297, Mt. Vernon, ME 04352 USA; Ph: 207-293-2457 or 800 451 0337; FAX: 207-293-2488; email: compost@woodsend.org; website: woodsend.org; Ascaris and coliform testing as well as full nutrient tests. Sells the Solvita(R) Maturity Test Kit which is now approved in CA, CT, IL, MA, ME, NJ, NM, OH, TX, and WA. Has developed a soil-respiration test kit that is approved by the USDA for soil quality investigations.

WOODS END EUROPE — AUC - Agrar und Umwelt-Consult GmbH:; Augustastrasse 9 D-53173 Bonn, Germany; Ph: 049 0228 343246; FAX: 049 0228 343237; Officially certified for pathogen survival testing. Sells the Solvita(R) Maturity Test Kit which is now approved in CA, CT, IL, MA, ME, NJ, NM, OH, TX, and WA.

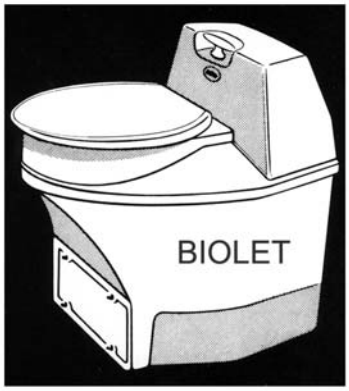
CONTROL LAB, INC. — 42 Hangar Way, Watsonville, CA 95076 USA; Ph: 831-724-5422; Fax: 831-724-3188

COMPOST THERMOMETERS

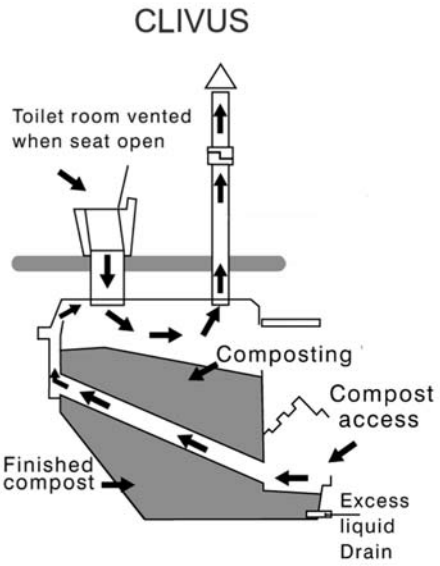
REOTEMP — 10656 Roselle Street, San Diego, CA 92121 USA; Ph: 858-784-0710 (Toll free: 800-648-7737); Fax: 858-784-0720; email: reotemp@reotemp.com; website: www.reotemp.com

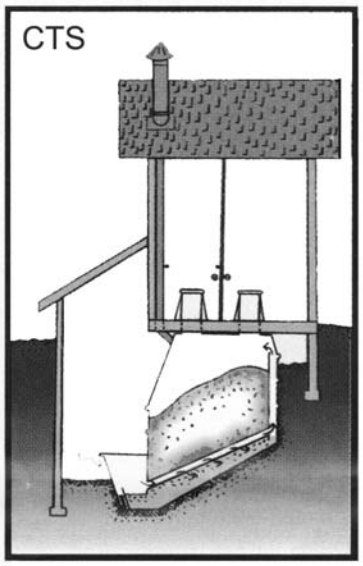
A Sampler of Commercial Composting Toilets and Systems

For more information about these and other composting toilets, search the internet.



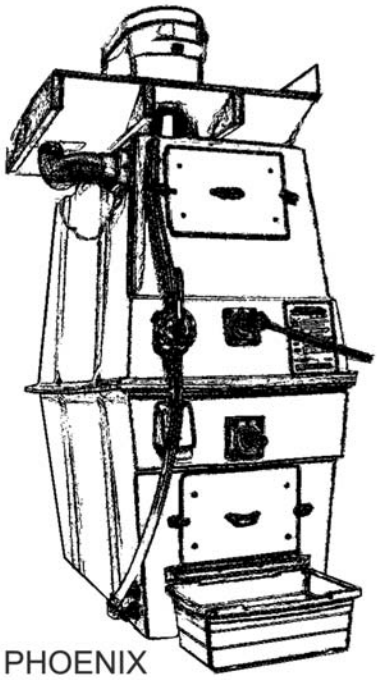
Clockwise from top left: Biolet, Vera Toga, Clivus, Carousel.





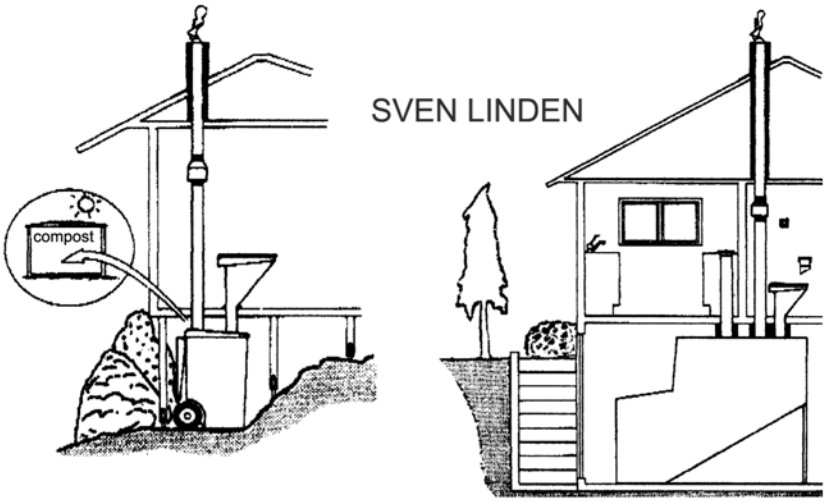
ENVIROLET

Clockwise from top left: Compost Toilet Systems, Dowmus, Envirolet, Solar Composting Advanced Toilet, Phoenix



PHOENIX

SCAT



Clockwise from top left: Sven Linden, Sven Linden, Aquatron, Dutch Hamar, Alascan, Bio-Sun, Sun-Mar.