COMPOSTING AND SAWDUST TOILETS

from this….

to this…..

Why? What is the Problem Anyway?

A Short History of the Flush Toilet:

Before the advent of the flush toilet, humanure, or 'night soil,' was applied to the land, and purchased as valuable commodity! As cities increased in size, the 'scavengers' or 'night soil collectors' could not keep up with the job, so overflow would occur, and additionally, their carts would 'almost always' leave a trail of manure down the street – not best practice for human health. So, in response to the demand for an alternative, inventive people created water closets and earth closets. . Earth closets were an in-house system where waste was immediately covered by a layer of earth, to be disposed of later. Water closets were created to immediately remove waste from the house, usually to a tank outside. Water closets were more appealing (out of sight, out of mind!). However, these posed an even greater risk of overflow, as well as the difficulty of managing contaminated water. Thus our complex sewage systems and treatment facilities were created in response to the need to manage this overflow and increased risk of infection posed by lacing large amounts of water with fecal matter. Most cities simply discharged their waste directly into nearby rivers and lakes.

Problems with Wastewater Management Today:

Basic description of Sewer Systems

- Grates remove large solids, or they are cut into small pieces
- Solids are screened, floated, and settled, and a polymer or alum is added to coagulate particles so they can settle out.
- Biological processes such as trickling filters digest the digestible carbon component, reducing the biological oxygen demand, but producing a lot of bacteria and concentrated solids (sludge).
- Secondary settling: more chemicals are added to make things stick together and sink.
- Fats, oils and greases are skimmed off.
- Sludge goes to processing, where it is dewatered and turned into a sludge cake, or 'biosolid'.
- This cake is landfilled, incinerated, land applied, or composted.
- The liquid sludge continues to be filtered, and is sometimes sent back to re-inoculate the entire process with beneficial bacteria 'activated sludge'
- The effluent goes to disinfection, meaning that it is chlorinated, which creates carcinogenic chlorine compounds (dioxins, among other things.) An alternative to this would be ozone or UV rays.
- Some plants then dechlorinate, by adding sulfur dioxide and filtering with carbon adsorption.
- Then the effluent is aerated to a dissolved oxygen level that is equal to that of the receiving water.
- Discharged into a river, lake, ocean, or injection well.

The Problems:

It uses too much water

Every day, most of us use an average of 1.5-5 gallons of drinking-quality water just to flush a toilet once! The average person in North America uses 7,300 gallons of drinking water each year on toilet flushing alone!

It pollutes

Household wastewater is additionally combined with stormwater, and industrial wastewater, creating a mix of potential human pathogens, fossil fuel contaminants, and various other toxins, then is treated with chemicals (some of which are carcinogenic), and discharged into rivers, oceans, lakes, or injected into our groundwater. Treated sewage effluent is rich in carbon dioxide, nitrate, and phosphate, creating eutrophication of lakes and rivers into which it is disposed. Piping often contains cadmium, lead, asbestos (old concrete piping)

It is expensive

It would be unfeasibly expensive to clean the water back to drinking water quality after being additionally contaminated with stormwater and industrial wastes.

It disposes of a potential resource

Human manure and urine, properly dealt with, are an extremely valuable and free soil amendment!

All this waste while our freshwater supplies are globally dwindling, being privatized, constantly polluted, and wasted!

Deforestation has degraded water catchment basins, and their water-holding power is lost. Mining, industry, power production, etc…have been releasing toxics into previously clean water.

The North American west is a perfect example of corrupted water distribution, overuse, and abuse. The desert cities are taking water from the far north, and water is being commodified from Alaska, to the Great Lakes, to Bolivia to feed these unnatural population explosions.

The US Department of Interior has identified the following cities as heading for a water crisis by 2025:

- Highly Likely: Las Vegas, Reno, Albuquerque, Denver, Houston, Salt Lake, and Flagstaff.
- Substantial: Los Angeles, Sacramento, Phoenix, San Antonio, San Diego.
- Moderate: Seattle, Dallas, Casper, Boise, and Salem.

SEE THE DEPARTMENT OF THE INTERIOR WEBPAGE FOR MORE INFO:WWW.DOI.GOV THEIR 'PLAN' IS CALLED WATER 2025

The primary way that governments have been addressing these difficulties is by increasing manipulation of natural flows and commodification, which will increase injustice of water 'flowing uphill towards money.'

In short, **water is precious and endangered**. If water becomes polluted, it is almost impossible to contain that pollution. It is our responsibility to our grandchildren and our Nations to fulfill the sacred responsibility given to us to protect and preserve our waters.

A note about Septic Systems:

Septic tanks and soil absorption systems (leachfields) are meant to settle out solids and drain the effluent into the ground. Nutrients and toxic chemicals are not removed in this process. Adsorption occurs in leachfields, in which particles and chemicals adhere to soil particles, where biological and chemical processes can break them down. This can be very safe and effective, depending upon your soil type, where the groundwater flows, and how low your pipes are buried. Pipes are typically placed 2 to 10 feet below the surface – far too low for active soil microbes and plants to reach it. Additionally, the leftover sludge is again, just simply taken to your standard wastewater treatment plant.

Composting Toilets

What is a composting toilet?

A composting toilet system contains and controls the composting of human waste, toilet paper, carbon additive, and food scraps (optionally) without water immersion. Operated properly, they break down the waste to 10 to 30% of its original size, and create an end product of rich humus. This humus must legally be buried or removed by a septage hauler in the United States, but is used as an active edible crop soil conditioner in other countries.

The main components of a composting toilet are:

- a composting reactor connected to one or more dry or micro-flush toilets
- a screened exhaust system (often fan-forced) to remove odors, carbon dioxide, and water vapor
- a means of ventilation
- a means of draining and managing excess liquid (leachate)
- process controls, i.e. mixers
- an access door for removal of the end product

All this is not truly necessary, but we'll get into that later………..

What is Composting?

Composting is controlled aerobic (oxygen-using) biological decomposition of moist organic matter, producing a soil conditioner. The organisms responsible for composting are bacteria, actinomycetes and fungi, Soil animals like worms, protozoans, nematodes, and arthropods perform major roles by degrading surface litter, consuming bacteria, and assisting aeration.

What's so good about compost?

- Humus, the end product of the composting process, builds soil structure and provides a productive environment for plants and essential soil organisms
- It is porous, therefore it shelters nutrients and provides lots of surface area to which nutrients can bond. (Humus traps 3 to 5 times more nutrients, water, and air that other soil constituents do.
- Compost aids in the suppression of plant diseases
- It releases nutrients gradually, like a time release vitamin pill
- Cheap! Free!

Types of Composting Toilet Systems:

Self Contained or Centralized Composting Toilet systems are either self-contained, in which the toilet itself and the small composting reactor are one unit, or centralized, where the toilet connects to a composter that is somewhere else. You can buy them already manufactured or build your own on site.

Batch (multiple chamber) vs. Continuous (Single Chamber)

A continuous composter is a single chamber composter, into which excrement is added to the top and the end product is removed from the bottom. A batch composter is one in which there are two or more interchangeable composters. One at a time is filled, then is allowed to cure while another one is being filled. Advocates of continuous composting maintain that it is simple, allows urine to constantly moisten the process, and allows the center of the mass to heat up through uninterrupted microbial activity. Batch composting advocates say that by not continuously adding fresh material, more thorough composting is allowed and is uninterrupted by added nutrients, pathogens, salts, and ammonia.

Active vs Passive: Passive systems are systems in which the material is allowed to decompose without active process control. Active systems may feature mixers, pile leveling devices, tumbling drums, heaters, fans, etc… If the process is active, composting happens faster, enabling the entire system to be smaller, but this creates more moving parts, potential need for elect

Successful Factors for Composting Toilet Systems

- **Love your Microorganisms!** Make sure there is a large population of bacteria, actinomycetes, fungi, yeast, algae, protozoa, and other organisms. This can easily be accomplished by adding a couple of handfuls of sifted compost from a warm outdoor compost pile. A scoop of rotting forest leaves is another good way to bring these precious beasts into your composting toilet.
- **Aeration.** If there is an oxygen deficit, the aerobic bacteria will die and anaerobic bacteria will replace them. These critters produce hydrogen sulfide, ammonia, and methane gas (smelly stuff). So, the system must be aerated. There are many ways and means of doing this. Commerical composting systems have designed venting systems, and mixing mechanisms to aerate the compost and provide a good surface area to volume ratio. The compost should have a loose, non-compacted texture. Ways to ensure this include adding bulking agents, ie wood chips, popcorn, etc…. to increase pore space, and the addition of earthworms. It is a balance, because too much air flow can remove too much heat and moisture.
- **Moisture Content**: Ideally, the composting material would have the moisture content of a wrung-out sponge – 45 to 70% moisture. If the moisture level drops too low, the material will dry out, but not decompose, leaving active pathogens. If the moisture content is too high, the microbes will drown, once again leaving anaerobic bacteria. Some people have found that connecting their dryer exhaust vent is a great way to provide warm, moist air.
- **Temperature**: The temperature needed for effective decomposition is 68 to 112 degrees. At this temperature, it is referred to as mesophilic composting. Biological zero is 41 degrees F, the temperature at which almost no microbes have metabolize nutrients. Because of the vent stacks installed in most composting toilet systems, they rarely reach the 'thermophilic' stage of composting, which is the hot composting that takes place in the core of active

yard/kitchen waste composters kept outside. Most small manufactured composting toilets have heaters and thermostats to maintain an internal temperature anywhere between 90 to 113 F to support the upper mesophilic range, and evaporating the leachate at the same time.

- **The right Carbon to Nitrogen ratio.** Microorganisms require digestible carbon as an energy source for growth, and nitrogen as well as small amounts of phosphorus and potassium, for protein synthesis to buid their cell walls. The optimum C:N ratio is 25:1. Urine has a low C:N ratio (it is very high in nitrogen). Urine primarily settles by gravity to the bottom of the composter, where it is either drained away or evaporated (this liquid is called leachate). In order to get the proportion of C to N we want for the best composting, carbon material needs to be added (sugar, starch, toilet paper, popped popcorn, kitchen scraps (NO MEAT!!!!) shredded newsprint, wood chips, saw dust….. A handful of dry carbon material per person per day is a good rule of thumb.

Pathogens

Pathogens are bacteria, viruses, amoebae, protozoa and parasites that can invade the body and cause illness. Feces can contain pathogens, which each have their own life cycle. Long term survival of pathogens after leaving the host is rare, but possible, and they are transmitted through direct contact with raw feces, vectors that pick up contaminated material and deposit it on food or drinking water (flies, etc..), washwater from bathing and laundry, contaminated meats and vegetables, and drinking contaminated water. Pathogens are reduced in conventional wastewater treatment systems by means of chemical or thermal disinfection. In a composting toilet, the same process happens through:

- Containment: Pathogens cannot survive for long once they have left their host. An organisms' lifetime is shortened in the hostile environment of an aerobic composter. Containing the excreta for an extended period of time brings about the death of pathogens.
- Competition: The competition among composting organisms for carbon and other nutrients is intense. Human pathogens become food for the well-adapted aerobic soil organisms that thrive in the composter. When the available nutrients are consumed, the microorganisms begin to consume themselves, and eventually, if no new food sources are presented, all of the matter will be fully oxidized and considered very stable and safe.
- Antagonism: Some composting organisms produce toxic substances with harm other organisms. For example, the actinomycete Streptomyces griseus produces streptomycin, a well known antibiotic. The soil bacteria Bdellovibrio bacteriovorus parasitizes E coli, eventually killing it.

Managing vectors

- Use a toilet stool with a water seal trap
- Use a fitted toilet seat lid and close it when you're done
- Screen ventilation openings

- If flies do occur somehow, apply pyrethrins and diatomaceous earth, and stop putting kitchen scraps in.

Choosing and Planning a Composting Toilet System

Lifestyle:

What are you willing to do? Do you mind being able to see the contents of the composter? What carbon source will you use?

Considerations for Installation

* Unless you're using a self-contained composter (lots of active maintenance), the composter is going to have to be located underneath the toilet below the floor, or in a separate room. If the toilet is completely waterless, the composter must be directly below the toilet, and adequate space needs to be provided to make connections to the toilet, exhaust pipes, leachate drains, and servicing.
* When locating your composter, make sure you have enough space to clean and empty it.
* If the composter is located in a basement or other small heavily insulated space, make sure there is plenty of ventilation when cleaning or emptying the composter.
* Most commercial systems require electricity to operate heating, forced ventilation, and exhaust systems. If the system does not require electricity, then they require an exhaust pipe of at least four inches or more in diameter
* If the composter must be kept outside, make sure it is heavily insulated in it's own building….Frozen composters will almost never regain efficient processing temperatures.

Approaches to heating

- Locate your composter in a heated room – no insulation worries! Locate near a south facing window, next to a boiler, furnace, washer, dryer, or water heater. Even an interior heated room would suffice.
- Actively utilize cheap heat! Use a heat exchanger connected to the exhaust system of a generator or the flue from a gas hot water heater, the lint filtered exhaust from the clothes dryer, or solar collection.
- Heat and insulate the composter itself – fish tank heaters work great. Incandescent light bulbs are also an effective addition.

Ventilation and Exhaust

Ensuring that air enters (ventilation) and exits (exhaust) the system in the right direction is critical for maintaining composting and preventing odors from entering the home. Seal-trap toilets are not as susceptible to this concern. A plumbing tee at the top of the vent stack keeps rain out and still allows for wind to suck air out of the stack.

Pulling Odors from the Composter

The wider the diameter to the connecting pipe and toilet seat opening, the greater the chance of odor. If the system needs to have a large connecting pipe, a tall exhaust pipe can make up for this. Negative pressure in the bathroom will also suck odors inside. This can be prevented by disconnecting or even reversing the bathroom exhaust fan

Toilet stools:

Connecting pipe diameter: If the opening is too wide, odors will come into the room, if it is too small, it will require frequent cleaning. A good size is 8 to 12 inches diameter.

Capacity Issues:

How many people will use the system every day?

Cost:

Composting toilets range dramatically in cost. Typically, the less maintenance the owner does, the higher the cost.

Do not forget lifecycle costs. Moving parts wear out.

LEACHATE:

What is Leachate?

Leachate, the liquid in the composter, is composed of urine, water from micro-flush toilets, and water released from the cells of organisms as they decompose. This liquid picks up dissolved salts and minerals, and accumulates at the bottom of the composter. From there, it needs to be drained to a planter system * disposed or evaporated. Leachate, as common sense would dictate, contains serious amounts of fecal microorganisms, therefore possible pathogens. These pathogens are dissolved in nitrogen (mostly in the form of aqueous ammonia and nitrates) and salt. Some manufacturers will state that this material is safe, because the high salt, ammonia, and the long time it usually is retained in the composter, but this has been shown to be untrue.

- **It has been estimated that 1 to 2 pints of leachate per person per day will not naturally evaporate and will have to be dealt with.**

Removing Leachate:

Some composters have fittings that can be connected to drain pipes. Others have a sewage pump with a float switch that automatically pumps leachate to a storage tank. Also, a marine bilge pump can be used to manually pump out leachate from most composters.

Evaporating leachate. Some toilets (particularly cottage ones) have internal electric heaters to evaporate leachate, but suck up ~ 2.7 kwh of electricity per gallon. This also creates accumulated salts and nutrients.

Draining leachate**: Draining lowers handling of leachate. It can be drained to a tank that is pumped by a septage hauler, a mini graywater/garden system, a septic system, a system to be combined with graywater for irrigation of plants, be diluted with 8 parts water and used to irrigate ***biologically active soils with plants.

Warning: US regulators usually require that leachate must either be evaporated or removed for conventional treatment.

With good engineering, a composter can drain leachate through a 1- 2 inch drain pipe. This size prevents clogging by solids. Drain lines to need to be vented. Install a union (an easily separated connection) between the composter and a vented drain to allow servicing of the drain line., If you can, place the composter on a raised platform so leachate will drain out by gravity.

Urine, the precious resource!

In wastewater, 90% of the nutrients (N and K) is contained in urine alone. Nitrogen that gets into ground and surface waters creates pollution (ie agricultural runoff) But, if oxidized and diluted, urine makes an excellent liquid nutrient for plants. Urine is normally sterile, is easy to drain and collect separately. Also, urine mixed with feces creates much more smell than either of them alone. There are basically three ways to effectively utilize this wonderful fertilizer.

1. Drain the urine directly into a system, combine it with graywater, and use it on site.
2. Collect the urine for later dilution with 8 parts water.
3. Make a urine composter. Pour urine mixed with sugar over a bale of hay or into a column packed with peat, sawdust, or shredded cardboard.
   An alternative to the biodegradable peat, etc… are little plastic sponges or coarse sand, in order to provide surface area for aerobic microbes. Drain this oxidized urine to use as liquid fertilizer.

Why sugar? The two bacteria responsible for converting urea into nitrate fertilizer are Nitrobacter and Nitrosomonas. These bacteria need carbon for their functioning. Urine is such a potent substance that it requires a huge amount of carbon in order to properly compost, unless an incredibly concentrated form of carbon is used. Wastewater treatment plants often use alcohol. Cane sugar works exceptionally well, and a third a cup of sugar per person per day will do it.

Graywater

Graywater vs Blackwater

Graywater is washing water from bathtubs, showers, sinks, washing machines, and dishwashers. (Note: some states' regulations consider water from kitchen sinks to be 'blackwater' because it may contain animal products.)
Graywater accounts for 50 – 80% of all combined residential sewage, and could potentially supply most, if not all, of a home's landscape (and orchard) irrigation requirements.

Realize that it is all but impossible to come up with a greywater system which is simultaneously inexpensive, ecological, easy to use, legal, and efficient. However, by sacrificing some of these parameters, the others can be satisfied. There are a large number of possible combinations of benefits and drawbacks, one or more of which will likely be a good fit for a particular situation. Your task is to determine the best fit options, decide if any of these are good enough to build, and then build the best one…

Branched drain to mulch basins or mini-leachfields

For ideal situations with continuous downhill slope from the points of greywater generation to the points of irrigation need, this design promises inexpensive, reliable, efficient distribution WITHOUT FILTER CLEANING. It is critical that hard-plumbed lines have proper slope (at least 1/4" per foot)…

One way to split the greywater flow to accomplish wider distribution is to not combine the flows in the first place; each fixture waters its own area. Coordination with fresh water irrigation may be complicated by using this technique. It works best as primary irrigation, with each flow matched to an appropriately sized, established tree.

Another way to split the flow is by using "double ells" (Figure 3, page 13). If there are ridges on the inside of these fittings they must be ground smooth-a rotary file in a drill works well. The maximum number of splits is probably four, in "family tree" style. In theory, the water will split predictably so a single irrigation zone sensor would get a representative reading off of any outlet. The double ell variation is a brand new Art Ludwig design. I would appreciate hearing of your experiences with it. According to the folks in Sacramento, a local jurisdiction could interpret this system as conforming to the California greywater law requirements for a mini-leachfield system, or the "other means of distributing greywater subsurface clause," providing you could demonstrate that the effluent would not surface. As part of the inspection they might require you to run a surge into the system and check for surfacing before giving final approval.

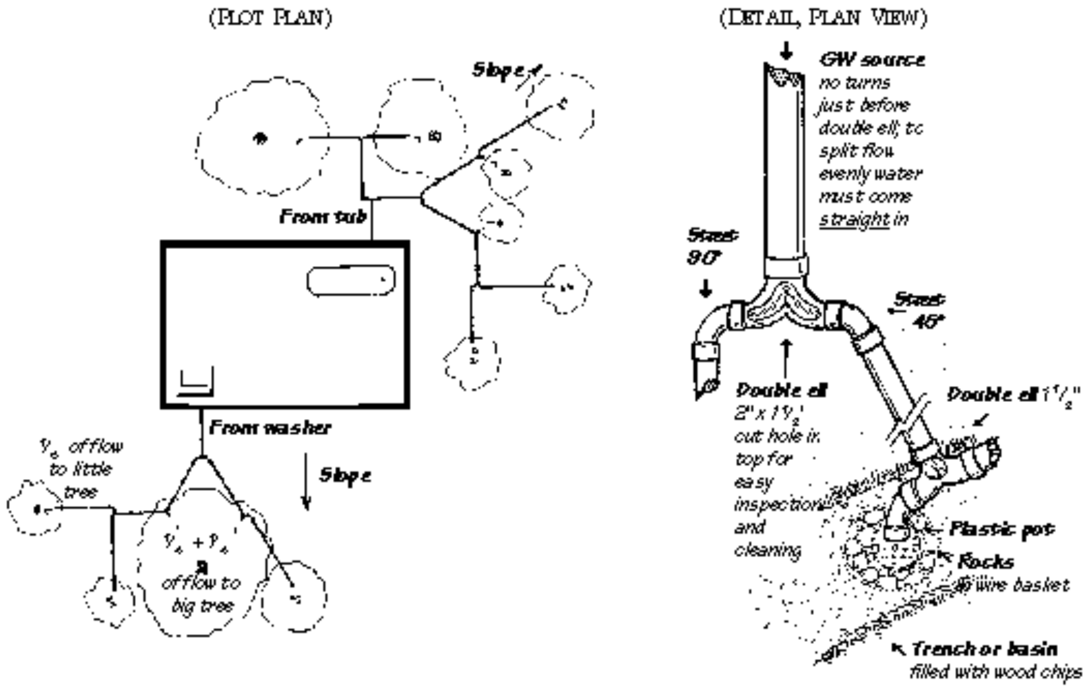
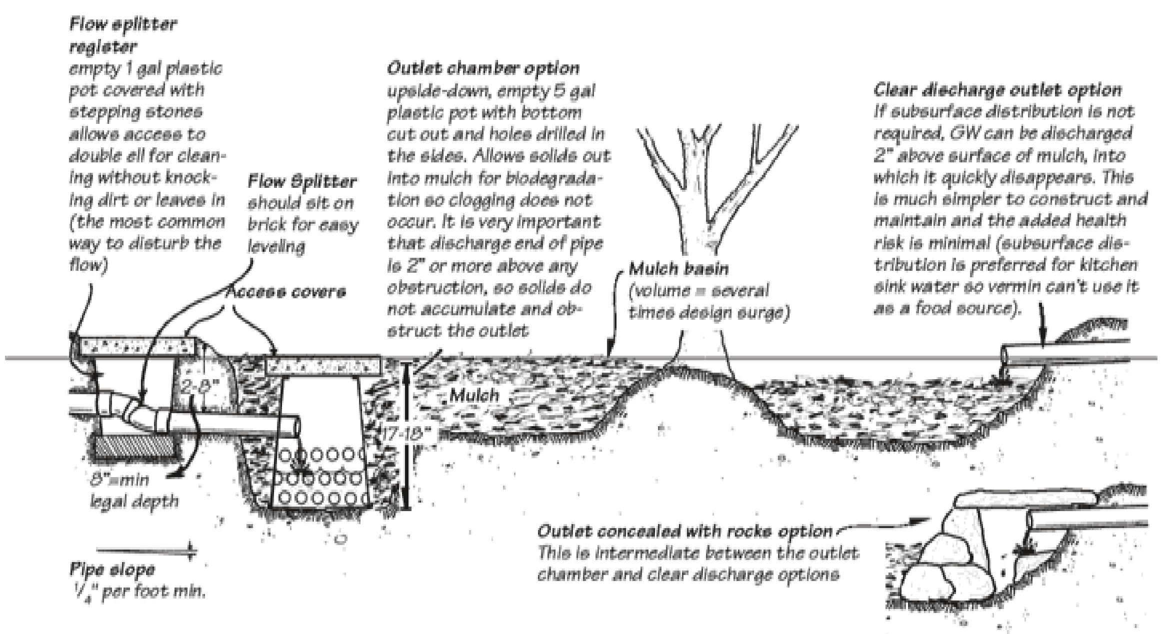


FIGURE 2: GREYWATER CONTAINED AND COVERED IN A BRANCHED DRAIN-FED MULCH BASIN
(ELEVATION VIEW)

Enclosed chamber option shown at left, clear discharge option shown at right
(you can skip the rest of the details for now, we'll refer back to this figure later).



Caring for your Graywater System

Soaps: Soaps are alkali salts of long chain fatty acids, which emulsify soils, microbes, and liquids and detach them from surfaces, and break the bonds holding these constituents to fabrics, allowing them to be rinsed away.

Most soaps are made with sodium hydroxide. The use of sodium based soaps increases the amount of sodium in graywater, while hydroxide raises the pH, or alkalinity. In some plants, sodium inhibits water and nutrient transport. Potassium based soaps are better to use, because potassium is a fertilizer and a beneficial nutrient. Most liquid soaps are made with potassium hydroxide. Potassium hydroxide is an excellent grease remover, turning the grease itself into soap, and Tri-potassium phosphate (TKP) is a powerful cleaner used on sewer pipes and automotive engines.

Degreasing Cleaners

D-Limonene is the active ingredient in recently available cleaners such as CitraSolv. It is an organic extract derived from citrus oils, is 100% biodegradable, noncorrosive, and contains no petroleum solvents.

DISINFECTANTS KILL MICROORGANISMS!!!!!!

Graywater and the magic C:N ratio

The carbon to nitrogen ratio of graywater is not ideal for efficient microbial breakdown in planted irrigation systems. The detergents, soaps, soils, fats, and grease in graywater add a lot of carbon to it, but it has relatively little nitrogen. Too little nitrogen will result in a buildup of undigested material, which may clog pipes and drains, and smell bad (remember anaerobic bacteria).

Where to get nitrogen? Protein containing shampoos (Neutrogena, Pantene), ammonium laureth or lauryl sulfate containing cleaners, **OR Urine!!**

Filtering graywater:

For graywater filtration, 160 microns is minimum, and 30 microns is preferred. For the best results (only needing to clean out your filters every month or so) use two filters, one 160 microns and one 30 microns.

Filter out the grease, oils, and fats, exclude toxic chemicals that can kill plants. Test it for pathogens if it is to be used for anything other than subsurface irrigation. Then, drain it in a way that evenly distributes it to the subsurface root zone of plants, where the microbes will transform the pollutants into simple constituents that are either used by plants, exhausted to the atmosphere, or stored as a soil constituent. This ecological way of treating graywater is known as a 'washwater/wastewater garden.' In environmentally sensitive areas, washwater gardens are contained and lined, so no effluent leaves the system. Wastewater gardens are graywater gardens in which the graywater was combined with leachate.

Wastewater Gardens

Definitions

These gardens are shallow, flat bottomed lined trenches or beds, filled with 6 inches of crushed stone and covered with 12 inches of sharp sand. Perforated pipes on the stone and beneath the sand distribute the filtered wastewater along the length of the trenches The trenches should be no more than 18 to 2 4 inches deep to maximize the uptake of water and nutrients by plant roots and to allow proper oxygenation. Air is introduced by venting the distribution pipes with riser vents, or breezers. Plants species are selected for their hardiness, rapid growth rates, and high water requirements. As the plants are either harvested or naturally defoliate, contaminants are removed from the systems. These gardens are more efficient treatment 'facilities' when protected from rain and snow, preferably in a warm greenhouse.

How they work:

Evaporation occurs as water moves upward through the sand by capillary action and is evaporated at the surface. Evaporation also occurs within the bed as aerobic bacteria release heat as they metabolize nutrients in the effluent. This heat converts the water into vapor, which is allowed to rise to the surface due to the spaces in the sand particles. Transpiration occurs as water absorbed by plant roots is drawn up into the stalk and stems of plants into the leaves, where it is released as pure water vapor through it's stomata.

The microorganisms transform any remaining pollutant/nutrients into plant available forms.

The typical average outdoor rates of processing in the temperate zones of the U.S. are from .05 to .02 gallons per day. This can be increased to .5 to 3 gallons per day by enclosing the beds in a greenhouse or translucent cover.

THE SAWDUST TOILET

This is the composting toilet system used by Sustainable Nations. It is simple, easy to maintain, ideal for rural locations, and takes no electricity or other inputs. Try it to believe how clean, healthy, and simple a composting toilet can be! Thank you to the originator of the Sawdust Toilet book, from which we liberally borrowed!

Simple methods of collecting humanure and composting it are sometimes called cartage systems or bucket systems, as the manure is carried to the compost bin, often in buckets or other waterproof vessels. People who utilize such simple techniques for composting humanure simply take it for granted that humanure recycling is one of the regular and necessary responsibilities for sustainable human life on this planet.

How it works is a model of simplicity. One begins by depositing one's organic refuse (feces and urine) into a plastic bucket, clay urn, or other non-corrodible waterproof receptacle with about a five gallon (20 liter) capacity. Food scraps may be collected in a separate receptacle, but can also be deposited into the toilet receptacle. A five gallon capacity is recommended because a larger size would be too heavy to carry when full. If five gallons is still too heavy for someone to carry, it can be emptied when half-full.

The contents of the toilet are kept covered with a clean, organic *cover material* such as rotted sawdust, peat moss, leaf mould, rice hulls, or grass clippings, in order to prevent odors, absorb urine, and eliminate any fly nuisance. Urine is deposited into the same receptacle, and as the liquid surface rises, more cover material is added so that a clean layer of organic material covers the toilet contents *at all times*.

A lid is kept on the toilet receptacle when not in use. The lid need not be air-tight, and a standard, hinged toilet seat is quite suitable. The lid does not necessarily prevent odor from escaping, and it does not necessarily prevent flies from gaining access to the toilet contents. Instead, the *cover material* does. The cover material acts as an organic lid or a "biofilter"; the physical lid (toilet seat) is used primarily for convenience and aesthetics. Therefore, the choice of organic cover material is very important, and a material that has some moisture content, such as rotted sawdust, works beautifully. This is not kiln-dried sawdust from a carpenter shop. It is sawdust from a sawmill where trees are cut into boards. Such sawdust is both moist and biologically active and makes a very effective biofilter. Kiln-dried sawdust is too light and airy to be a 100% effective biofilter. Furthermore, sawdust from wood-working shops may contain hazardous chemical poisons if "pressure-treated" lumber is being used there. It seems that present-day carpenters are more than willing to expose themselves to the chemical hazards of poison-soaked lumber, which contains cancer-causing chemicals. There is no need for composters and gardeners to duplicate such unwise exposure.

I use rotted sawdust as a toilet cover material because it is a readily available, very inexpensive, local resource which works well. I used to haul a free load home from a local sawmill every so often in the back of my pick-up truck, but now I just have a fellow with a small dump truck deliver me a load every year or two. I have the sawdust dumped in a pile in a corner of my backyard adjacent to my compost bins where it can remain exposed to the elements and thereby slowly decompose on its own, as rotting sawdust makes compost more readily than fresh sawdust. The sawdust itself doesn't cost me anything, but I usually have to pay about five dollars to have it loaded onto the dump truck and another twenty-five to have it hauled. This is an expense I'm happy to pay every year or two in order to ensure for myself a functional compost toilet system. I would speculate that many other cellulose-based materials or combination of materials would work as a toilet cover material, including ground newsprint.

In the winter, an outdoor pile of sawdust will freeze solid. I have to layer some hay over mine and cover it with a tarp in order to be able to access it all winter. Otherwise, feedsacks filled with sawdust stored in a basement will work as an alternative, as will peat moss and other cover materials stored indoors.

The system of using an organic cover material in a small receptacle works well enough in preventing odors to allow the toilet to be indoors, year round. In fact, a full bucket with adequate and appropriate cover material, and no lid, can be set on the kitchen table without emitting unpleasant odors (take my word for it). An indoor sawdust toilet should be designed to be as warm, cozy, pleasant, and comfortable as possible. A well-lit, private room with a window, a standard toilet seat, a container of cover material, and some reading material will suffice.

When the bucket is full, it is carried to the composting area and deposited on the pile. Since the material must be moved from the toilet room to an outdoor compost pile, the toilet room should be handy to an outside door. If you aredesigning a sawdust toilet in a new home, situate the toilet room near a door that allows direct access to the outside.

It is best to dig a slight depression in the top center of the compost pile and deposit the fresh material there, in order to keep the incoming humanure in the hotter center of the compost pile. This is easily achieved by raking aside the cover material on top of the pile, depositing the toilet contents in the resulting depression, and then raking the cover material back over the fresh deposit. The area is then immediately covered with additional clean, bulky, organic material such as straw, leaves, or weeds, in order to eliminate odors and to entrap air as the pile is built.The bucket is then thoroughly scrubbed with a small quantity of water, which can be rain water or graywater, and biodegradable soap, if available or desired. A long-handled toilet brush works well for this purpose. Often, a simple but thorough rinsing will be adequate. Rain water or wastewater is ideal for this purpose as its collection requires no electricity or technology. The soiled water is then poured on the compost pile.

It is imperative that the rinse water not be allowed to pollute the environment. The best way to avoid this is to put the rinse water on the compost pile, as stated. However, the rinse water can be poured down a drain into a sewer or septic system, or drained into an artificial wetland. It can also be poured at the base of a tree or shrub that is designated for this purpose. Such a tree or shrub should have a thick layer of organic material (biological sponge) at its base and be staked or fenced to prevent access to children or pets. Under no circumstances should the rinse water be flung aside nonchalantly. This is the weak link in this simple humanure recycling chain, and it provides the most likely opportunity for environmental contamination. Such contamination is easy to avoid through considerate, responsible management of the system. Finally, never use chlorine to rinse a compost receptacle. Chlorine is a chemical poison that is detrimental to the environment and is totally unnecessary for use in any humanure recycling system. Simple soap and water is adequate.

After rinsing or washing, the bucket is then replaced in the toilet area. The inside of the bucket should then be dusted with sawdust, the bottom of the empty receptacle should be primed with an inch or two of sawdust, and it's once again ready for use. After about ten years, the plastic bucket may begin to develop an odor, even after a thorough washing. Replace odorous buckets with new ones in order to maintain an odor-free system. The old buckets will lose their odor if left to soak in clean, soapy water for a lengthy period (perhaps weeks), rinsed, sun-dried, and perhaps soaked again, after which they can be used for utility purposes (or, if you really have a shortage of buckets, they can be used in the toilet again).

Here's a helpful hint: when first establishing such a toilet system, it's a good idea to acquire at least *four* five gallon buckets, with lids, that are *exactly the same*, and more if you intend to compost for a large number of people. Use one under the toilet seat and two, with lids, set aside in the toilet room, empty and waiting (save the fourth as a back-up). When the first becomes full, take it out of the toilet, put a lid on it, set it aside, and replace it with one of the empty ones. When the second one fills, take it out, put the other lid on it, set it aside, and replace it with the other empty one. Now you have two full compost buckets, which can be emptied at your leisure, while the third is in place and ready to be used. This way, the time you spend emptying compost is almost cut in half, because it's just as easy to carry two buckets to the compost pile as one. Furthermore, you potentially have a 15 gallon toilet capacity at any one time (20 with the extra bucket), instead of just five gallons. You may find that extra capacity to come in very handy when inundated with visitors.

SAWDUST TOILET WITH HINGED SEAT

The above diagram shows a simple sawdust toilet permanently built into a toilet room. The compost receptacle (bucket) sits directly on the floor. A standard toilet seat is attached to an 18" square piece of plywood, which lifts up on hinges to allow easy access when removing the compost material. Bucket setback from the front edge of the plywood is 1&1/2". Height of top surface of plywood is 1/2" lower than height of bucket. Bucket protrudes through cabinet to contact bottom of toilet seat ring. Plastic bumpers on bottom of toilet seat ring are swiveled sideways so as to fit around bucket.

Why should all of the buckets be exactly the same? If you build a permanent toilet cabinet (seat), the top of the bucket should protrude through the cabinet to contact the bottom of a standard toilet seat. This ensures that all organic material goes into the container, not over its edge. Although this is not usually a problem, it can be with young children who may urinate over the top of a bucket receptacle when sitting on a toilet. A good design will enable the bucket to fit tightly through the toilet cabinet as shown in Figures 8.1, 8.2, and 8.4. Since all plastic buckets are slightly different in height and diameter, you will have to build your toilet cabinet to fit one size bucket. You should have extra identical ones when backup capacity is needed to accommodate large numbers of people.

It is much better to set a full toilet receptacle aside, with a lid, and replace it immediately with an empty one, than to have to empty and replace a full one while someone is waiting to use the toilet. There are some things in life we would all like to avoid: you have no money in the bank, your gas tank is empty, you're out of firewood, your pantry is bare, the sun's not shining, the dog has died, and "nature calls," but the shit bucket's full. Put some harmonica music to that last sentence and you'd have "*The Shit Bucket Blues*." One can avoid singing that tune by properly planning and managing a sawdust toilet system.

Theoretically, with enough containers, a sawdust toilet system can be used for any number of people. For example, if you are using a sawdust toilet in your home, and you are suddenly visited by thirty people all at once, you will be very happy to have empty containers ready to replace the ones that fill up. You will also be very happy that you will not have to empty any compost containers until after your company leaves, because you can simply set them out of the way in the toilet room as they fill up, and then empty them the next day.

Experience has shown that 150 people will require four five gallon containers during a serious party. Therefore, always be prepared for the unexpected, and maintain a reserve toilet capacity at all times by having extra toilet receptacles available, as well as extra cover material. Incidentally, for every full container of compost material carried out of a toilet room, a full, same-sized container of cover material will need to be carried in.

Expecting five hundred people for a major gathering out in the woods? Sawdust toilets will work fine, as long as you keep enough buckets handy, as well as adequate cover materials, and some volunteers to manage it all. You will collect a lot of valuable soil nutrients.

The advantages of a sawdust toilet system include low financial start-up cost in the creation of the facilities, and low, or no energy consumption in its operation. Also, such a simple system, when the refuse is thermophilically composted, has a low environmental cost, as little or no technology is required for the system's operation, and the finished compost is as nice and benign a material as humanure can ever hope to be. No composting facilities are necessary in or near one's living space, although the toilet can and should be inside one's home and can be quite comfortably designed and totally odor-free. No electricity is needed, and no water is required except a small amount for cleaning purposes. The compost, if properly managed, will heat up sufficiently for sanitation to occur, thereby making it useful for gardening purposes. The composting process is fast, i.e., the humanure is converted quickly (within a few days if not frozen) into an inoffensive substance that will neither attract rodents nor flies. In cold winter months, the compost simply freezes until spring thaw, and then heats up. If the compost is unmanaged and does not become thermophilic, the compost can simply be left to age for a couple of years before horticultural use. In either case, a complete natural cycle is maintained, unbroken.

SAWDUST TOILET WITH HINGED TOP
1
2
3
legs
4
5
6
7
Mark holes for toilet seat attachment
8
Drill holes
9

THE COMPOST BINS

A sawdust toilet requires three components: 1) the toilet receptacle; 2) cover materials; and 3) a compost bin system. The system will NOT work without all three of these components. The toilet is only the collection stage of the process. The composting takes place away from the toilet, and the compost bin system is important.

1) *Use at least a double-chambered, above-ground compost bin*. A three-chambered bin is recommended. Deposit in one chamber for a period of time (e.g., a year), then switch to another for an equal period of time.

2) *Deposit a good mix of organic material into the compost pile, including kitchen scraps*. It is a good idea to put all of your organic material into the same compost bin. Pay no attention to those people who insist that humanure compost should be segregated from other compost. They are people who do not compost humanure and don't know what they're talking about.

3) *Always cover humanure deposits in the toilet with an organic cover material* such as sawdust, leaf mould, peat moss, or rice hulls. *Always cover fresh deposits on the compost pile with coarser cover materials* such as hay, weeds, straw, or leaves. Make sure that enough cover is applied so that there is neither excess liquid build-up in the toilet nor offensive odors escaping either the toilet or the compost pile. The trick to using cover material is quite simple: if it smells bad or looks bad, cover it until it does neither.

4) *Keep good access to the pile* in order to rake the top flat, to apply bulky cover material when needed, to allow air to access the pile, and to monitor the temperature of the pile. The advantage of aerobic composting, as is typical of an above-ground pile, over relatively anaerobic composting typical of enclosed composting toilets, is that the aerobic compost will generate higher temperatures, thereby ensuring a more rapid and complete destruction of potential human pathogens.

The disadvantages of a collection system requiring the regular transporting of humanure to a compost pile are obvious. They include the inconvenience of: 1) carrying the organic refuse to the compost pile; 2) keeping a supply of organic cover material available and handy to the toilet; 3) maintaining and managing the compost pile itself.

NORMAL COMPOSTING BIN SEQUENCE

It's very important to understand that *two* factors are involved in destroying potential pathogens in humanure. Along with heat, the *time* factor is important. Once the organic material in a compost pile has been heated by thermophilic microorganisms, it should be left to age or "season." This part of the process allows for the final decomposition to take place, decomposition that may be dominated by fungi and macroorganisms such as earthworms. Therefore, a good compost system will utilize at least two composting bins, one to fill and leave to age, and another to fill while the first is aging. A three-binned composting system is recommended, as the third bin provides a place to store cover materials, and separates the active bins so there is no possible accidental transfer of fresh material to an aging bin.

When composting humanure, fill one bin first. Start the compost pile by establishing a thick layer of coarse and absorbent organic material on the bottom of the bin. This is called a "biological sponge"; its purpose is to act as a leachate barrier. The sponge may be an 18 inch layer of hay or straw, grass clippings, leaves, and/or weeds. Place the first container of the humanure/sawdust mix from the toilet directly on the top center of the sponge. Cover immediately with more straw, hay, weeds, or leaves - the cover acts as a natural "biofilter" for odor prevention, and it causes air to become trapped in the developing compost pile, making physical turning of the pile for aeration unnecessary.

Continue in this manner until the bin is full, being sure to add to this bin *all* of the other organic material you produce. There is no need to have any other compost piles - one is enough for everything produced by the humans in your household. If you have small animals such as chickens or rabbits, their manure can go into the same compost pile. Presumably, pet manures can also go into the same compost pile as well although pet manures, like human manures, can contain human pathogens, so thermophilic composting and/or adequate aging of the compost are essential. Small dead animals can also be added to the compost pile.

You need to do nothing special to prepare material for adding to the compost pile. You do not need to chop up vegetables, for example. Just chuck it all in there. Most of the things compost educators tell you cannot be composted *can*, in fact, be composted in your humanure compost pile (such as meat, fats, oils, etc.). Add it all to the same compost pile. Anything smelly that may attract flies should be dug into the top center of the pile. Keep a shovel or pitchfork handy for this purpose and use the tool *only* for the compost. Keep a clean cover material over the compost at all times, and don't let your compost pile become shaped like the Matterhorn - keep it somewhat flattened so nothing rolls off.

When you have a sudden large quantity of cover material available, such as an influx of grass clippings when the lawn is mowed, weeds from the garden, or leaves in the fall, place them in the center bin for storage and use them to cover humanure deposits as you need them. It is assumed that you do not use any poisonous chemicals on your lawn. If you do, bag the lawn clippings, take them to a toxic waste dump, and on the way, reflect upon the folly of such toxic behavior. Do not put poisoned grass clippings on your compost pile.

Filling the first bin should take a year - that's how long it takes us, a family, usually of four, with a lot of visitors. We start to fill a compost bin every summer solstice or at some point near that time. Cover the finished compost pile with a thick layer of straw, leaves, grass clippings, or other clean material (without weed seeds) to insulate it and to act as a biofilter, then leave the pile alone. Start filling the second chamber, following the same procedure as the first (start with a biological sponge). When the second chamber is nearly full (a year later), the first one can begin to be emptied onto the garden, berries, orchard, or flower beds. The finished compost does not need to be dug deeply into the soil or buried in a trench on another planet. It can either be used as mulch, or it can be dug or tilled into the top layer of your garden soil.

A compost pile can accept a huge amount of refuse, and even though the pile may seem to be full, as soon as you turn your back it will shrink down and leave room for more material. So when I say fill the first bin before filling the second, I mean *fill* it. A year is a good period of time for doing so in any area where there is an annual growing season. In the tropics, a shorter period may be necessary; I don't know. You readers who live in the tropics will have to figure that out. In the cold winters of the north, it is quite likely that the compost will freeze solid. You can, however, keep adding to the pile all winter. In the spring when it thaws out, the compost should work up a head of steam as if nothing happened.

Follow a natural timing cycle when making compost, one that is in tune to your agricultural cycle. A yearly cycle works best for me in Pennsylvania, where we have an annual growing cycle (one growing season per year). By late spring, the compost bin has been completely filled and it's time to let it sit until the next spring, when the finished compost will be ready to be removed and added to the garden.

The system outlined above will not yield any compost until two years after the process has started (one year to build the first pile and an additional year for it to age). However, after the initial two year start-up period, an ample amount of compost will be available on an annual basis.

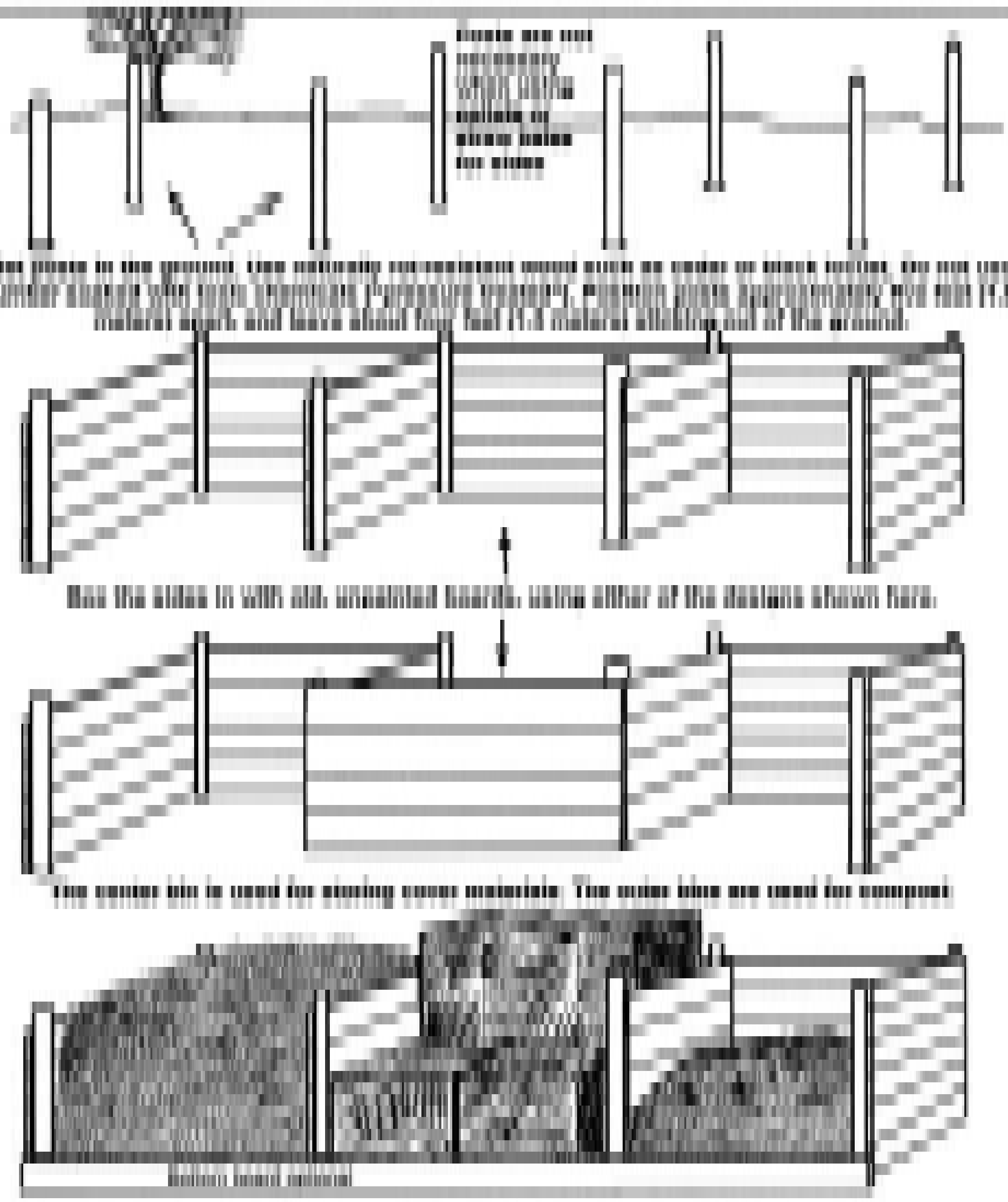
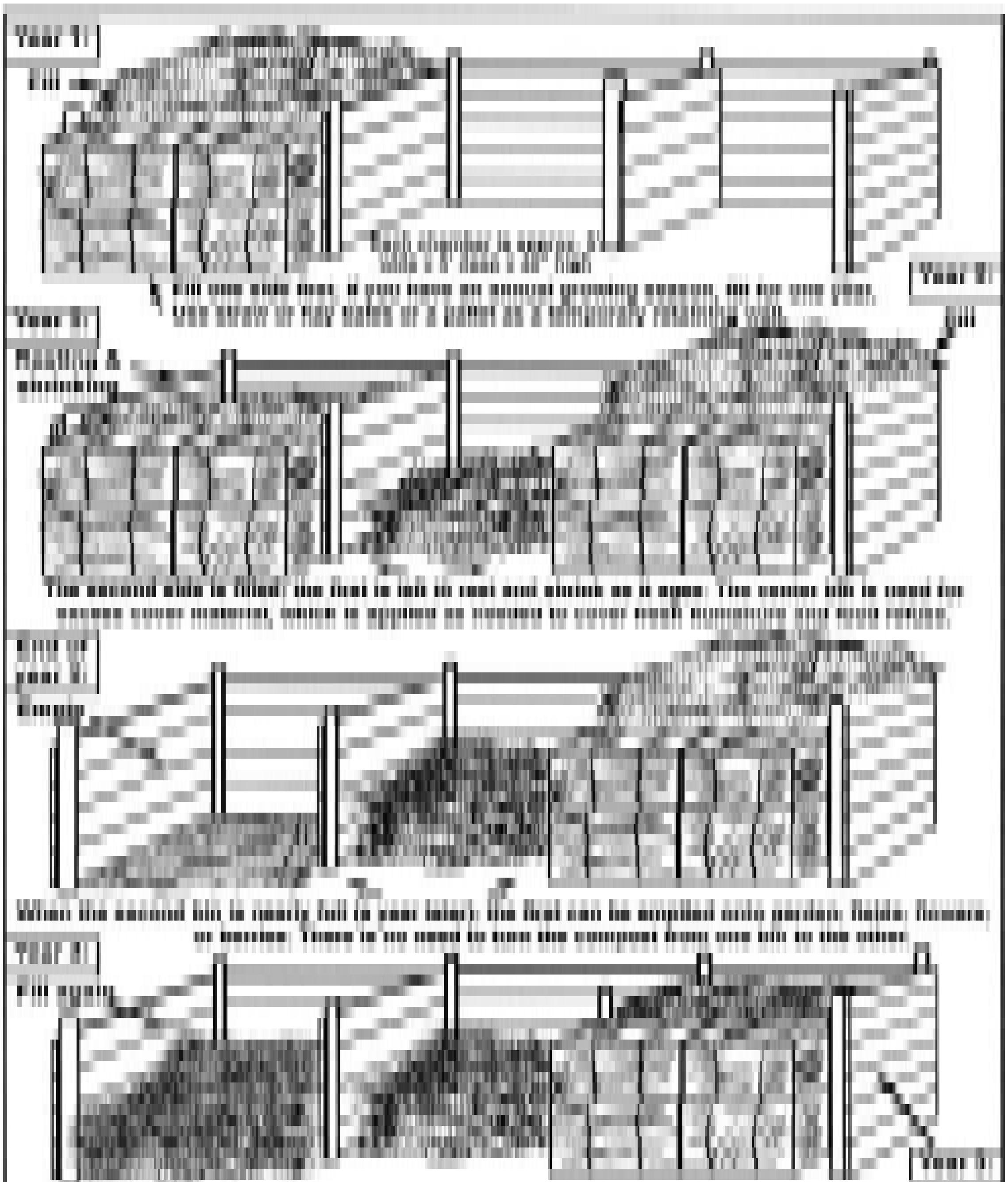


Figure [illegible]

CONSTRUCTING A THREE-CHAMBERED COMPOSTING BIN

The three-chambered bin is ideally suited for humanure composting. The bin can be built of pallets, wood, or screwed together frames of boards. Straw or hay bales (or pallets) can be used to close the open side when filling with compost. Later, the old straw can be used as a cover material. The center bin is used for storing extra cover materials such as garden weeds, lawn grass and leaves, or bales of hay or straw.



THE CEASELESS CYCLE OF COMPOST MAKING

PATHOGENIC POPULATIONS AND A TWO YEAR RETENTION TIME

DO'S AND DON'TS OF A THERMOPHILIC TOILET COMPOSTING SYSTEM

DO - Collect urine, feces, and toilet paper in the same toilet receptacle. Urine provides essential moisture and nitrogen.

DO - Keep a supply of clean, organic cover material handy to the toilet at all times. Rotting sawdust, peat moss, leaf mould, and other such cover materials prevent odor, absorb excess moisture, and balance the C/N ratio.

DON'T - Segregate urine or toilet paper from feces.

DON'T - Turn the compost pile if it is being continuously added to and a batch is not available. Allow the active thermophilic layer in the upper part of the pile to remain undisturbed.

DON'T - Use lime or wood ashes on the compost pile. Put these things directly on the soil.

DO - Keep another supply of cover material handy to the compost bins for covering the compost pile itself. Coarser materials such as hay, straw, weeds, leaves, and grass clippings, prevent odor, trap air in the pile, and balance the C/N ratio.

DO - Deposit humanure into a depression in the top center of the compost pile, not around edges.

DO - Add a mix of organic materials to the humanure compost pile, including all food scraps.

DO - Keep the top of the compost pile somewhat flat. This allows the compost to absorb rainwater, and makes it easy to cover fresh material added to the pile.

DO - Use a compost thermometer to check for thermophilic activity. If your compost does not seem to be adequately heating, use the finished compost for berries, fruit trees, flowers, or ornamentals, rather than food crops. Or allow the constructed pile to age for two full years before garden use.

DON'T - Expect thermophilic activity until a sufficient mass has accumulated.

DON'T - Deposit anything smelly into a toilet or onto a compost pile without covering it with a clean cover material.

DON'T - Allow dogs or other animals to disturb your compost pile. If you have problems with animals, install wire mesh or other suitable barriers around your compost, and underneath, if necessary.

DON'T - Segregate food items from your humanure compost pile. Add all organic materials to the same compost bin.

DON'T - Use the compost before it has fully aged. This means one year after the pile has been constructed, or two years if the humanure originated from a diseased population.

DON'T - Worry about your compost. If it does not heat to your satisfaction, let it age for a prolonged period, then use it for horticultural purposes.

Fecophobes, as we have seen throughout this book, believe that all human excrement is extremely dangerous, and will cause the end of the world as we know it if not immediately flushed down a toilet. Some insist that humanure compost piles must be turned frequently - to ensure that all parts of the pile are subjected to the internal high temperatures.

The only problem with that idea is that most people produce organic refuse a little at a time. For example, most people defecate once a day. A large amount of organic material suitable for thermophilic composting is therefore usually not available to the average person. As such, we who make compost a daily and normal part of our lives tend to be "continuous composters." We add organic material continuously to a compost pile, and almost never have a large "batch" that can be flipped and turned all at once. In fact, a continuous compost pile will have a thermophilic layer, which will be located usually in the top two feet or so of the pile. If you turn the compost pile under these conditions, that layer will become smothered by the thermophilically "spent" bottom of the pile, and all thermophilic activity will grind to a halt.

In healthy human populations, therefore, turning a continuous compost pile is not recommended. Instead, all humanure deposits should be deposited in the top center of the compost pile in order to feed it to the hot area of the compost, and a thick layer of insulating material (e.g., hay) should be maintained over the composting mass. Persons who have doubts about the hygienic safety of their finished humanure compost are urged to either use the compost for non-food crops or orchards, or have it tested at a lab before using on food crops.

On the other hand, one may have the need to compost humanure from a population with known disease problems. If the organic material is available in *batches*, then it can be turned frequently during the thermophilic stage in order to enhance pathogen death. After the thermophilic stage, the compost can be left to age for at least a year.

If the organic material is available only on a continuous basis, and turning the pile, therefore, is counterproductive, an *additional* year-long curing period is recommended. This will require one more composting bin in addition to the two already in use. After the first is filled (presumably for a year), it is left to rest *for two years*. The second is filled during the second year, then it is left to rest for two years. The third is filled during the third year. By the time the third is filled, the first has aged for two years and should be pathogen-free and ready for agricultural use. This system will create an initial lag-time of three years before compost is available for agricultural purposes (one year to build the first pile, and two more years retention time), but the extra year's retention time will provide added insurance against lingering pathogens. After the third year, finished compost will be available on a yearly basis. Again, if in doubt, either test the compost for pathogens in a laboratory, or use it agriculturally where it will not come in contact with food crops.

Sawdust works best in compost when it comes from logs, not kiln-dried lumber. Although kiln-dried sawdust (from a wood-working shop) will compost, it is a dehydrated material and will not decompose as quickly as sawdust from fresh logs, which are found at sawmills. Kiln-dried sawdust may originate from "pressure-treated" lumber, which usually is contaminated with chromated copper arsenate, a known cancer-causing agent, and a dangerous addition to any backyard compost pile. Sawdust from logs can be an inexpensive and plentiful local resource in forested areas. It should be stored outside where it will remain damp and continue to decompose.

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Joseph Jeakins.