An Unsolicited Design Review of Composting Toilets & Composting Methods

-how sewers don't work
-batch composting systems for urban dwellers
-compost processing methods that work
- the best research articles about shit that no one wants to talk about

In the course of preparing for our new business venture, New Ground Sanitation, we've done a lot of research on composting toilets and the issues of public saniation in the urban US. This document is a collection of the best toilets and composting techniques we've seen. There are many social and legal obstacles to composting sanitation alternatives, this zine focuses on the best technical solutions to the problem. For more information on the legal and social issues see our zine, "DIY Research & Development for Neighborhood-Scale Sanitation."

Cloacina is:

1. The Roman goddess of the sewers, back with a new plan.
2. Mat and Molly's project on ecological sanitation @ *www.cloacina.org*

This document researched and compiled by:
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Molly: most of the drawing
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R.J. Steinert, Dennison Williams, Earle Barnhart, ReCode:Oregon, PHLUSH, PSU, Reed, Lewis & Clark, and Berkeley Libraries,(Librarian names, c'mon! -molly) and Dr. Meg Lippincott

Mathew dedicates this to all the librarians in the world, especially his mom.
Molly would like to thank her friends for being willing to talking about poop with her.

what the authors are up to: New Ground Sanitation Services

We're breaking new ground, developing the United States' first composting portable toilets, and we're literally making new ground, using high-temperature composting to generate safe, nutrient-rich soil additives.

Our Team is experienced in design, manufacturing, software logistics, and mobile communications.

Hardware: Mathew Lippincott & Molly Danielsson,
Software: RJ Steinert & Dennison Williams

2011 Development & Test Deployments:

Phase 1 (Jan-March 2011): Build high-temperature, semi-automated composting greenhouse for year-round treatment, test four different container configurations.
Phase 2 (March-May): Design portable toilets around optimal processing container.
Phase 3 (June-October): Apply to the State seeking a variance for field trials of our unique system. Service small events with a fleet of six-eight toilets.

2012 Full-Scale Deployment: Deploy and refine ecological sanitation services at festivals
Long-term: Use portable toilet logistics as a model for new, neighborhood-scale waste management.

The Problem: US sewers spill more than 850 billion gallons of raw sewage per year, greater than 40 times the volume of excrement that is their primary pollution hazard and reason for existence. We need a new plan for the US, not just a patch. More importantly every civilization in the world has fallen because of a lack of soil nutrients to sustain their population, our soil is what sustains us.
Our Mission: To create low-energy open-source sanitation solutions based on the real transformation of waste into healthy soil.
Our Solution: Use containerized collection and automated, electronically monitored processing to meet the legal and cultural expectations of US toilet users. Small-scale co-composting (combined composting of excrement, food, paper, and other organic wastes) facilities such as ours save money and water, broaden access to sanitation, and produce compost that restores soils. Our toilets will be manufactured and rented for events in the Northwest.

Impact

In 2012, our first year of full-scale operation, we will divert over 40 tons of excrement from entering sewers, introduce tens of thousands of people to a new sanitation model, and empower thousands as sanitation advocates through ecological sanitation training before festivals. We will build greenhouses equipped with monitoring systems to quantitatively track waste reclamation and carbon capture.

Implementation

Festivals and other multi-day events outside city limits are our initial target market. Festivals have urban population densities and extensive waste trails. With on-site composting services, ecologically-minded festivals can move beyond a “leave no trace” model and towards leaving a positive impact--a big pile of high-quality compost. At large-scale events, our portable composting toilets will introduce ecological sanitation to thousands of people in just one weekend. User feedback from thousands of festival goers increases the public profile and viability of composting toilets as an option for residential use.

Quitting Sewage

Sewers are an expensive hazard and we want them shut down. A wide variety of systems are needed to replace sewers including greywater drainage, managed wetlands, and on-site industrial wastewater treatment. But without new toilets these systems will remain on the fringe, an extra expense on top of our present sewers.

We've sketched out a rough plan that starts with toilets and focuses on financial costs, rollout strategies, and infrastructure tests here in Oregon. We're developing an open source portable composting toilet for special events to show the viability of composting toilets in the urban US. Our development process is open, so feel free to re-use our charts, images, and words, join our project, or give us aid.

The Sewer Problem

Sewer's don't treat or eliminate excrement, they move it, and maintaining miles of pipes is expensive. Portland's sewer fees are among the highest in the nation, ranking first in a 2007 study by Black & Veatch, followed by Redmond, WA.[2] Complaints about the cost of sewer bills are ranked third in calls to Portland's mayor's office, right behind police brutality[3]. Despite the high bills, our old pipes put 12,000 Portland properties, roughly 10% of the service district, at risk of sewage flooding. Yet our fees aren't fixing this risk, they're merely preventing it from rising while the Bureau of Environmental Services (BES) builds The Big Pipe, a giant reservoir intended to drastically reduce Combined Sewage Overflows (CSOs) whereby rainfall drives raw sewage directly into the Willamette.[4] Portland's situation is far from unique– 38% of U.S. municipalities self-report dumping raw sewage in waterways, and it will be very expensive to stop the practice.[5]

Moving excrement through the sewers to a centralized collection point is so expensive that we can't afford to truly treat it. Portland's Bureau of Environmental Services runs an EPA Platinum-certified treatment plant, but the problem is too big. During the rainy season (assuming sewage arrives at the plant) sewage is strained through grates, sent through settling tanks faster than during dry weather, bleached, de-bleached, and emptied into the Columbia. It's a big, fast-moving, well oxygenated river. It does alright with the extra phosphorus and other fertilizers. Some of the solids are recovered and anaerobically digested and applied to the land, but not before mixing with industrial waste and losing much of their phosphorus and plant-available nitrogen.[6](see page 10)

The Official Solution

The Portland BES

Sewer cleaner truck crashed in sinkhole made by clogged, leaking sewer. Portland, OR, 12/26/2006, KOIN 6 News

Portland OR, Sewer Costs[1]

In millions. Operations and maintenance costs only. Does not include construction, engineering, and administration.

Dry vs. Wet Toilet Output [7]

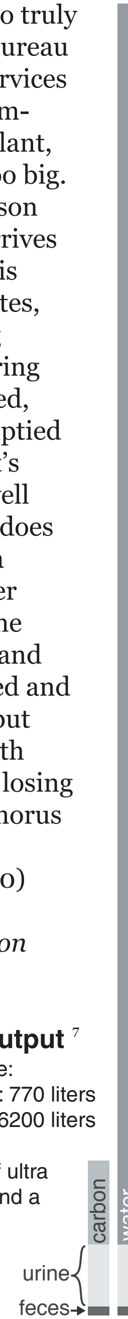
One person's yearly usage:

Dry toilet with carbon : 770 liters

Wet toilet with water: 6200 liters

based on a comparison of ultra low-flow dual-flush toilet and a composting toilet.

(*see page 7 for the breakdown*)



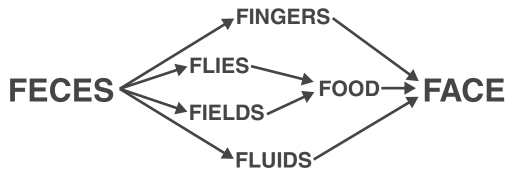
is wants to see restored ecosystems diverting stormwater from the sewers. They've pushed for downspout disconnection, bioswales on the streets, and on-site industrial waste treatment. They've experimented extensively with recovering nutrients from sewage, partnering to build the world's first commercial phosphorous recovery plant in Tigard, and running anaerobic digesters and composters in Portland.

Still, in the BES's best-case future every dual flush, low-flow toilet will still produce a fetid stream of water far out of proportion to the excrement it flushes. No rational solution starts by increasing the problem by an order of magnitude. Sewers' inherent inefficiency at excrement collections means that their costs can be shifted between ecology, energy, money, and society, but never mitigated.

Fear in Sanitation

When considering the safety of alternative sanitation systems, it is important to review them within the context of current practice. Our current sewage system dilutes our excrement with storm water and industrial waste and only treats the pathogens in our waste 150 days of the year (when it's not raining), the rest of it is dumped in the river. By introducing huge quantities of fluids, flushing multiplies danger and fear.

Vectors of Fear and Disease



The F-Diagram (Wenblad et al. Fig 2.1)

Diffuse mixtures of poop and water are scary– the Romans, proud sewage pioneers, used the word "Mixtus" for filth.[7] What they meant was the mix in their Cloaca Maxima.

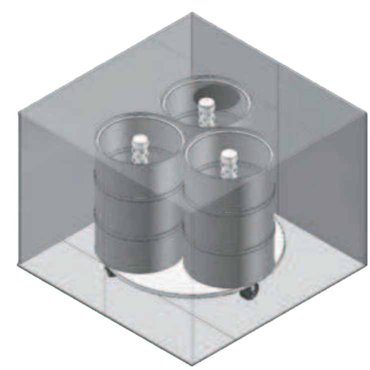
Restoration of our waterways is one of the great projects of our time, involving difficult negotiations over use, responsibility, and rights

Vera Snurredassen, Norway's most popular composting toilet. Made in the USA as the Ecotech Carousel (illegal in OR, needs NSF cert.) credit: Vera Miljø

of way. Collective decision making is hard enough without an undercurrent of fecal-oral diseases surrounding water usage. We need to remove excrement from our water and deal with it separately and at an appropriate scale.

Dry Sanitation

Any system that collects an unsaturated product (less than 75% water) or adds no water to excrement is a dry toilet.
Most -but not all- dry toilets are composting toilets, meaning they use controlled aerobic (with oxygen) decomposition to digest organic material. Composting systems can be mechanically simple because they are biologically complex; out of all excrement treatment options, composting contains the most diverse population

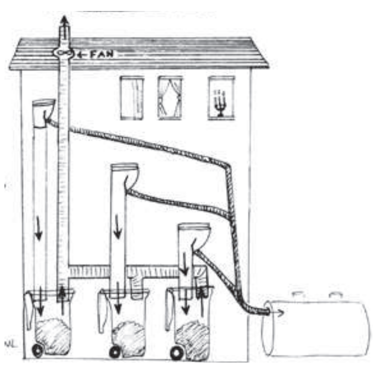


Biorealis Systems rotating 55 gallon drum composter, designed by Robert L. Crosby of Alaska, plans released under the open Design Science License.

of organisms capable of breaking down the widest variety of compounds, including pesticides, surfactants, pharmaceuticals, and other hazards of the industrial era.[8]

Modern dry sanitation systems systems are used extensively in Japan, and according to Hidenori Harada's studies, below population densities of 1,972 households/km^2, collection of excrement for central treatment is cheaper than collecting with piped sewage.[9] Portland's population density is 1655.31.[10] A comparison of centralized vs. decentralized composting systems in India concludes that decentralized composting has higher participation rates and marginally lower costs than centralized composting. Higher participation leads to the added benefits of cleaner streets and public areas.[11]

Moving from water-borne sewage to dry sanitation will mean managing different and unfamiliar fears and disease vectors, but we must not mistake our discomfort with change for actual danger.

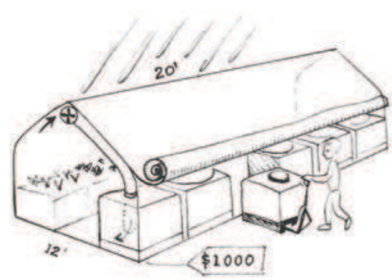


The Gerbers Collective outside Stockholm collects in wheelie bins that are empied every 90-120 days into static piles. Compost is retained 5-7 years.

North-North Tech Transfer

Composting systems are climate specific, and temperate zone dwellers can learn from the experiences of their neighbors. We can build on the experiences of Scandinavia, Canada, Alaska, Minnesota, New England, Montana, Australia, and elsewhere[12].

In residential settings the highest user-satisfaction has been found with batch composting toilets, where vessels are rotated out of collection every few months and left to compost. Innovators from Alaska to Tazmania are deploying high-performance site-built systems using standardized containers, further lowering costs. These systems have primarily been built in low-density areas, assuming that containers can be left to compost for 1-7 years, depending on climate and whether containers are kept indoors or outdoors.

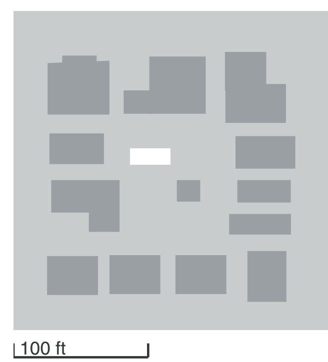


We like the idea of composting greenhouses using standardized, hazardous-waste certified containers as neighborhood-scale processing centers.

Urban space is at a premium, and leaving full vessels around for years isn't practical in dense areas. Around the urban periphery of Stockholm, Sweden and Erdo, Inner Mongolia, containerized collection systems have been coupled with local composting facilities serving apartment blocks with static piles. By adding further containment and a hotter, faster composting cycle, these systems can be brought into the urban core.

Compact On-Site Composting

Combinations of logistics, environmental sensors, container collection, and high-temperature composting will allow dry sanitation in city centers. Large new constructions like the C.K. Choi Building in Vancouver, B.C. are already beginning to use composting toilets with professional maintenance contracts. Networked electronic sensors will bring down maintenance costs, and AlasCan is already offering remote monitoring packages.



Footprint of a greenhouse serving a block with 30 residential units mixing houses and apartments in SE Portland. (greenhouse in white).

Containerized collection and

high-temperature composting offer space savings that may enable cost-effective retrofits of existing structures. Although not yet deployed commercially, this is where we see the most potential. High-temperature composting eliminates disease risks and reduces compost volume quickly, simplifying management and transport. Modular systems deployed block-by-block and shared between buildings reduce collection costs while diverting the organic portion of municipal solid waste (MSW) for re-use as high-quality compost.

Networked logistics minimize errors, simplify coordination, and distribute expertise. As a systemic solution, containerized urban composting can grow with the city, adding capacity at the rate of construction. It can also be far more redundant and resilient than water-borne sewage, important qualities in cities prone to earthquakes, floods, and volcanoes.

Developing Future Systems

Sanitation is a delicate issue, and it is social factors and user experiences that drive adoption, not the technics of treatment. Only through relentless cycles of user feedback and refinement in low-stakes environments will alternatives to water-borne sanitation become competitive.

Temporary events frequently achieve urban densities in low density areas. Handling toilets for multi-day festivals and events is an opportunity to engage a broad population of users in testing and refining containerized logistics without sinking costs into permanent structures. Natural Event Australia, Thunderbox UK, and others have proven the viability of this model outside of the US.

We're going to run tests on composting greenhouses as a promising system suited to US laws and social mores. Greenhouses are an economical way to maintain high temperatures through all four seasons while constructing extra barriers around compost. Our research suggests that they'll fit well in medium-density urban areas, and with some development, we believe they can be made to work in high-density areas too.

As small, semi-enclosed ecosystems, composting greenhouses also have a romantic allure. They promise heat recycling, carbon capture, and near total nutrient recovery. They're a step away from the oppressive rhetoric of "footprint" reduction and towards a regenerative city. Or so we hope. Look for our test results this spring.

[1] "Infrastructure" 49.1m and "Operational Issues" 50.5m pg 240 & 241, City of Portland, OR FY2010-2011 budget
13.9m cost of treatment plant: <http://www.portlandonline.com/bes/index.cfm?c=29323&a=265796>

[2] "Portland Sewer Rates lack third-party check" Janie Har, The Oregonian: March 27 2010. On Oregonlive.com <http://www.oregonlive.com/portland/index.ssf/2010/03/portland_sewer_water_rates_lac.html>

[3] "Take Your City and Shove it" page 12 Portland Mercury: Oct. 14, 2010.

[4] "A Fecal Matter." page 30, Nigel Jaquiss Willamette Week: June 10, 2010.

[5] "As Sewers Fill, Waste Poisons Waterways," Charles Duhigg, New York Times: Nov. 22 2009.

[6] from tour of plant by Ron Lilienthal

[7] Glowers, Emily. The Anatomy of Rome from Capitol to Cloaca, The Journal of Roman Studies, Vol. 85, (1995).

[8] (Kang Xia 100) see *Citations*

[9] "An approach for Sanitation Improvement" Hidenori Harada, SuSanA Macao Meeting: 2008

[10] US Census 2000.

[11] Decentralized Composting - Assessment of Viability through Combined Material Flow Analysis and Cost Accounting, Dreschler, et. al. EAWAG: 2006.

[12] Great Sources: Switzerland: Eawag/Sandec, Sweden:Stockholm Institute Australia:The On Site Conference, Massachusetts: Center for Ecological Pollution Prevention

Imagine our city without sewers

Our city without sewers . . . it can happen now–
converting flush toilets, re-plumbing with vacuum toilets, building with direct drop systems in mind. How things would look:

West side new construction with direct-drop composting toilet system managed on site by co-op/condo in on-site greenhouse. Urine collected separately for fertilizer. (See Gerbers, page 27)

Greywater drains into small managed wetland and surface runnoff into municipal floating wetlands positioned at sewer outfalls in the river.

static aerated piles enrich farm soil

pump-out trucks move urine and compost tanks to farms for com-posting

Conversion keeps flush toilets but adds inline solids separation *(see the Aquatron)* to the existing piping to immediately remove excrement to pumpout tanks. Can be used with vacuum flush toilets to reduce the amoutn of water used to flush. Graywater is run through a UV filter and then a denitrifying sand column before system discharging into the sewer.

East side house re-plumbed for Vacuum flush toilets empty to containers in the garage. Containers are moved every few months to the neighborhood composting greenhouse.

Industrial plant with on-site settling tanks and particulate scrubbers to capture pollutants. *(happening some places now)*

Out-buildings and temporary structures use bucket toilets that are emptied into the composting containers in the composting greenhouse.

House with vacuum system and a compost grinder in the kitchen for sending food scraps straight to the compost. Containers are also treated in composting greenhouse.

Neighborhood composting grenhouse serving 120 people. Each container is batched for 6-8 weeks, abating pathogen risks and reducing its volume by half. It is then emptied and removed to nearby farms.

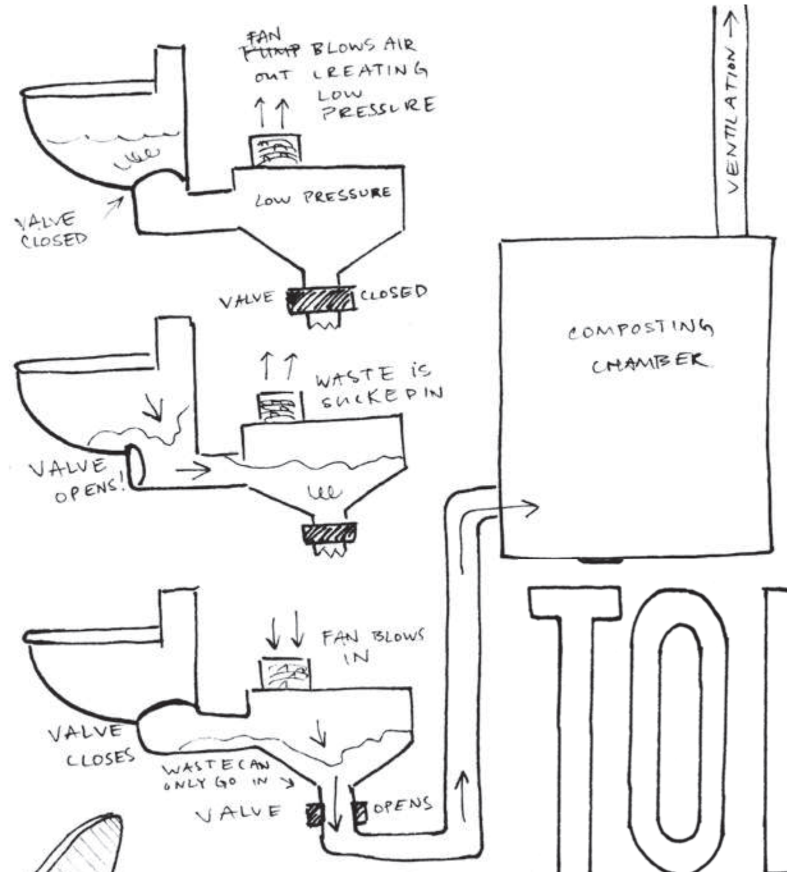
A homeowner goes it alone with his own composting toilet system.

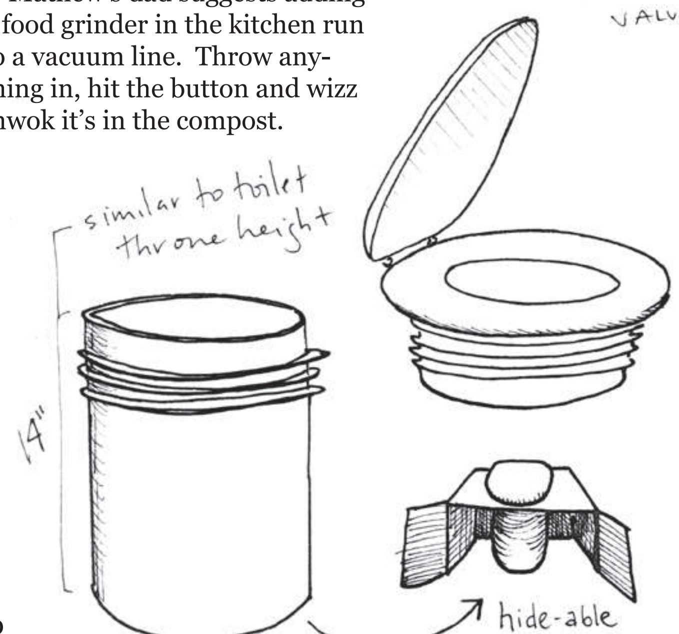
Vacuum Flush

Vacuum flush systems use a little bit of water (1 cup to ½ gallon) and sometimes foamed soap as a medium to transport excrement through narrow (1-1½”) piping. Because they don’t rely on gravity, vacuum systems can flush upwards. Flexible vacuum piping can be snaked through the walls of existing buildings, making vacuum systems an excellent choice for retrofits. Domestic systems need development: most current systems are made for airplanes, yachts, prisons/office buildings, and are outside many homeowners budgets.

Foam flush vacuum toilets also have a futuristic feel, with scifi sounds suited to their precision action. In cultures enamored of gadgetry, we expect they’ll recieve a lot of attention.

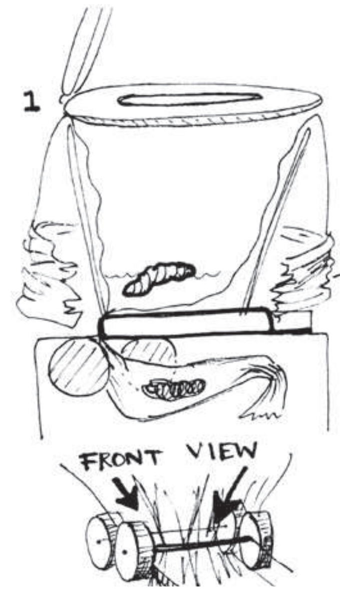
Mathew’s dad suggests adding a food grinder in the kitchen run to a vacuum line. Throw anything in, hit the button and wizz thwok it’s in the compost.



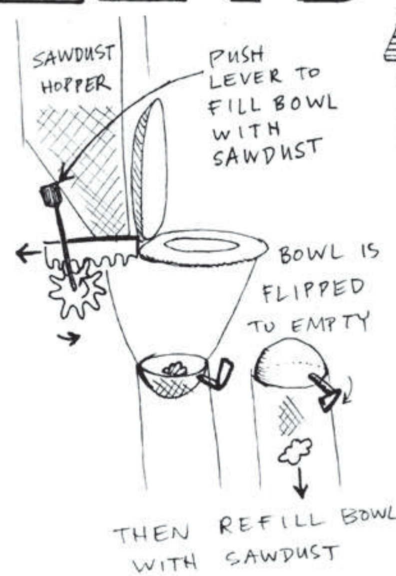


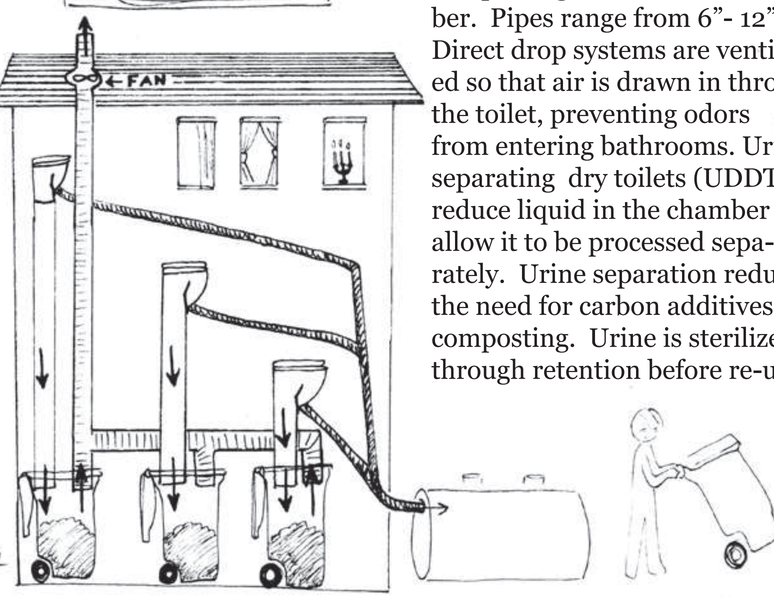
Carbon Cover

materials like sawdust, rice husks, ground straw, etc. block odors, absorb ammonia, and balance nutrients, and improve aeration during composting. The simplest systems use scoops of sawdust for cover. Mechanical systems exist to dispense measured quantities of sawdust into a clean bowl, providing a physical and visual barrier between toilet and chamber. Carbonaceous additives significantly reduce leachate, especially when when used with urine separation.



LETS





Packaging Toilets

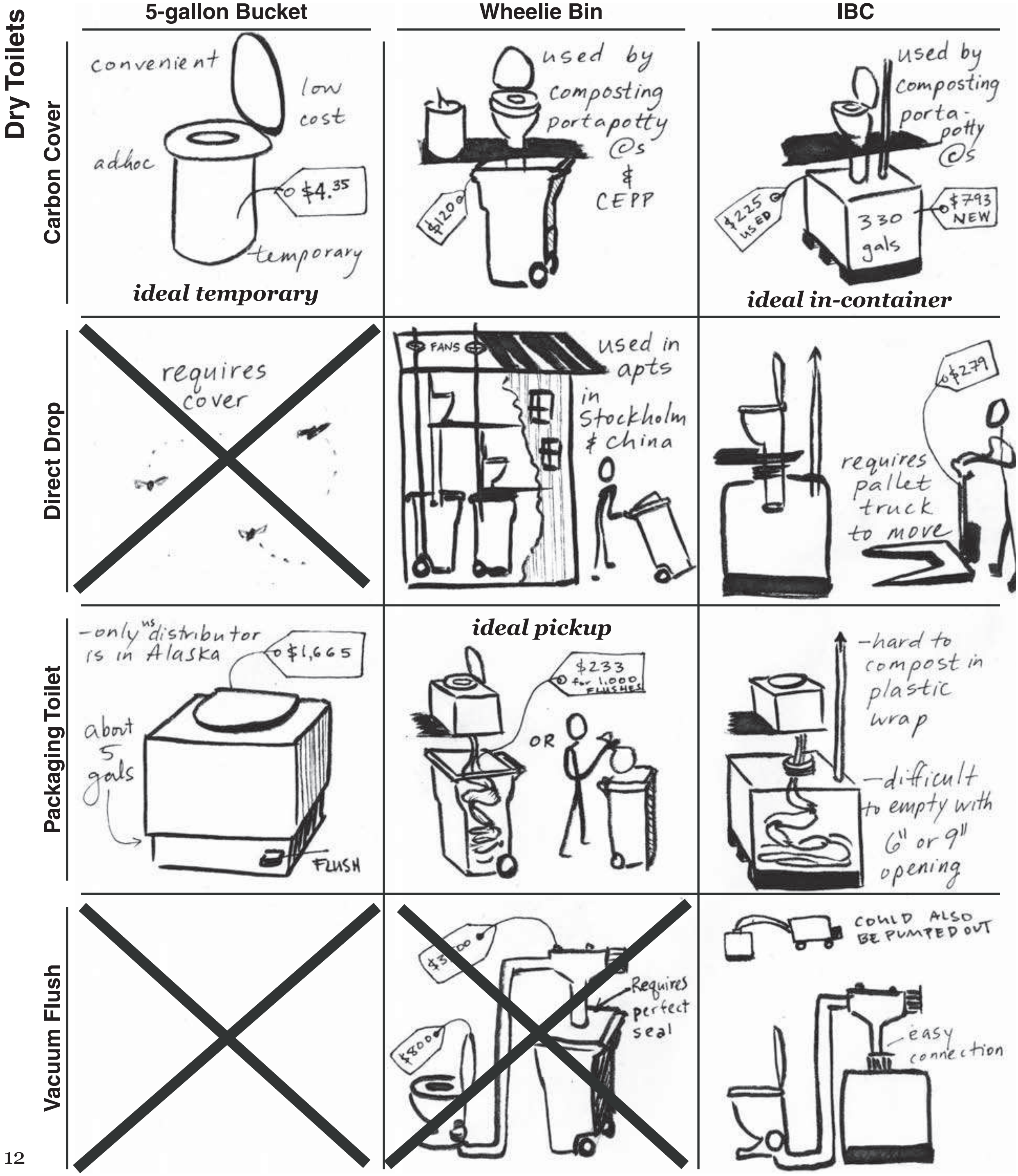
Packaging toilets were invented by Buckminster Fuller for his Dymaxion bathroom in 1927, and put into production in the 1960's. A continuous feed of plastic lines the bowl and is pulled down by rubber wheels into a lined container. Currently non-biodegradable plastics are used, but packaging toilets could use any gas-permiable biodegradable polymer such as PLA or PHA/ PHB . After collection, the plastic lining needs to be broken up for composting. Suggested byEarle Barnhardt.

Collection of individual samples allows easy analysis. Good health info is in there, but Pacto© toilets are used mostly by border guards.

Direct Drop Toilets

Most composting toilets open to a wide pipe located directly above a composting or collection chamber. Pipes range from 6"- 12". Direct drop systems are ventilated so that air is drawn in through the toilet, preventing odors from entering bathrooms. Urine separating dry toilets (UDDTs) reduce liquid in the chamber and allow it to be processed separately. Urine separation reduces the need for carbon additives in composting. Urine is sterilized through retention before re-use.

x Containers



Our Ideal Systems

Carbon Cover & IBC

An IBC hooked to a toilet with a carbon cover system can hold roughly 330 person-days (one person/gallon/day). If used with an efficient vacuum flush (4 oz flush+ 20 oz excrement), an IBC could hold 1500 flushes. In a diversion system urine can be collected in another IBC. IBCs would ideally be near vehicle access for fast, regularly scheduled pickup.

Packaging & Wheelie Bin

Because the thin polymer wrapping of a packaging toilet adds very little to every toilet "event," packaging toilets are very space efficient. Wrapped excrement goes into a lined container, multiple layers of containment make packaging toilets a good choice for pickup, when excrement is emptied from containers at curbside.

Carbon Cover & Bucket

Bucket systems are very high performance toilets for the price. Anywhere a bucket can be carried can become a bathroom. Especially in camping, temporary, and disaster situations they are the perfect flexible toilet system. Bucket liners and good lids add another layer of separation. With lids attached, buckets are easily transported by hand or by vehicle and stored until they can be emptied.

Containerized Toilets in the Real World

IBCs

Thunderbox is a UK collective that spends the summers running composting portable toilets for music festivals. Their portable toilets are built around urine diverting dry toilets and IBCs. Their IBCs rarely fill up during events, and the containers are transported full, composted, emptied with a dry vac, and then composted further.

There are a variety of IBCs on the market today. The ones we like the most have large 9" openings positioned off-center, allowing a toilet to be placed easily below, an air hole in the back that can be hooked to ventilation, and a 2" drain on the bottom. Manufacturers in the US include Bonar Plastics (subs. of Promens).

Packaging Toilets

Packaging toilets have not yet been integrated into a composting system, but we see a lot of possibility with packaging designs. Earle Barnhart of The Green Center recommended the idea to us. Available in Alaska from Taiga Ventures Tel. +1 (0)907 452-6631.

Wheelie Bins

Wheelie bins are a popular composting toilet container. At the Gerbers Collective outside Stockholm, Sweden, wheelie bins are used for collection, after which they are emptied into outdoor bins for further composting. This system has been copied and scaled up in Erdos, China, where, despite some excellent refinements and awesome new sawdust toilet designs, the installation was screwed up by developers and bureaucracy (Zhu 35).

The Center for Ecological Pollution Prevention created a system called the "Wheelie Batch" that involves fishing nets suspended inside wheelie bins to enhance aeration. When bins are full, they are moved to sunlight to compost in the container.

Starting in 2003, Natural Event, Australia uses wheelie bins in portable toilets. They then leave it in the bins for over a year.

5-Gallon Buckets

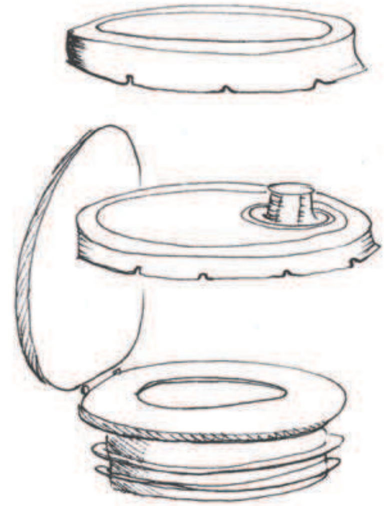
Modern bucket collection is best known as humanure, a term invented by Joe Jenkins, a bucket-system evangelist. Classic bucket collection just ended for 250 seasonal locations in Skaneateles, New York, where pickup ran from 1908-1998. User satisfaction was high, but the city of Syracuse has since purchase small composting toilets. Residents empty the small toilets into 1-yard composting bins for further treatment, just like a humanure.

Don't think these are ideal? Pick out and expand your own scenario from Dry Toilets × Containers

5-Gallon Bucket

Any system that depends on humans moving things by hand will probably use five gallon containers. five gallons (20 liters) is the largest amount that most adults can lift with one arm. five gallons of water weighs 45lbs (20 kg), and most organic substances are less dense than water. The modern HDPE 5-gallon bucket is ubiquitous, cheap, and recyclable. It is easy to move, easy to seal, and easy to clean.

5-gallon bucket toilets are the perfect disaster toilets. Everyone should own one, especially in an earthquake zone.

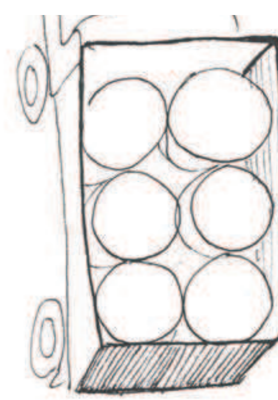


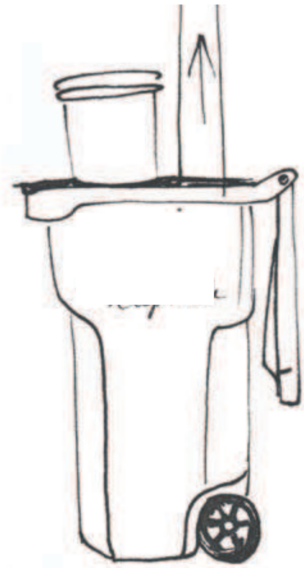
Jerry Can

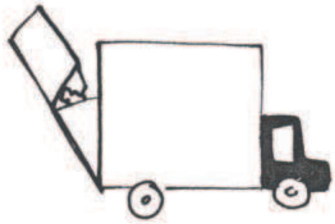
The 5 gallon (20 liter) Wehrmachtskanister became a global standard by 1944 and remains so. Universally commended for its subtle ease in filling, pouring, passing, and thermal expansion/contraction.

55-Gallon Drum

The 55 gallon (210 liter) drum is found in all varieties of plastic and steel. When full of water or other liquids, it weighs approximately 460lbs (220kg) and is easily moved by a hand truck on smooth ground. It is also designed to be turned sideways and rolled, or stacked in fours on a standard pallette. Because it is cylindrical, the 55 gallon drum does not pack very tightly. Ubiquity and price makes it a commonly repurposed container, and many happy homeowners use them for composting, usually with a long retention.







Wheelie Bin

The wheelie bin is a standard curbside collection container designed for easy manual handling and mechanized emptying into municipal vehicles. A slot and metal bar opposite the lid's hinge is easily grabbed by a hydraulic lift. Wheelie bin standards mainly concern the lift interface and not size, but most bins hold around 70 gallons (260 liters). Rectangular bins pack well, and are often color coded by contents. Negatives in regards to excrement are the large, hard-to-seal top and a volume less than optimal for in-vessel composting. Otherwise, wheelie bins have a lot to offer.

INERS

The best container is the one that's right for the job. Here are five extremely common containers with different adantages regarding capacity, transportation, and transfer. Before picking a container, know your criteria: who must handle the container and what are they doing with it? Is it to be emptied, stored, or used as a processing vessel? Is it for liquid or solids? does it need to be modified? How many do you need and what can you afford? Do you need a steady supplier of containers or can you make one mass order? What is available in your area?

IBC

The IBC, or Intermediate Bulk Container, is designed for the transport of liquids, and ranges from 220 to 330 gallons. Sized to subdivide intermodal containers (large steel shipping containers) and to fit on standard pallettes, the IBC is easily stacked and packed. IBCs are too big to be moved without a forklift. Drains are standard and top openings range to 10" (30 cm). The IBC is an international standard for hazardous waste transport. Its size of greater than a cubic yard makes it a compost chamber.


x Containers
Processing Methods
5-gallon Bucket
Wheelie Bin
IBC
open pile
1. OPEN
2. ADD
3. COVER
requires bin lifter OR bin liners
$3K
IBCs have a 6" or 9" opening which is difficult to empty
static aerated
hard to empty
small in vessel
too SMALL
≈1 year residence time
might work better with modification for leachate drain
lid can be opened or closed
woodchips could act as smell barrier
requires fan to mee O2 deman
large in vessel
$18K
$58K
10yd3
hard to empty
20yd3 = 75K
40yd3 = 110K
30yd3 = 94K
Greenhouse & Open Pile
$1,600
10'x12' green house
requires lifter + flat ground for lifter
In Vessel & Greenhouse
?
-requires forced aeration
-possibly needs aeration drain
-can't fill bin to top
requires aeration
built in 2" drain for aeration or leachate
empty with wet, dry va

Our Ideal Systems

IBC in Greenhouse
Each IBC is a good-sized compost pile and thermal mass at more than a cubic yard. In a greenhouse it absorbs heat from the sun, raising its temperature, and cycles CO2 and O2 with plants, holding warm air inside. This thermal efficiency and extra containment make it an excellent candidate for community systems at northern lattitudes that need to remain active all year round.

Wheelie Batch
A wheelie bin can be outfitted in a number of ways to maintain aerobic conditions: either a net or mesh bottom to hold waste above it's own leachate, and perforated pipes coming in from above or below to blow air through. A great system if one has time and space for it.

Bins & Buckets
Easy options that don't totally isolate users from excrement, creating social and legal problems. Lining buckets and bins with with compostable plastic and emptying into in-vessel systems provide extra barriers.
Many are shocked by the sight of an uncovered static pile, but it offers great treatment and minimal risk when handled responsibly.

Containerized Composting in the Real World

Gerbers, Sweden/Erdos, Inner Mongolia
At Gerbers excrement receives two stages of processing- during collection, excrement slowly dries out and moulders, reducing its volume and lowering it's coliform count, this is called primary processing. After roughly 120 days of collection, containers are emptied under a layer of compost in large outdoor bins for secondary treatment in static piles. Compost is retained in these for over three years. Bins in Erdos are larger, up to 12 ft, and turned by machine.

Joe Jenkins
Joe Jenkins' humanure system collects excrement in 5-gallon buckets, using nitrogenous urine and available carbon from sawdust to run a thermophilic pile. Jenkins' own bins remain thermophilic through the Pennsylvania winter. He retains compost 1-2 years, depending on how hot the pile gets. Although there are regular chores in a humanure system, there are few surprises and or maintenance headaches.

Wheelie Batch
David Del Porto's Wheelie Batch is our favorite amongst a large collection of drum & bin systems. Del Porto wins for use of a fishing net, rather than a clumsy plastic or metal aeration insert to drain leachate from compost. Users have enough bins or barrels to retain compost for 1-3 years. Dead simple, no transfer of excrement from one container to another, primary and secondary treatment happen in the same container.

Large In-vessel Composting
Portland's sewage treatment facility used to have a large in-vessel system (custom built and huge) for processing all their solids. They found that the difficulty of maintaining a supply of evenly-sized large wood chips made it hard to justify the higher-value (class A) soil amendment they produced. They have since returned to anaerobic digesters and methane production.

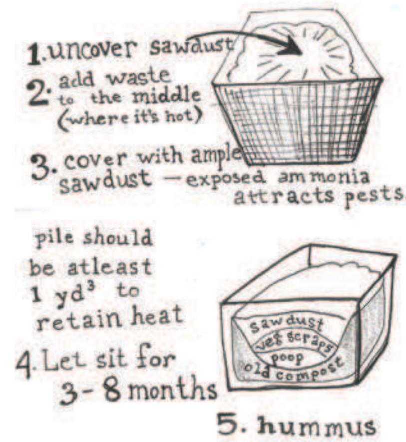
IBCs as In-Vessel Composting Containers
Both Thunderbox UK (*discussed in Toilets x Containers*) and CompostEra of Sweden compost in IBCs. CompostEra builds cottage systems that are designed for long-term (3-7 year) collection from houses and vacation cottages, demonstrating just how much an IBC can hold if allowed to collect slowly and compost in-vessel.

Composting Methods: *Static Piles & Forced Aeration*

For the purpose of this document we're defining compost as aerobic decomposition even though anaerobic decomposers do play a role in compost piles, especially during the later stages.

definition: A static pile is a pile that is not turned, distinguished from a windrow which is turned regularly for aeration. Static piles are aerated by natural convection or forced air (static aerated pile) and work well on a small scale (Joe Jenkins recommends 1 to 2 cubic yards). Convection can't aerate a large pile, so large compost facilities use forced air.

Static Pile: Cheap Small Scale Option



Static Aerated Pile: Cheap Large Scale Option

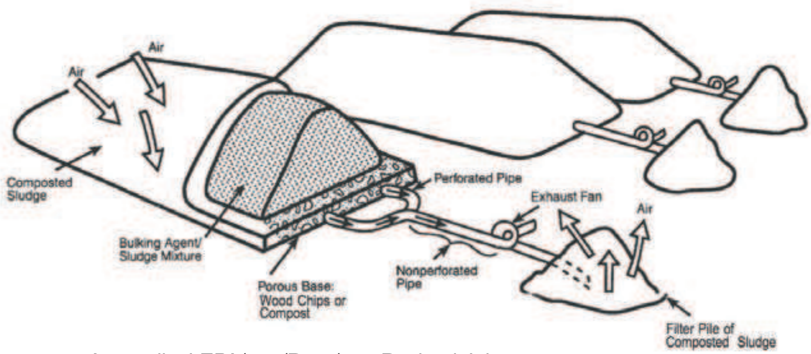


Figure 6.3, Appendix J EPA/625/R-92/013 Revised July 2003

How to Construct an Aerated Static Pile (taken from Appendix J of the EPA's guide to Composting Biosolids, EPA/625/R-92/013, Revised July 2003)
Aerated Static Piles should be covered with an insulation layer of sufficient thickness to ensure the temperatures throughout the pile, including the pile surface, reach 55 C. It is recommended that the insulation layer be at least 1 foot thick. Screened compost is a more effective insulation than unscreened compost or wood chips. Screened compost also provides more odor control than the other two materials.

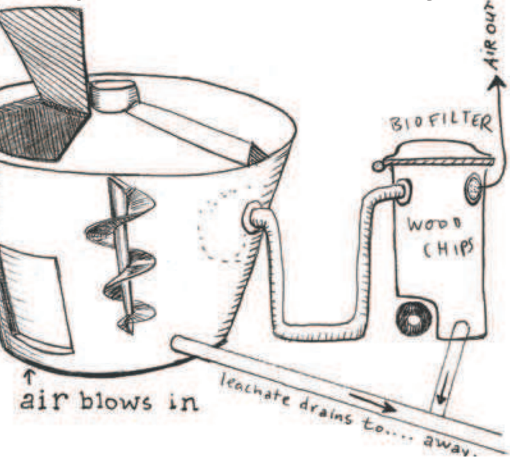
Air flow rate and the configuration of an aeration system are other factors which affect temperature. Air flow must be sufficient to supply oxygen to the pile, but excessive aeration removes heat and moisture from the composting material. Aeration piping too close to pile edges may result in uneven temperatures in the pile and excessive cooling at the pile toes. If holes in the perforated piping are too large or not distributed properly, portions of the pile may receive too much air and be too cool as a result.

In-Vessel Systems

definition: In vessel composting is controlled decomposition that takes place in a container. The container can be large or small but must provide an environment with enough air, moisture and insulation for decomposition to happen. In-vessel systems are aerated by natural convection or forced air and work well on all scales, though cost can be prohibitive.

How they run: In vessel systems can be manually agitated to speed up the process of decomposition (*see Earth Tub or Earth Bin or the classic Garden Tumbler*). Commercial composting toilets such as the Phoenix below, run continuously, using baffles and rotating tines to aerate and break up the composting mass. In earlier designs, such as the Clivus Multrum, this task is often done manually with a rake.

Aerated In Vessel:
Earth Tub by Green Mountain Technologies



Containment invites management- when a soft, permeable barrier of active organic material is replaced with a hard, impermeable border, the natural convective aeration of a well-assembled pile must be replaced with the forced aeration of timers and fans. Full containment is a fiction- to remain aerobic, gasses must be exchanged outside the pile. Especially in northern climates, rain barriers and insulation may be needed for year-round composting, but most reasons for keeping compost in impermeable containers are legal and social.

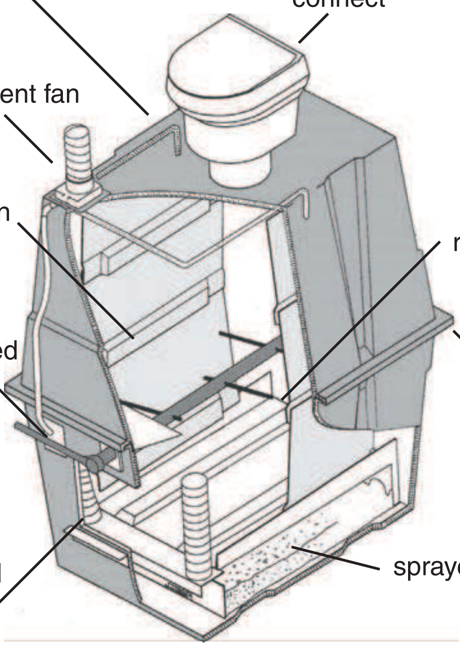


Image Credit: Phoenix Composting Toilet, Advanced Composting Systems, LLC.

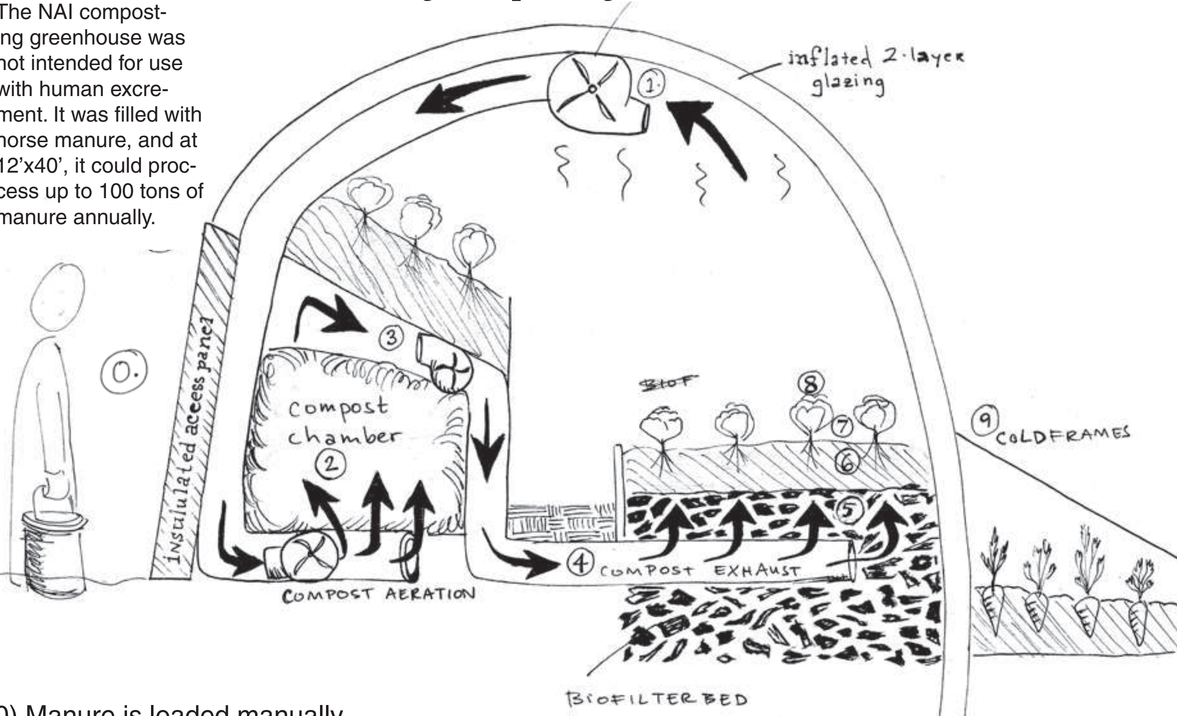
In institutional settings-
Continuous in-vessel systems are valued for their predictable, simple, and easily scheduled maintanence. Parks services are extremely fond of the Phoenix continuous composter. Similar systems from Clivus Multrum, SunMar, and AlasCan are also popular.

Static Piles in Greenhouses

Greenhouses have the potential to be extremely nutrient and energy efficient, capturing heat, ammonia, and CO_2 coming off of compost for soil and plant growth. Composting is an aerobic process, and especially at northern latitudes there is a balance between adding air and losing heat by convection. The New Alchemy Institute composting greenhouse was designed to address this problem by creating a partially closed nutrient cycle. Air inside the greenhouse was exchanged between the compost and a biofilter/ plant beds, exchanging CO_2 for oxygen. Despite some difficulties balancing ammonia and heat generation, the greenhouse was able to raise plants and maintain thermophilic composting through a New England winter. Milwaukee's Growing Power sees improved winter plant growth with simple piles on the inside of their hoophouses, but they are not focused on thermophilic composting.

New Alchemy Composting Greenhouse, 1983-1991

The NAI composting greenhouse was not intended for use with human excrement. It was filled with horse manure, and at 12'x40', it could process up to 100 tons of manure annually.



0) Manure is loaded manually
1) Hot oxygen-rich air at the top of the greenhouse is blown down into pile.
2) Aerated Compost organisms produce CO_2.
3) Volitized ammonia and CO_2 are blown into biofilter
4) Inside the biofilter's tube ammonia combines with water vapor to form ammonium
5) bacteria convert ammonium to nitrite
6) bacteria convert nitrite to nitrate
7) Plants absorb nitrates and CO_2
8) Plants release oxygen to be cycled back to the compost pile
9) Coldframes catch heat and extra nitrates from biofilter

Composting Toilet Safety: *Isolation & Diverse Decomposition*

Your excrement's major nutrients are equivalent to commercial NPK (nitrogen, phosphorus, potassium) fertilizers currently produced by energy intensive mining and industrial processes.

Compostion of Human Feces and Urine*

	per capita per wet	per capita dry	moisture	Nitrogen	Phosophorus	Potassium	Carbon	Calcium
Feces	0.3–0.6 lbs	0.08–0.16 lb	67%	5–7%	3–5.4%	1–2.5%	40–55%	4–5%
Urine	13/4-2¼ pints	0.12-0.16 lb	95%	15–19%	2.5–5%	3–4.5%	11–17%	4.5–6%
Urine contains 14 g/L of inorganic salts and 4 g/L organic ammonium salts. (Putnam 41). *Farallones Institute 118.								

When considering the safety of new sanitation systems, it is important to review them within the context of current practice. Many sewage systems have biosolids programs, where solids are stettled out of sewage, treated, and applied to agrigultural land.

According to Biosolids Applied to Land, a 2003 National Academy of Science study and literature review, EPA biosolids standards were created without conducting a risk assessment of pathogens (Biosolids 13), and relied on a risk assessment of industrial pollutants that even the EPA itself has been highly critical of (173-175). for the first ten years of biosolids standards (1993-2003), no new risk assessment was undertaken. Now the EPA is working to correct this derth of data, and through the National Exposure Research Laboratory extensively supports research on biosolids. No matter what the results of biosolids research, sewage is not a system that lends itself to accountability. For example, biosolids aren't tested for PCBs because PCBs are illegal, but 100% of samples collected in a Wisconsin study contained PCBs (NRC 94). Portland's BES voluntarily tracks PCBs and other pollutants during waste treatment and biosolids recovery, but identifying sources is difficult, as is keeping up with industrial chemistry: "Twenty years after application of biosolids at 25 Mg ha/yr for four consecutive years, the concentration of total PBDEs was 840 βg/kg, almost 8000 times the background level in the area" (Xia 99) . PBDE are structurally similar to PCBs and used as flame retardants. Their effects include interference with brain development, altered hormone function, and cancer (Wilson).

No treatment is guaranteed safe, but the most complete decomposition happens when the widest variety of decomposing organisms expose the material to the greatest number of extreme environments. When measuring the effectiveness of treatment methods against pathogens, every virus, parasite, and bacterium can't be tested for, or known. We therefore use indicators, easily tested pathogens whose presence corresponds to a wider variety of pathogens. Many pathogens, like the bacterium H. Pylori, have no available environmental assay (we can't detect them in soil). Other pathogens have difficult and often inconclusive assays, like Caliciviruses. For many pathogens, extensive studies just haven't been done- prions, for instance, and viruses like Astroviruses, and Rotaviruses (267-278 Biosolids). That said, composting destroys a broad spectrum of hearty indicators.

Research on the persistance of pharmaceuticals and endocrine disrupting compounds in our environment is fairly new (Sumpter 11), but early research seems to suggest that hot aerobic composting is a more effective treatment than either anaerobic digestion and saturated aerobic processes for nonylphenol and possibly other pharmaceutical and personal care products (PPCPs) (Xia 102).

Containerized composting and networked sensors will simplify the dynamic systems approach needed to study bioaccumulating compounds, emergent pathogens, and secondary transmission rates (Biosolids 325). Composting isolates, and monitors during treatment, greatly increasing the available data on our diseases and ourselves.

Diversity is the key to the safety and broad effectiveness of composting against pathogens and organic pollutants. Anaerobic and saturated anaerobic (in liquid) processes are not as diverse.

"Composting may accelerate the degradation of organic contaminants due to their exposure to high microbial diversity and activity (especially thermophilic organisms), abundant substrates, high temperature, changing pH, and successive shifts in aerobic and anaerobic conditions in microenvironments" (Kang 100).

Most pathogens are adapted for a narrow temperature range around their host's body temperature, and very few survive outside of that range (ATC 30). Most composting guidelines and regulations suggest reaching high temperatures or long retention times. Almost all suggestions correspond to the safe zone of indicated in the chart of *Ascaris* inactivation below.

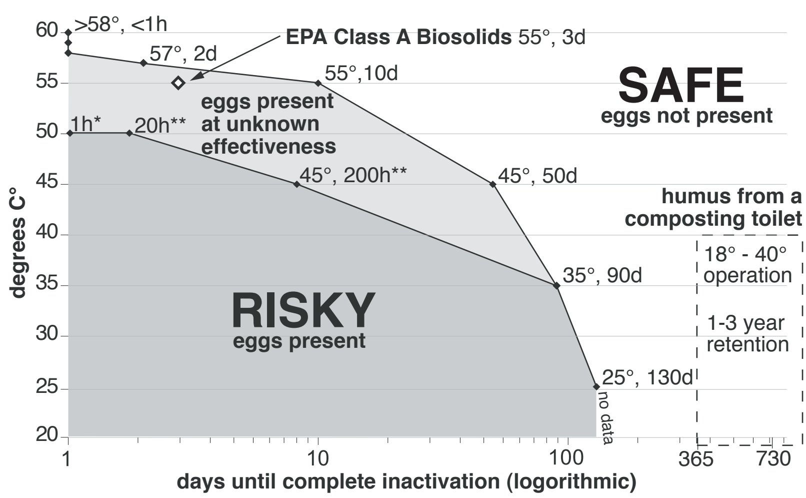
Tomatoes are Red for Safety

Hardy tomato seeds can survive as well as *Ascaris,* and many municipal co-composting systems now throw them in as an indicator (Germer). If tomatoes spontaniously sprout up, then pathogens may have survived too.

Complete Inactivation of *Ascaris* (Roundworm) in Compost

The toughest, longest lived pathogens spread through spores and eggs with hard shells. *Ascaris* eggs are larger and have classically been easier to detect than other hard-shelled pathogens, such as spore-forming bacteria. Human and pig *Ascaris* are used as "indicator" organisms, introduced to evaluate a processing technique alongside common indicators fecal coliform and *Salmonella*. Low levels of indicators denotes effective treatment of a range of pathogens.

A new charged particle assay for *Clostridium perfringens,* another hard-shelled pathogen, may be cheaper than that for *Ascaris*, and is being considered as a possible replacement for *Ascaris* testing.



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

**Feachem, et al. (1980). "Appropriate Technology for Water Supply and Sanitation." The World Bank, Director of Information and Public Affairs, Washington D.C. 20433.

All other data points: "Biosolids Applied to Land," Table 6-2, pg 265, National Research Council of the National Academies, Washington DC, 2002.

original citation: Mbela, K.K. 1988 MS Thesis. Dept. of Environmental Health Sciences, School of Public Health and Tropical Medicine, Tulane University, New Orleans, LA

Compost from Clivus Multrum based on operational instructions: ClivusMultrum.com

Feces Disease Indicators
From EAWAG Co-composting Review
(Strauss et. al. 21)

Fecal Coliforms

Death within 1 hour at 55º C and within 15-20 minutes at 60º C.

Indicators for E.*coli* and a host of gut bacteria. They are a prime indicator in wastewater treatment and any process involving feces.

Salmonella

Growth ends at 46º C; death within 30 minutes at 55-60º C and within 20 minutes at 60º C.

The bacterium behind typhoid, particularly dangerous because it can bloom in compost after treatment is finished. The best guard against re-infection is an active and healthy decomposer population (Biosolids 283)

Ascaris

Not always present in composing feedstock, complicating measurements. Often pig Ascaris is introduced as a substitute to measure. Assay is difficult because egg viabiity requires a 3-4 week culture (Biosolids 279)

Clostridium perfringens

A spore-forming bacteria with similar survivability to Ascaris, *C. perfringens* spores are more common in the environment, and require a simpler assay. *C. perfringens* is a leading cause of foodborne illness (Biosolids 278).

Urine Disease Risks

In healthy people urine is usually sterile, although it may pick up bacteria or feces while leaving the urethra. Those with severe kidney and bladder problems may transmit infections through blood contaminated urine (Schönning 3). If infected with blood from a user with kidney problems urine could contain hepatitis A & B, CMV, JCV and BKV (flu-like viruses), albeit at low levels with a low risk of infection (Schönning 13).

Addressing Urine Disease Risks

When retained outside the body, the urea and water in urine quickly change to ammonia and then ammonium during retention, raising the pH from around 7 to around 9 (Schönning 8). The pH change and presence of ammonia (which is toxic to all living cells at high concentrations) is enough to inactivate most bacteria within 2 hours (Biosolids 57).

Retention of urine at 20º C for 6 months reduces the risk of pathogen exposure to negligible (10^{15} reduction) for bacteria (*C. jejuni*), protozoa (*C. parvum*) and viruses (Rotavirus) found in feces that may be present in collected urine (Schönning 9). After urine is applied as a fertilizer to fields, pathogen inactivation continues from UV-radiation and exposure to soil biota (Schönning 23). Simple UV sterilization or aerobic co-composting of urine is an additional treatment option. In Sweden urine is used as a fertilizer for any crop after a one month retention at 20 C (must be applied one month before planting for crops that are to be eaten raw) (Winblad 10).

Pharmaceuticals

Most Pharmaceuticals are excreted primarily through urine and secondarily through feces (Daughton 1). Pharmaceuticals end up in our waterways from both treated and raw sewage. The health effects of our pharmaceuticals on other animals range from sex changes to kidney failure to disturbing the symbiotic relationships between bacteria and plants; though research has only begun in the past 10 years (Sumpter 11, Xia 93).

The research indicates that aerobic composting can significantly reduce (84-90%) pharmaceuticals within five months and that mesophilic temperatures are more effective than thermophilic (Hakk 949). The most diverse group of decomposers lives in the mesophilic range. In-vessel, unmanaged open pile, or managed open piles are all effective at degrading veterinary antibiotics (Dolliver 1).

3rd Party Standards
There are no global standards for judging compost after processing, but Australia follows the EPA, and the NSF works with the CSA (Canadian Standards Association). The EPA and NSF water quality and compost quality standard is:
Fecal coliform <200 cfu/g, Moisture < 75% by weight (based on NSF 41 7.1.4)

The NSF is a non-profit consumer product testing company evaluating commercial toilets.

The EPA requires solids strained from sewage (known as Biosolids) to be retained, then tested for *Salmonella*, heavy metals and fecal coliform. For Class A biosolids fecal coliform levels must be less than 1000 most probable number (MPN) per gram of total solids dry basis. *Salmonella* must be less than 3 MPN/4 grams of total solids dry basis. Only one enteric virus and one helminth egg is acceptable per 4 grams of total solids dry basis (EPA 26, 27). Class A biosolids can be used without restriction.

The Hamburg Environmental Authority requires leachate discharged to surface water to be tested twice a year: COD < 80 mg/L, 5th day BOD<20 mg/L (Susana 5).

Terminology & Formulas
BOD: Biochemical Oxygen Demand indicates the amount of dissolved oxygen required for aerobic organisms to devour organic matter in the water sample. A high BOD indicates the sample will become anaerobic quickly which is harmful to waterbodies. (wikipedia)

COD: Chemical Oxygen Demand indicates the amount of oxidizing agent required to oxidize all of the organic compounds in the liquid including non-biodegradable pollutants (which are not measured by BOD tests). (wikipedia)

Saturated >75% liquid

Aerobic Decomposition
$$(CH_2O)x + O_2 \rightarrow CO_2 + H_2O + 672\text{Kcal/mole of heat}$$

Anaerobic Decomposition
$$(CH_2O)x + H_2O \rightarrow CH_4 + CO_2$$

Anaerobic Digestion

When microorganisms derive oxygen from oxidized compounds such as sulfates and nitrates rather than gassous oxygen, the process is known as anaerobic digestion. Anaerobic digestion is often suggested as an alternative to aerobically treating excrement, but it is more rightly seen as a pre-treatment to capture methane.

As a waste treatment technology anaerobic digestion requires further aerobic composting in order to break down waste into plant useable forms and eliminate pathogens and any harmful contaminants (Farallones 124).

Anaerobic digestion pays for itself above 100,000 metric tons of input (5 million people) but hasn't been found to yield net profits (Murphy 867, 869, 872).

The biogas (mostly methane) produced by anaerobic digestion of one person's daily feces is enough to power one compact fluorescent for one hour, or boil 2 cups of water (assuming the gas is 55.5% methane) (See citations for calculation). A household would require 500 pounds of untreated waste to capture a months worth of cooking fuel (Farallones 124)

Citations: *A lot of these are behind academic paywalls. We'll email them to you, just ask info@cloacina.org*

Abbot, Rich. "Skaneateles Lake Watershed Composting Toilet Project". Small Flows Quarterly. 5:2,2004. <http://www.nesc.wvu.edu/nsfc/Articles/SFQ/SFQ_sp04_PDF/SP04_Juried.pdf>

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Daughton, Christian and Ilene Ruhoy. "Environmental Footprint of Pharmaceuticals: the Significance of Factors Beyond Direct Excretion to Sewers." Environmental Toxicology and Chemistry, Vol. 28, No. 12, pp. 2495–2521, 2009.

Dolliver, Holly, et al. "Antibiotic Degradation During Manure Composting." Journal of Environmental Quality. 37:1245–1253, 2008. doi:10.2134/jeq2007.0399

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Glowers, Emily. The Anatomy of Rome from Capitol to Cloaca, The Journal of Roman Studies, Vol. 85, (1995).

Hakk, Heldur et al. "Decrease in Water-Soluble 17β-Estradiol and Testosterone in Composted Poultry Manure with Time." Journal of Environmental Quality. 34:943–950, 2005. doi:10.2134/jeq2004.0164

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Natural Event: Hamish Skirmer partially documents his work best here.
<http://www.jenkinspublishing.com/messages/messages/1489/1490.html?1271128022>

Pacto Toilets available in the US through Taiga Ventures, Fairbanks, Alaska Tel. +1 (0)907 452-6631.

Putnam, D. F. Composition and concentrative properties of human urine. NASA. 1971.

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Schönning, Caroline and Thor Axel Stenström. "Guidelines on the Safe Use of Urine and Faeces in Ecological Sanitation Systems." Swedish Institute for Infectious Disease Control, Stockholm Environmental Institute, 2004.

Schönning, Caroline. WHO: Urine Diversion: hygienic risks and microbial guidelines. Swedish Institute for Infectious Disease Control (SMI): 2001.

United States Environmental Protection Agency. Environmental Regulations and Technology: Control of Pathogens and Vector Atraction in Sewage Sludge. EPA/625/R-92/013. July 2003.

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Xia, Kang, et al. “Occurrence and Fate of Pharmaceuticals and Personal Care Products (PPCPs) in Biosolids.” Journal of Environmental Quality. Vol 34, January-February 2005.

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*Calculation for energy from anaerobic digestion of one person’s daily feces:

1 Watt-hour is 3,600 Joules Ref: http://www.onlineconversion.com/energy.htm
1,000 grams of water requires 2,257,000 Joules to convert to a gas (boil) Ref: http://en.wikipedia.org/wiki/Enthalpy_of_vaporization
So, 1,000 Watt-hours = 3,600,000 joules which can boil 1,600 grams of water.
Water weighs 3.8 Kg per gallon. Ref: http://www.fourmilab.ch/hackdiet/www/subsection1_4_2_0_7.html
one person’s shit= 120.5 g per day or 0.0001204 metric tons/day

[(130 m3 /t *21MJ/Nm3 * 1000 kJ/MJ)/3600 kJ/kWh] * 30/100 = 225kWe h/t;
equation from Murphy, Jerry, Niamh Power. “A Technical, Economic and Environmental Comparison of Composting and Anaerobic Digestion of Biodegradable Municipal Waste.” Journal of Environmental Science and Health. 41:865–879, 2006.

0.001204 *330 kW/t= 0.36 KWh or 36 wh
0.4 *0.36=0.144 gallons of water boiled with 0.36 KWh or 2.3 cups of water
1,600 grams is 0.42 gallons of water.
So, 1KWH can boil 0.4 gallons of water.

Recommended Reading List

USDA, NRCS and Fairbanks Soil and Water Conservation District, “Composting Dog Waste”, 2005. < ftp://ftp-fc.sc.egov.usda.gov/AK/.../dogwastecomposting2.pdf >
A concise illustrated guide to composting excrement. I only hope that the dog owners realize how practical it’d be to join their dogs.

Davison, Leigh and Sam Walker. “A Study of Owner-built Composting Toilets in Lismore, New South Whales, Australia”. Centre for Ecotechnology, Southern Cross University, 2003.
This study found that owner-built composting toilets performed as good or better than manufactured composting toilets in a suburban area of Australia.

Del Porto, David and Carol Steinfeld, “The Composting Toilet System Book” Center for Ecological Pollution Prevention: Concord, 2000.
Toilets pictured in this zine are well described in the Composting Toilet Systems Book if you want any sort of composting toilet, buy this book.

EPA, Environmental Regulations and Technology: Control of Pathogens and Vector Attraction in Sewage Sludge. EPA/625/R-92/013 July 2003.
Appendix J is a surprisingly concise summary of how to compost biosolids, if only EPA compliance was as easy as following this guide.

“Ecological Sanitation” Winblad, 2004 (in citations)
A thorough and inspiring overview of Swedish Ecosanitation initiatives.

Expensive Infrastructure Costs Those Who Can Least Afford It the Most

People love to tell us that our work would be "great for the 3rd world," provoking us to strained smiles. We're working on the problem of toilets in our community, not in distant places we hardly understand. Good public sanitation is needed here, and sewers will never provide it.

Contrary to popular belief, open defecation (pooping straight on the ground) is still a major problem in the United States. Just last week our friend Samantha off-handedly said, "hey, it would be great if you could do something about the people who shit in my back yard." her yard abuts a city lot, and dispossessed city residents lacking toilets squat to relieve themselves in the quiet, dark corner. Clean & Safe, a private police force and cleaning service retained by downtown businesses, spends $10-12,000 cleaning shit off the street. (PHLUSH)

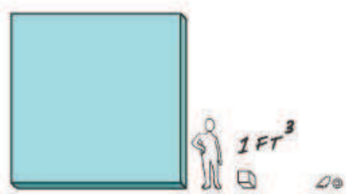
There are several ways to handle this situation- she could set up automated lights to scare people away as if they were raccoons, or call the police. Neither of these is actually a solution. Cops and security systems are like sewers, pushing the problem into someone else's back yard. Public toilets could be provisioned, at great expense. The Portland Loo, a well-designed and easily cleaned public toilet costs $57,000 to install. This cost can only be justified in high-traffic areas, not residential streets like Samantha's that might only see a few daily uses. Or the residents could provision their own toilets, at a trivial expense. A 5-gallon bucket with a toilet seat can be made from salvaged materials, and sawdust is freely available. But this last option comes with a caveat– where would the buckets be emptied? Dispossessed residents by definition have little to no property, no chance of getting licensed and inspected sewer hookups, and no place to run a composting system.

NGO's have been trying to end open defecation for years, and they've found that building toilets is far less effective than educating people about sanitation, and empowering them to build their own toilets. One very successful education campaign is called Community Led Total Sanitation. Educators facilitate community workshops on open defecation and fecal-oral disease transfer, and then leave, providing no suggestions, money, or materials for toilets. The results are stunning, and on a per-toilet basis it is possibly the cheapest sanitation project going (Kar).

Expensive and inflexible infrastructure backed up by the force of government exacerbates social disparities. The least expensive and most dignified solution to the very real health threat in Samantha's neighborhood– independently-provisioned sanitation for all residents– is not permissible. If her neighborhood ran their own composting facility, accepting one more input of organic matter (like a few bucket toilets) would be trivial. But the state claims a monopoly on the provision of toilets through it's demand of water-borne transport, making a hookup astronomical. Bad technical decisions become bad social decisions; public sanitation aught to mean sanitation for the whole public. Our sewers enshrine alienation from decomposition into law, and the cost of enforcing environmental alienation is social alienation, threatening everyone's health.

YEARLY VOLUME
OF YOUR
EXCREMENT.

THIS IS THE AMOUNT OF WATER USED BY THE LATEST DUAL FLUSH TOILETS IN ONE YEAR.



IF YOUR EXCREMENT WERE PROPERLY HANDLED, ITS NUTRIENTS COULD FERTILIZE A 50' BY 50' GARDEN AND PRODUCE 6070 SERVINGS OF FRUITS & VEGETABLES. THAT'S ENOUGH TO FEED 6 PEOPLE 3 SERVINGS EVERYDAY FOR A YEAR.

1 FT²