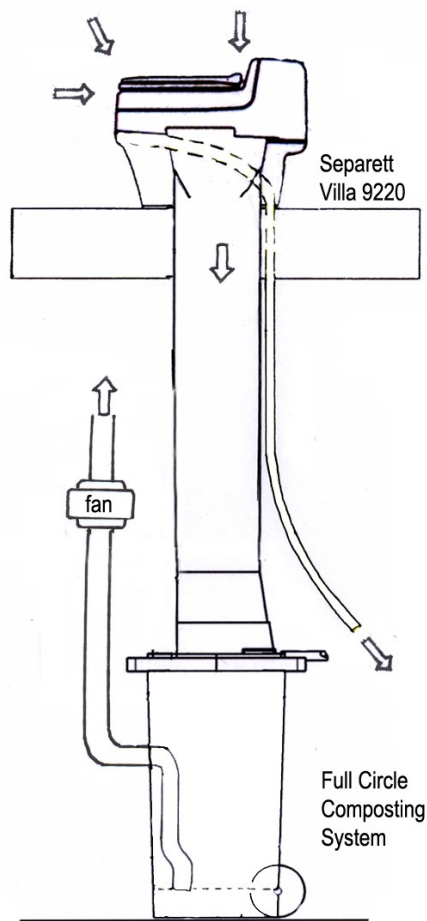


A Report on

A New, User-Friendly, Urine-Diverting, Waterless, Composting Eco-Toilet

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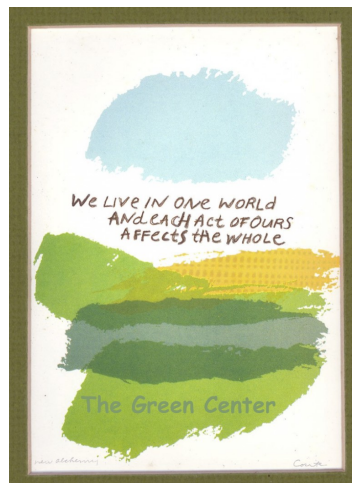
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"Among our major tasks is the creation of ecologically derived human support systems - renewable energy, agriculture, aquaculture, housing and landscapes. The strategies we research emphasize a minimal reliance on fossil fuels and operate on a scale accessible to individuals, families, and small groups. It is our belief that ecological and social transformations must take place at the lowest functional levels of society if humankind is to direct its course towards a greener, saner world."

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A NEW ECO-TOILET SYSTEM

1. Introduction

An eco-toilet is any toilet that uses less water and recovers more nutrients than a conventional flush toilet. Ideally, it should do both – use no water and recover all nutrients.

Starting June 2014, the authors of this report have been using and testing a new eco-toilet design that does both. It combines a waterless, urine-diverting toilet from Sweden, and a modular-bin composting system from Vermont. The Swedish Separett Villa 9220 has a more sophisticated toilet design than American composting toilets, and the Full Circle modular bins are the most practical American composting system. The result is an eco-toilet that is pleasant for the user, waterless, urine-diverting, energy efficient, meets high sanitation standards, is easy to use and maintain, and recovers virtually all the nutrients.

This hybrid design came about from observing many different eco-toilets at the Cape Cod Eco-Toilet Center, a project established and managed by the Green Center. By comparing technologies and innovations of many different composting toilet systems, the best ideas of each could be combined. This is the first use of a Full Circle composting system in Massachusetts and the first use of the Separett Villa 9220 urine-diverting toilet in the US.

Eco-Toilets – The Last Frontier of Sustainability

Flush toilets use lots of water and recover no nutrients. The trend in eco-toilets is towards waterless toilets, separation of waste streams with a different treatment for each type of waste, and recovery of nutrients. Urine-diverting, composting toilets can safely recover virtually all of the nutrients from human waste, using no water, and keeping them out of wastewater and groundwater, where they pollute the environment.

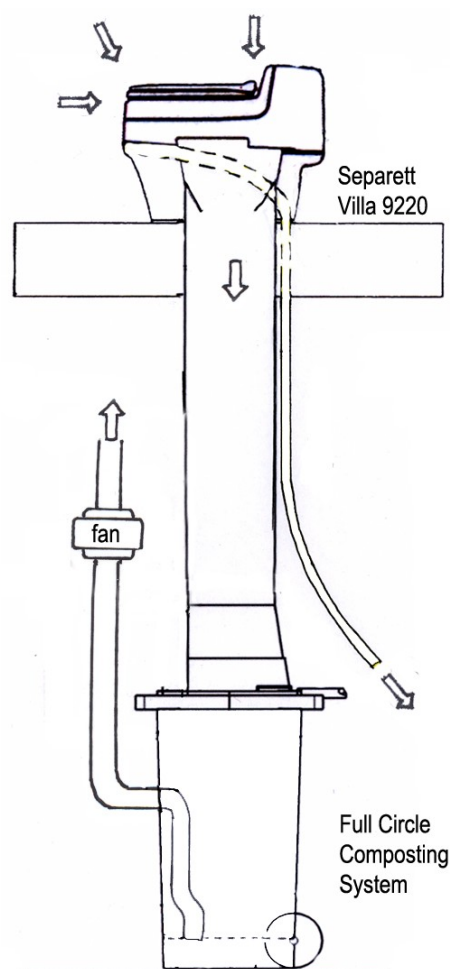
This hybrid Separett/Full Circle eco-toilet design is part of Falmouth's Eco-Toilet Demonstration Program, which is exploring better ways to manage human waste nutrients. The Barnstable County Department of Health and Environment is monitoring homes with eco-toilets, to determine the degree to which eco-toilets reduce the amount of nutrients in wastewater.

The Green Center, Inc. is a non-profit research/education organization. The Cape Cod Eco-Toilet Center is a public education project of the Green Center.

For more information on the systems described in this report, go to:

www.capecodecotoiletcenter.com, www.thegreencenter.net, www.fullcirclecompost.org, www.richearthinstitute.org, www.separett.usa.com, www.ecodrumcomposter.com

or contact: Earle Barnhart, Hilde Maingay at capecodalchemists@gmail.com



2. Description and Operation of Hybrid Eco-Toilet System

Separette Villa 9220

This Urine-Diverting (UD) toilet has 2 compartments. The front for urine and the back for feces, toilet paper, pine wood shavings and if desired, paper towels and facial tissue. The toilet has a cover ('guard') over the chute when not in use, that opens when someone sits on the seat or puts pressure on the toilet seat. The guard screens the chute from view and prevents objects from falling in.

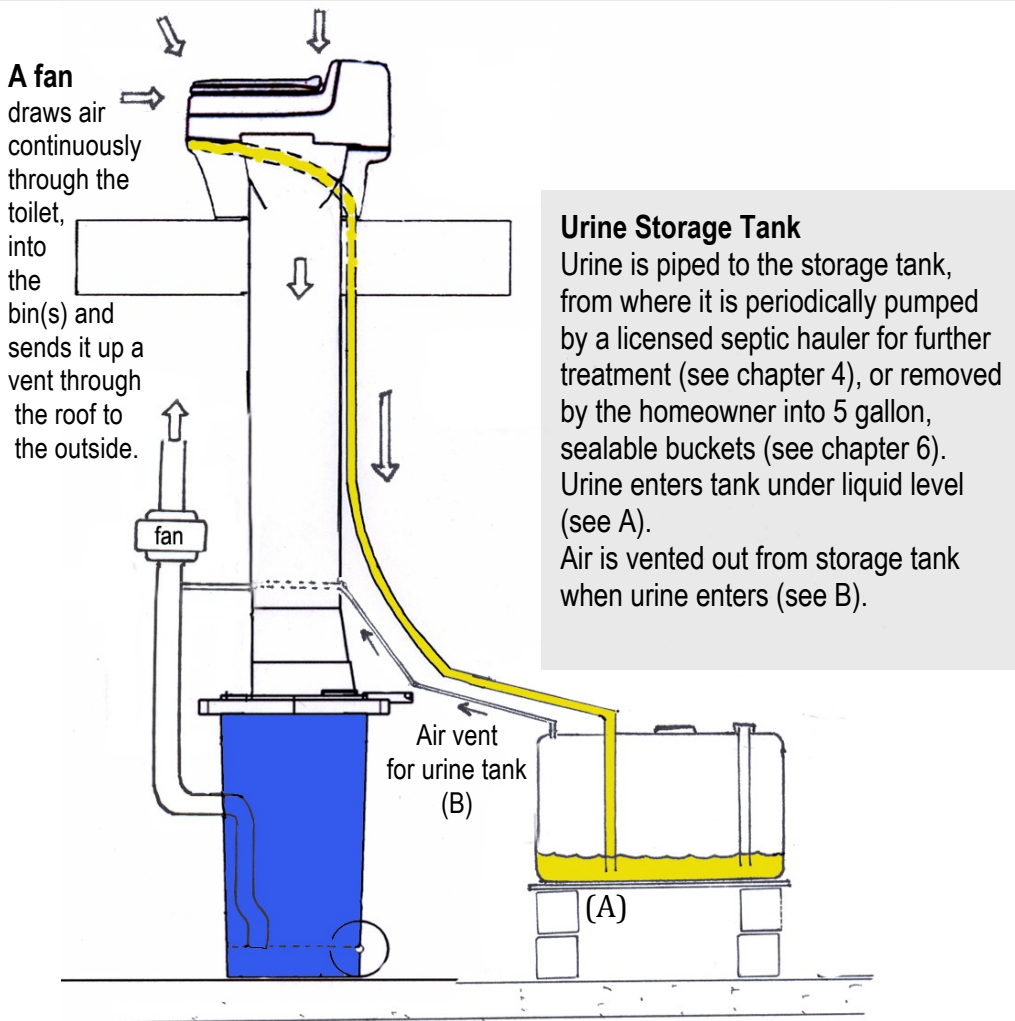
After each deposit of feces, one half cup of pine wood shavings is put into the chute. This improves the composting process.



Guard (blue) half open.



Separett 9220 Villa in authors' bathroom



Full Circle Composting System

This system is a series of interchangeable wheeled composting containers located on the floor below the bathroom, typically in the basement.

When the active container fills, it is disconnected from chute, capped, set aside nearby, connected to aeration, and allowed to compost for further retention time.



Full Circle Composting Systems in authors' basement

3. User Experience: Better Than a Flush Toilet

Features

The Separett Villa 9220 toilet contains a visual guard to screen the view of the compost chute and prevent objects from falling in.

Usage

Both men and women sit to use the toilet; the urine-diverter works best in the sitting position. Toilet paper is used as customary, and half a cup of wood shavings is put into the compost chute after each 'contribution' of feces.

Odorless

Bathroom air and odors are constantly drawn down into the toilet and down into the chute, eliminating all odors in the bathroom.

There is never any odor in the bathroom.

Quiet

The toilet is waterless. There is no sound of flushing or refilling. The fan is far away in the vent pipe in the basement not behind the toilet or in the ceiling.

Easy to Clean

The toilet surfaces can be cleaned with a damp cloth or with a paper towel, which can be thrown down the chute. Unlike flush toilets, there are no cleaning brushes, no cleaning chemicals, no splashing of toilet water and no exposure to pathogens while scrubbing a toilet bowl.

High Sanitation Level – No Exposure to Pathogens

Continuous movement of air down into the toilet reduces pathogens in bathroom air, compared with splashes from flush toilet bowls while peeing, flushing and cleaning. The compost is made in sealed, aerated modular bins that are not opened for any maintenance until the bin is full.

The Full Circle system *never* needs mixing or stirring of compost. While replacing the compost bins, the user never has contact with the waste materials. A full bin is aerated for further composting for an additional twelve months.

No Plumbing Failures or Toilet Disasters

Because it uses no water, there are never toilet overflows or leaks of contaminated water. The low-watt fan can run on batteries during power outages, or be powered by PV.



4. Recovery of Nutrients From Urine

Why Recovering Nutrients from Urine

Almost all of the nitrogen, phosphorus and potassium in our food are excreted in our urine and feces.

These are valuable nutrients that can replace chemical fertilizers and are needed to grow our food sustainably for all generations to come. Flushing these nutrients wastes drinking water and pollutes groundwater, rivers, ponds, lakes, estuaries and the ocean. Recovering the nutrients avoids pollution, reduces carbon emissions from the manufacturing and use of chemical fertilizers, and supports reliable food production.

90% of the nitrogen and about 50% of the phosphorus we excrete is in our urine. 80% of all the nitrogen in our household wastewater comes from urine alone. Excess nitrogen in saltwater ponds and excess phosphorus in fresh water ponds cause severe eutrophication and decline of aquatic ecosystems.

Location of the Urine Storage Tank

The tank can be either in the basement or outside in the ground near the house.

Sizing the Urine Storage Tank

The Separett is a waterless toilet. Urine goes into the tank undiluted.

The average person excretes about 120 gallons per year. The storage tank should be large enough to hold at least 6 months of urine, so a two-person household should have a tank that is at least 150 gallons in size. The capacity actually needed is affected by the number of people in the household and the lifestyle of the household (ranging from rarely home to entertaining lots of guests). The total capacity can include more than one tank. We recommend an on-site capacity to hold a year's volume, to reduce the number of pump-outs required.

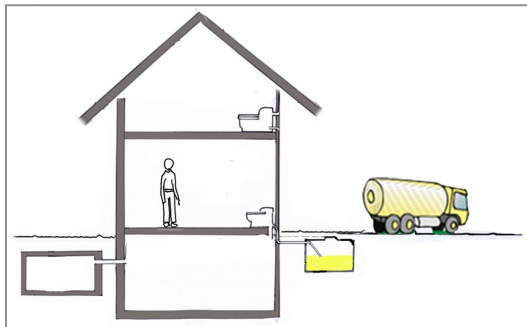
Emptying the Urine Storage Tank

The urine can be removed from the tank by:

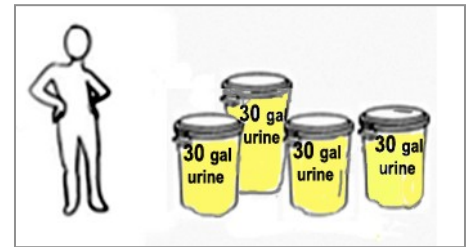
- filling five-gallon sealable buckets or jugs with tight lids via a spigot located near the bottom of the storage tank. This can be done by the homeowner.
- using a commercial, licensed pumping service.

Warning signal

An electronic system can be installed that warns the homeowner and/or the service company that the tank is nearly full and service is needed in a few weeks.



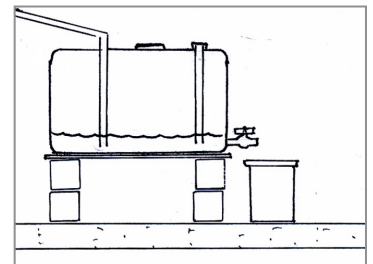
Periodic removal by pumping service.



120 gallons of urine/person/year



Urine tank



Filling 5-gallon buckets



**The Green Center, Inc.
Earle Barnhart
Hilde Maingay**

5. Recovery of Nutrients From Solid Toilet Wastes

The compost in a bin starts as a layered mixture of feces, toilet paper, wood shavings and optionally facial tissues and paper towels.

Projected time to fill a bin when used by two people is 6-12 months.

Exchanging bins when full

To see if bin is full, open lid and look, or install an optional electronic warning sensor.

When a bin becomes full it is disconnected from the chute, (Fig.1) and a new empty bin is put in its place, (Fig. 2).



Fig. 1. Removal of full bin from chute

Preparing bin for longer secondary composting

The full bin is topped off with some garden soil, a layer of wood shavings and some water, and a new lid put on. It is then connected to continuous aeration, (Fig. 3) using the same fan system that provides ventilation for the active bin, allowing it to compost more completely for a longer retention time. During that time pathogens are gradually eliminated in the process.



Fig. 2. Installation of new empty bin to chute

Finished Compost

The volume and weight of the finished compost will be much less than the starting material, due to more complete decomposition and evaporation of moisture. The volume of compost in the bin, after a one-year retention time, is reduced by 50-80%. The volume of finished compost produced by one person in one year is about 18 gallons. Further retention time will reduce the volume more.

The finished compost material removed from the bin is slightly moist and looks like rich garden compost, (Fig. 4). The bin can be wheeled outdoors to be emptied. The empty bin is stored for later use.

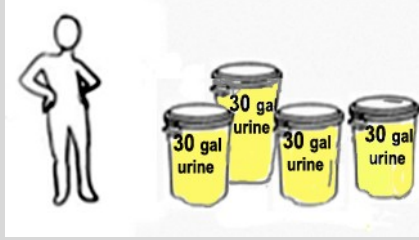


Fig. 4. finished compost material



Fig. 3. Full bins connected to aeration

6. Home-Scale Recycling of Nutrients from Urine



One American adult produces about 120 gallons of urine per year. Depending on what a person eats, the NPK (nitrogen, phosphorus, potassium) ratio varies, but is approximately 10:1:4. Urine contains many other minerals needed by plants as well.

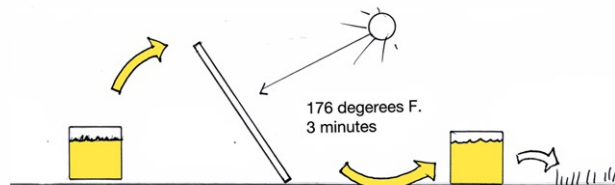
Sanitizing Urine.

Urine should be sanitized before use.

This can be achieved by storing the urine for six months or by heating it to 176 degrees F for three minutes.



6-month storage
in 5-gallon buckets



Solar sanitizing, as developed by the Rich Earth Institute in Vermont (photo on right)



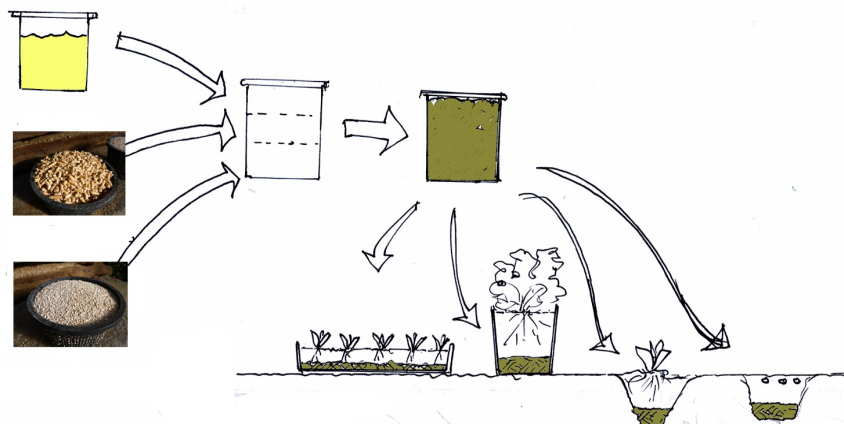
Recycling Urine

Urine is an excellent fertilizer, replacing commercial chemical fertilizers. It can be used as:

- 1) **A liquid**, often diluted with water to optimize uptake by plants. Gardeners typically dilute urine and water in a 1:5 ratio and apply it directly to the soil under plants (not on the plants). It can also be applied 1:1 to hay fields. The levels of N, P and K are well matched to the needs of grain crops as well.



- 2) **A moist mix**, when urine is mixed with dry absorbent sawdust pellets and diatomaceous earth to produce a moist, odorless mixture that can be easily handled, stored and applied as a soil amendment. This moist mix can be used in seedling trays, in pots with seedlings, and when transplanting or seeding in the ground.



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7. Home-Scale Recycling of Nutrients from Compost

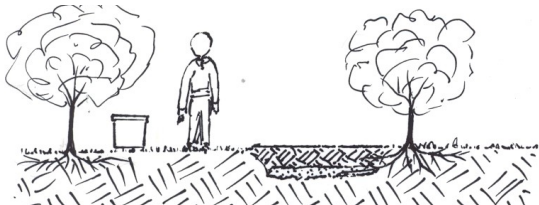


The volume of compost produced by a person in one year from a Full Circle composting system is about 18 gallons of earth-like material. The amount may vary depending on the proportions of original material (feces, toilet paper, wood shavings, facial tissue, paper towels).

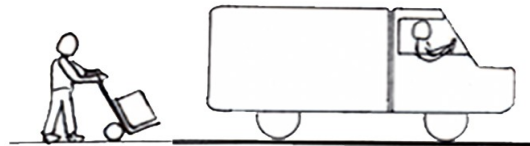
Recycling the Nutrients from Compost

The use of compost from composting toilets is regulated in some states because it might contain pathogens. In order to use or dispose the compost, the following regulations are in place in Massachusetts:

"Humus/Composting Toilets are subject to the following (310 CMR 15.289) [part 6]: Residuals from the system must be buried on-site and covered with a minimum of six inches of clean compacted soil, **or** collected by a licensed septage hauler, **or** disposed of in another manner and location approved by the local Board of Health."



Buried on-site under 6" compacted soil



Collected by licensed hauler

Alternatively, compost can be legally applied to the surface of the soil after being re-composted at high temperature--a method originally developed for turning sewage sludge into Class A biosolids, which contain no detectable levels of pathogens and "...used in small quantities by general public have no buffer requirements, crop type, crop harvesting or site access restrictions." (EPA).

However, high-temperature composting is impractical for most homeowners and is likely unnecessary. Room-temperature composting is known to eliminate pathogens over time, but regulations have yet to be established to specify how long compost should be stored before being used in agriculture.

Regulations Needed to Facilitate Safe Compost Use on a Home-Scale

Many states apply rules to composting toilets that were originally designed to regulate large-scale, centralized sewage sludge processing. Because humus from composting toilets is very different from sewage sludge, and because the scale of operation is so much smaller, these current legal requirements discourage beneficial use of the compost. This situation would be greatly improved by new rules tailored to composting toilets, specifying minimum composting times that were scientifically shown to eliminate pathogens, allowing safe reuse as fertilizer at the home-scale.



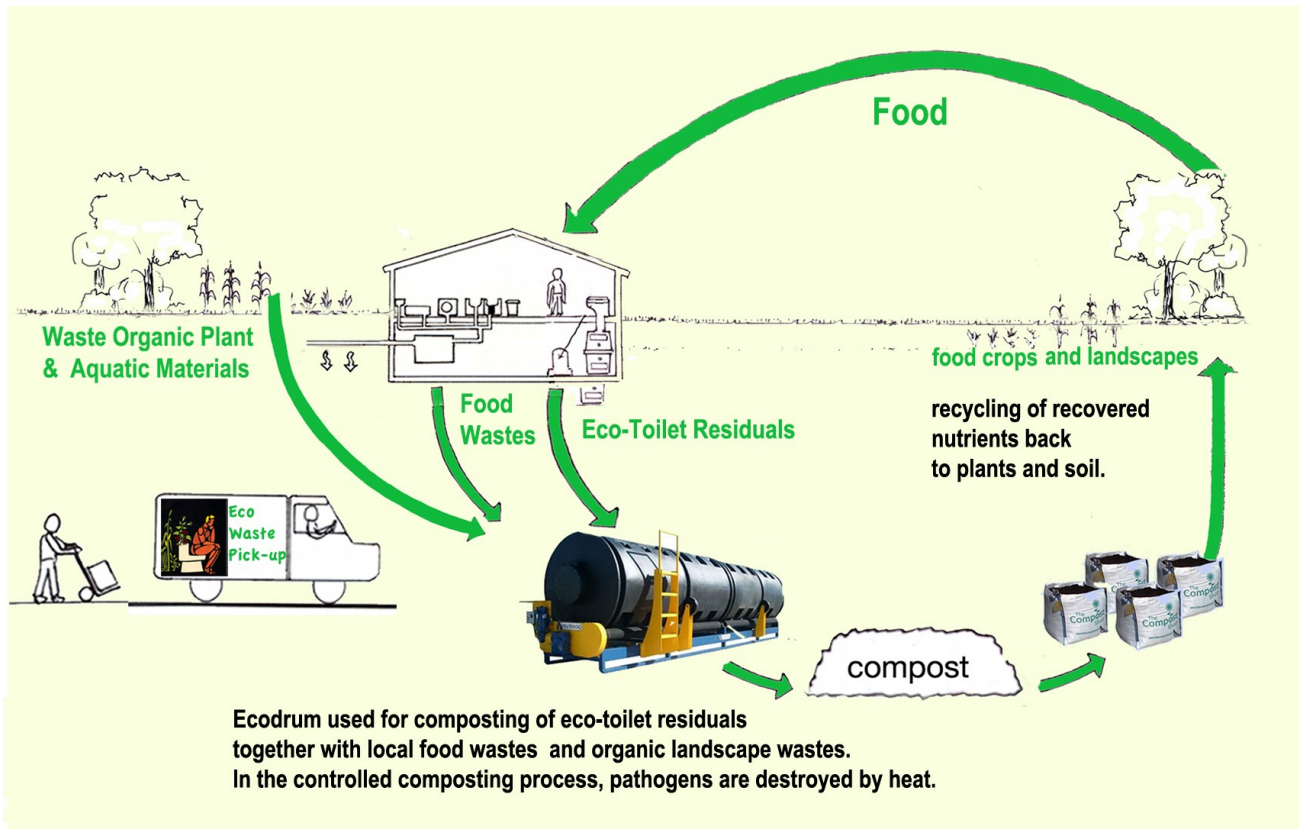
**Full Circle
Secondary Composting**



**Separett
Outdoor Composter**

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8. Local and Regional Recycling of Eco-Toilet Nutrients



Ecodrum Composter

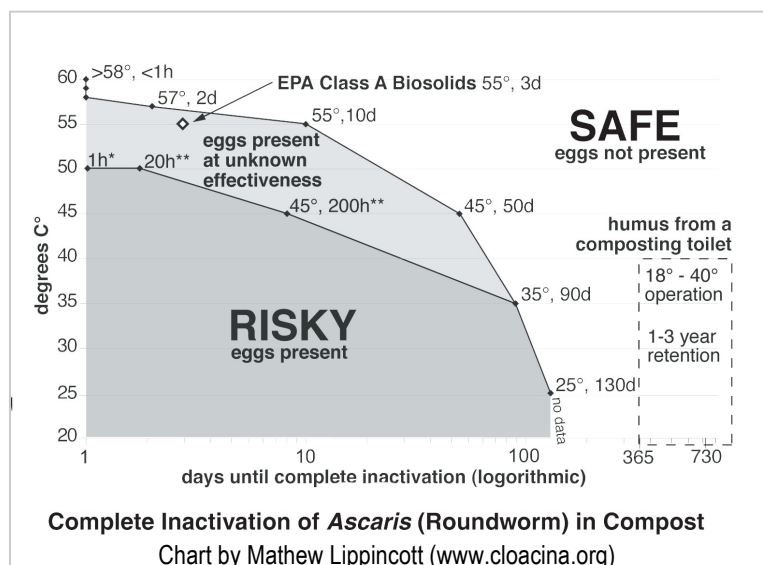
An Ecodrum is a contained, insulated, rotating drum composter. With the proper mixture of compost from eco-toilets and other organic materials, the compost passing slowly through the rotating drum becomes hot enough to kill all pathogens, hot enough for a period long enough to produce a Class A Biosolid. Thermometers in ports in the drum monitor the temperature to ensure proper treatment.

Elimination of Pathogens by Time and Temperature

Tests have shown that there are a range of combinations of temperature and time that will eliminate pathogens. This chart shows the conditions that will inactivate one of the most persistent pathogens, *Ascaris* (Roundworm).

Effective conditions include 55 degrees C (131 F) for 3 days, or a lower temperature for a longer time, such as 25 C (72 F) for 130 days.

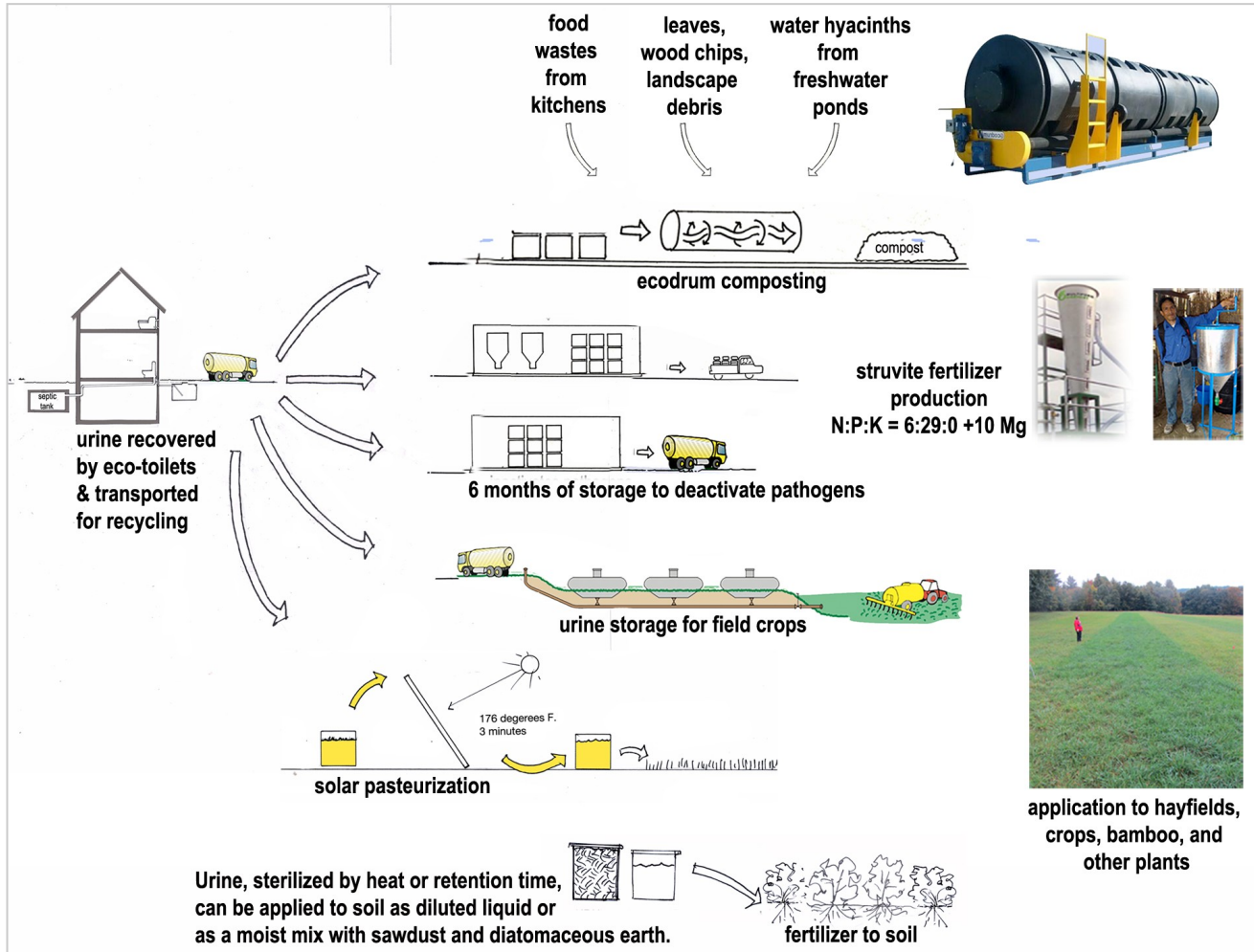
Additional studies are needed to determine the length of time at ambient temperatures required to reach Class A classification.



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9. Local and Regional Recycling of Nutrients from Urine

Urine contains many valuable nutrients, which come from the food we eat, such as nitrogen, phosphorus, potassium, calcium, magnesium and many others. Urine can be applied as a liquid fertilizer, or can be composted with other organic materials and made into a nutrient rich soil amendment. Urine can also be processed into a dry, granular slow-release fertilizer called struvite.



80% of all the nitrogen in household wastewater comes from urine alone. When urine is diverted, it no longer pollutes groundwater and other water bodies with excess nitrogen. When urine is recycled, it becomes a valuable resource to agriculture and ensures sustainability.

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