out think the box

OPERATION & MAINTENANCE MANUAL

Single User Dry Toilet System Using IAPMO WE•Stand

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PREPARE. RESPOND. ADAPT.

out think the box

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PREPARE. RESPOND. ADAPT.

introduction

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Building and operating an ecological sanitary (eco-san), dry toilet compost system that treats human excreta makes day-to-day sense, as well as during disaster events when a functional sewage system is compromised. This type of a system can protect public health by eliminating pathogens from the immediate environment, which a conventional flush toilet system cannot.

Eco-san dry toilet compost systems are a form of ecological sanitation addressing many of the shortcomings of conventional water-based methods of processing humanure/ human excreta. These conventional methods (centralized sewer systems and septic tanks with drain fields) are:

- Energy and potable water intensive.
- Huge consumers and contaminators of potable water.
- Not able to exploit the valuable nutrient flow.
- Imperfect in their treatment of their waste water, and
- Dependent on a functional power grid or sewage system.

Unfortunately, septic tanks often do not even adequately eliminate the nutrients in their wastewater, and the discharge from the process ends up contaminating the ground water under the drain field with nitrates and other nutrients. Centralized sewer systems are professionally monitored to do a better job at nutrient elimination, but pathogens remain at the end of the rapid sewage treatment process, and must be destroyed by chlorination, ozonation, or other treatment.

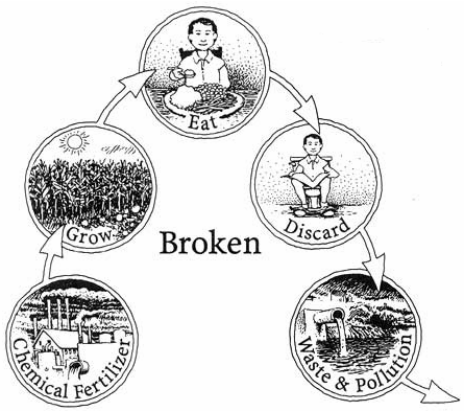


Figure 1. The Broken Sewer System Process

Some such systems were designed to accommodate storm water, and during high volume rain events raw sewage is discharged directly into the environment. Another important consideration is that sewage systems are burdened with contaminants e.g. heavy metals, that cannot be removed with the current process. Hence, the discharge from these systems, which often ends up in our rivers, loads the ecosystem with many undesirable contaminants. Because nutrients are lost in both these systems, our agricultural systems have become dependent on fossil fuels to grow our crops. Furthermore, if the power, water, or sewage grid fails, such as after an earthquake

or other natural disaster, these systems will become non-functional, creating a potential, great public health hazard.

Eco-sanitary, dry toilet compost systems are designed to exploit the nutrient flow in human excreta/humanure (feces/faeces and urine) with minimal energy inputs. When properly designed, they allow full utilization of the nutrient flow while destroying any potential pathogens. They work by turning humanure, combined with carbon bulking materials, and, with or without normal household and garden compostables, into humus, the biologically decomposed, soil-like, output of the compost processor.

Urine, which is generally odorless and pathogen free, can also be processed separately in a comprehensive humanure recycling system to recover its valuable nutrients—it is an ideal compliment to organic gardening and an integral part of sustainable agricultural systems.

Developing a supplemental humanure treatment is a good idea for:

- Exploiting on site the otherwise wasted nutrient flow,
- Reducing the potable water and energy consumed in the process, all while,
- Creating a more robust system that will remain functional when either the electric or sewer grid fails during an environmental disaster e.g. earthquake, wild fires, and
- Reducing fossil fuel consumption and the carbon footprint.

Transfer (also called batch) composting toilet systems are the simplest, most effective, and most economical way to turn urine and humanure into a safe, valuable fertilizer, and compost resource. It is a hands-on technique relying on users taking an active and informed role in the process.

This Operation and Maintenance Manual will aid the user in becoming familiar with the process, and about best practices, enabling the production of top quality compost. The system covered in this manual has been designed according to the International Association of Plumbing and Mechanical Officials (IAPMO) Water Efficiency and Sanitation Standard (WE-Stand).

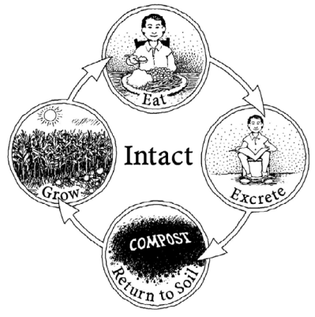


Figure 2. The Eco-friendly Intact Process

IMPORTANT ASIDE RE: the following info-graphic, which summarizes the overall process. However, secondary treatment/processing is needed. Just collecting materials beneath a toilet, with random additions of carbon (humanure), evidence has shown that pathogens are not reliably destroyed even with long storage times. And, humanure is only a waste if it's not used.

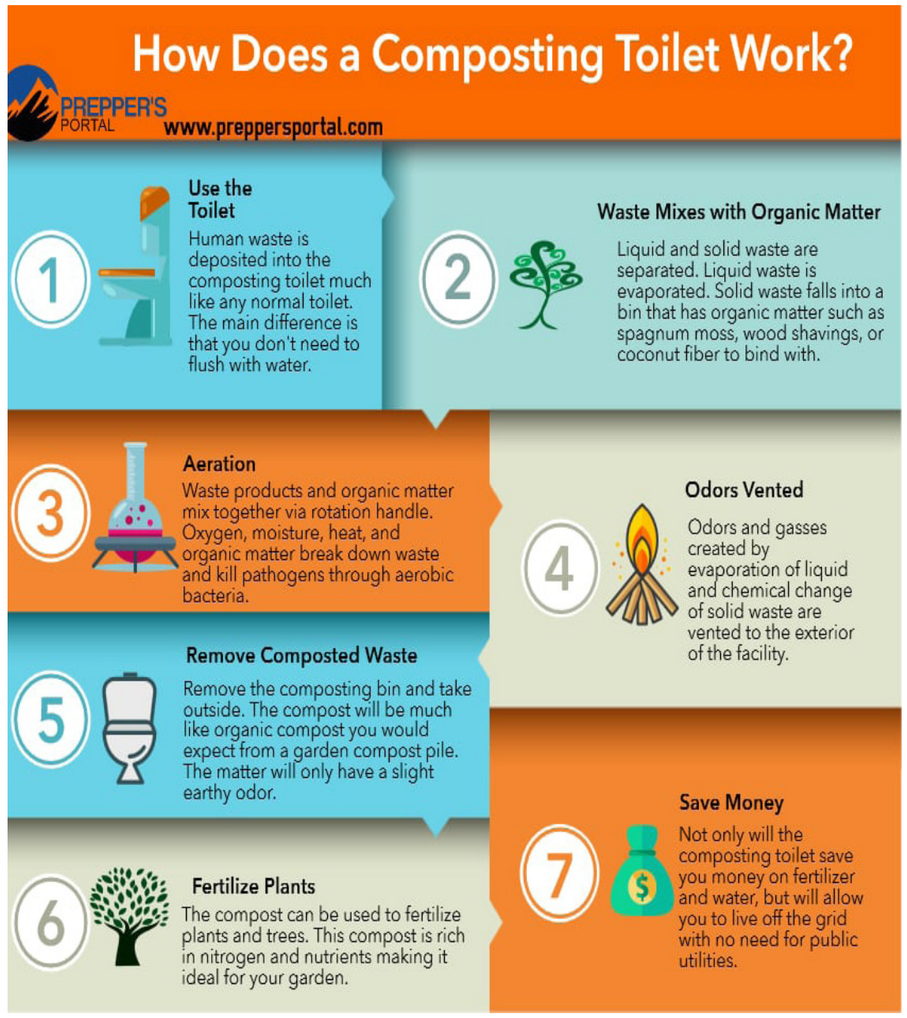


Figure 3. Basics on how a Dry (Composting) Toilet Works

commode

Eco-sanitary (Ecosan) dry toilet systems collect humanure in commodes/toilets that contain a receptacle, such as a container. Carbon cover bulking material is added to seal the humanure from the air, preventing odors, and balancing the nutrients—this way, the contents can later be properly composted in a dedicated composting processing area.

The Nature's Head Toilet

The Nature's Head Toilet is a waterless, urine separating/diverting design. The main collection section holds approximately 60 to 80 uses for a single user. Generally, a single user, full time usage will require emptying approximately ever 4-5 weeks. The urine bottle holds 2.2 gallons and will require more frequent emptying; about once per week for a single user.

Figure 4. Nature's Head Toilet

Other off the shelf offerings include Sun-Mar, Envirolet, and Biolet.

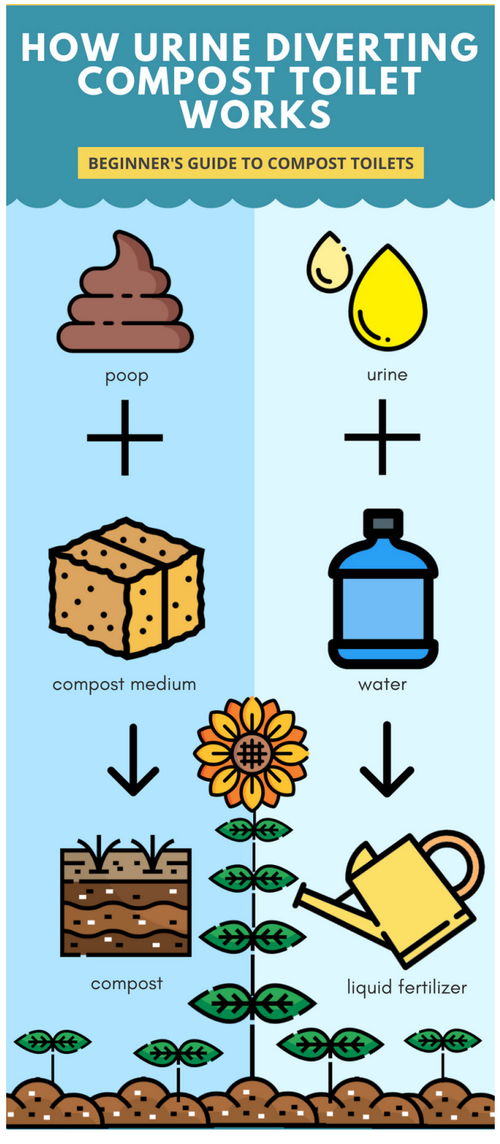


Figure 5. INFOGRAPHIC - How a Urine Diverting Compost Toilet Works (Simplified)

Another, simplified design is inspired by the Loveable Loo™ by Joe Jenkins; see http://humanurehandbook.com/. Commodes/Toilets are constructed using fir, pine, and other untreated woods for the cabinet, as well as plywood for the lid. A standard toilet seat is used. All wood is sealed with a waterproof finish to protect the wood, creating a smooth, non-absorbent, and easily cleaned surface.

Loveable Loo | The Cabinet

The cabinet is designed to hold a 5-gallon container, the collection device. This system uses several 5-gallon containers, so several containers of humanure can be collected at one time, and added to the compost processor in one batch—giving the compost sufficient mass to reach hot, pathogen-killing, temperatures. The commode cabinet and adjacent container require only a very small footprint on a floor and can be installed without electricity, water, or a plumbing connection. They can be installed in almost any location. Several commodes can be accommodated by a single compost processor.

Keeping the commode out of direct sunlight, dry, and clean will prevent warming the toilet and avert possible condensation.

The cost to build this toilet is substantially lower (<$50) than the Nature's Head Toilet.

Figure 6. Loveable Loo™

Figure 7. A Loveable Loo™ derived container commode with an adjacent container of cover material.

Figure 8. A Loveable Loo™ derived container commode top opened to show collection container inside with wood chips.

commode materials list

Commode	Nature's Head
cabinet	Polyethylene plastic
lid	Polyethylene plastic
toilet seat	Polyethylene plastic
containers	1.16 ft³ (~7.5 gallons) with sliding trap door (human excreta collection device) ~2.2 gallons (urine collection device)

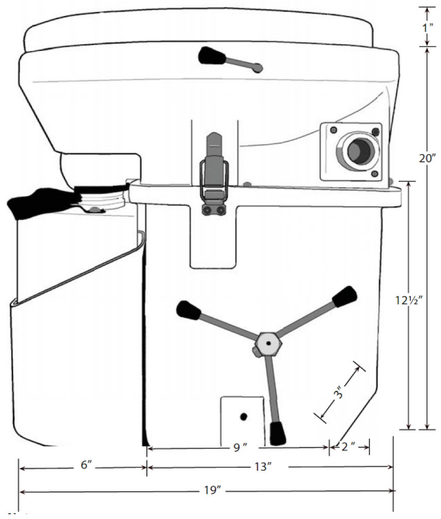


Figure 9. Nature's Head Toilet (Side View)

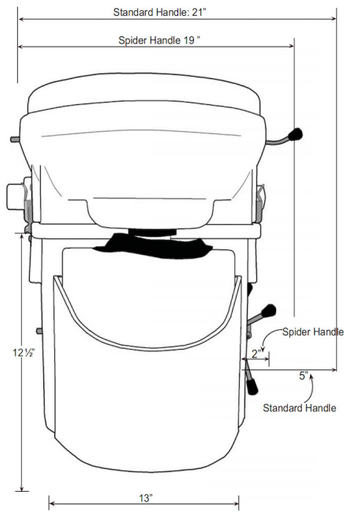


Figure 10. Nature's Head Toilet (Front View)

Commode	Design inspired by Joseph Jenkins' Loveable Loo™
cabinet	Sealed fir, pine, or other untreated wood capable of holding a 5-gallon container
lid	Plywood
toilet seat	Standard, compression molded plastic
container	5-gallon with lid (human excreta collection device)

cover material

The cover material, also known as carbon bulking material, is used to cover humanure deposits within the container. This material should be carbon rich, absorbent, and chemical free; some examples follow:

- Finely chipped wood and leaves
- Untreated sawdust (semi-broken down is best)
- Dry leaves, ideally shredded
- Shredded paper
- Coffee bean or cereal hulls
- Untreated wood shavings

A mixture of fine and coarse materials, ideally with three-dimensional structure is best. Fine materials will break down more easily. Coarse materials allow oxygen to penetrate into the compost bin, but at the same time prevent the movement of odors, as well as potential invaders like flies. That said, flat materials alone like shredded paper and leaves can form mats, which retard oxygen flow. Hence, it is best to mix flat materials with other more coarse materials.

Figure 11. Cover material (wood chips)

using the commode

Best Practices

Steps for using the Nature's Head Toilet

ONE. Open the lid.

TWO. Add about two gallons of pre-moistened carbon bulking material to the base of the unit to the level of, or cover the agitator bar when in a horizontal position.

THREE. Sit down for both bowel movements (feces/faeces) and urination. During bowel movements, the main compartment trap door must be open. Toilet paper is typically placed in the toilet after making a deposit. Do not add additional carbon bulking material after solids usage. Place toilet paper inside.

FOUR. Using hand crank, make 3-4 slow revolutions to mix the human excreta to promote the decomposition process.

FIVE. Spray the bowl with water or a dilute vinegar solution to keep the toilet tidy, and cleanse the urine passages.

SIX. Close the lid to keep out unwanted pests.

See Appendix - Using the Nature's Head Toilet

Steps for using the Loveable Loo™

ONE. Open the lid.

TWO. Add about four cups of carbon cover material in an empty 5 gallon container bottom.

THREE. Sit down for both bowel movements (feces/faeces) and urination.

FOUR. Make bowel movement with or without urine and toilet paper. Place cup or two of cover material in the commode to completely cover deposits.

FIVE. Level the cover material surface after each use by pressing down after covering, to adequately cover deposits, and to effectively prevent odors and pests attraction. If liquids are added, ensure no surface liquid is visible.

SIX. Close the commode lid to keep out pests.

NOTE: NEVER put any chemicals, anti-bacterial products, bleach, deodorizers, or inorganics into the toilet; these may disrupt the composting process harming the beneficial microbes.

compost

More about Compost AKA Top Soil

Just like regular compost, humanure compost needs oxygen, moisture, and a balance of carbon and nitrogen to work optimally.

Humanure, as well as most other household compostables, is relatively high in nitrogen, so the cover material added should be rich in carbon, to create a balance.

It is fine to use a humanure composting system to compost small quantities of other materials such as chopped garden weeds, and all of the usual things that go into a healthy compost bin. Because of the high degree of sanitary hygiene insured by the compost system design, pet waste can also be safely composted.

RECOMMENDATION: Do not add lime or ash, as these may inhibit microbial activity.

Figure 12. Finished compost applied to an orchard tree

compost processor

Not your everyday humanure treatment facility

Bins (Cairns)

The compost processor for this system consists of three cylindrical bins (cairns). The walls are constructed of 14 gauge galvanized, open mesh welded wire and thick tree bark, providing vermin proof construction, and ventilation. The tree bark provides insulation for the compost inside from cooler outside temperatures.

The bottom is constructed of a 12" deep tree bark layer soak pit to collect any liquid, called leachate, that may result from composting. The wire mesh duly acts to prevent insects, birds, and rodents from entering the compost processor. The bins are arranged in a location away from foot traffic and to keep uninvited visitors out. All the bins have a waterproof roof that prevents rain from entering the composting area, and also keeps vermin out. The roofs can be easily open during the adding or removing of compost.

Leachate

There is no leachate generated for this single user system. Even when adding fresh compostables, there is not enough accumulated moisture to warrant creation of any leachate. This system prevents potential pathogens from entering local soil and ground water, and is a non-issue where protection of the environment is concerned.

processor materials list

Compost Processor	Features
Bin/ Cairn System (3 count)	**DIMENSIONS** • Exterior volume (36" height x 28" diameter = 12.8 ft^3) • Interior volume (36" height x 27" diameter~=11.9 ft^3) **WALLS** • (External) 14 gauge, galvanized, welded wire 1" x 2" mesh opening • (Internal) 0.5"+ tree bark slabs • Vermin proof **BOTTOM (SOAK PIT)** • 12" (depth) wetted wood chips, saw dust, and dry oak leaves • Waterproof **ROOF ASSEMBLY** • 1" (total) pressed waterproof plywood • Rain accumulation prevention • Vermin mitigation
Ventilation	Welded wire mesh
Security	The installation is in a secure location well away from main foot traffic.

adding/processing

Here's where all the 'magic' happens...

Physical Construction

Starting a new compost bin (cairn) processor requires laying a 12" thick layer of coarse, dry absorbent organic material (tree bark) inside a 12" (1') deep by 102" (9') long by 36" (3') wide trench (soak pit barrier). This barrier soaks up any liquids that may seep down through the 36" high bin, and insulates the center of the bin to keep it warmer.

Adding/Processing

RECOMMENDATION: Wear gloves during this operation.

ONE: Before emptying the commode containers into the processor, make a small depression in the center of a bin using a dedicated shovel.

RULE OF THUMB: When emptying containers into the processor, choose a time early or late in the day when it is cool to minimize exposure to flying insects during the emptying process.

TWO. Empty the container of human excreta/humanure into the middle of the processor bin to create a protected 'nest' of humanure

Figure 13. Full, 5 gallon containers staged and ready for batching

in the center of bin.

THREE. Using the same carbon cover material used in the commode/toilet, and cover the added material completely with a 3"-6" inch thick layer. Also place a 3"-6" layer of carbon bulking cover material around the edges to insulate the bin center. Alternately, use some of completed compost from prior batches.

FOUR. Place the lid/cover on top to seal the bin.

NB: Collecting and adding several containers of humanure all at one time is recommended; this is called 'batching'.

adding/processing

(MORE) Here's where all the 'magic' happens...

More About Batching in General

Batching insures the compost will reach high temperatures adequate to kill pathogens quickly in systems at least 1 m x 1 m x 1 m in dimension. Batches may be added as frequently as desired, but one batch every one to two weeks is recommended. This technique reliably develops temperatures as high at 165 °F (74 °C) within several days of adding a new batch. These initial high temperatures literally cook the compost, continuing for weeks due to the insulating properties of the perimeter cover and base material, as well as from the air spaces in the center of the processor bin. Gradually, over several months, the temperature returns to ambient temperature.

FIVE (Nature's Head Toilet): Add carbon bulking material, and re-assemble the toilet. Once the contents from the Nature Commode containers has been emptied into the center of a processor bin, reassemble the Nature Commode. It is unnecessary to clean the interior of the solid waste container, since decomposition will continue from the residual matter clinging to the wall sides. Cleaning the base unit with any chemicals, may inhibit the toilet's ability to generate the good bacteria that breaks down the humanure.

FIVE (Loveable Loo™): Rinse the commode containers clean in the cleaning area. Gently scrub the sides of the container with a soft brush (if necessary), and pour the rinse water into the center of the processor bin. Soap may be used, or a light spray of 10% bleach/water solution to sanitize the containers. If it is a sunny day, the containers can be left out in the sun to dry and sanitize by the ultraviolet radiation in sunlight, and deodorize.

SIX: Rinse any tools used.

Subsequent containers are added to the active composting bin in a similar fashion.

ONE: Draw back the cover material to the perimeter of the bin.

TWO: Empty the contents of the new containers into the bin center. At this time, also add any rinse water (rinsate).

THREE: Add another 3"-6" fresh layer of carbon cover material on the top.

FOUR: Remove and dispose gloves in trash, and thoroughly wash hands.

using the compost

How to use Top Soil from the Top Soil 'Factory'

When the compost processor bin is full, ensure it is well covered, and leave it alone without adding anymore human excreta/humanure (feces/faeces and urine) for at least four months. This is a recommended minimum time testing has shown to insure elimination of all pathogens in several types of hot composting toilet systems. As the compost ages, it will shrink significantly as the material inside breaks down and finally cools to ambient temperature.

Usage

After at least four months have passed, test the compost to determine if it can be used in the garden. The Micrology Labs Coliscan Test Kit can be used to measure reduction in coliform forming bacterial growth at four months. [See appendix for How to perform a soil test for fecal coliforms]

Remove the wire mesh outer wall of the cairn, so the tower of finished compost will fall down. Transfer all the compost from a bin at one time, so it can be completely emptied and prepared for re-use, is recommended.

The compost will have settled about one third from the original height. The top layer tends to be fluffier and drier, while the bottom layer is denser and moist, just like forest duff, sweet smelling compost from a finished bin.

A fine-toothed pitchfork, also called a silage fork, is helpful to transfer most of the compost into a wheelbarrow.

After emptying the bin, replace the top, and the system will be back to normal configuration ready for use.

Figure 14. Tools used for maintaining and harvesting compost (silage fork, cleaning scrub brush, shovel)

system design

Design and Construction Details

Design, Construction and Performance Characteristics

The design, some construction and performance details of the compost processor are covered in this section.

The system has been designed according to the International Association of Plumbing and Mechanical Officials (IAPMO) Water Efficiency and Sanitation Standard (WE•Stand). The most important performance characteristics of the system specified by this code requires:

- The system is comprised of separate collecting devices and a compost processor.
- The system is constructed of durable, non-corrosive, materials.
- The compost processor must be covered to prevent any rain from entering.
- There will be no discharge of composting leachate into the environment.
- The compost processor will be enclosed and adequately ventilated in a fashion that does not attract or allow vermin to enter e.g. insects, rats.

About 13.5 months of material can be held in this 3-bin (cairn) configuration. (A one year minimum is typically required before use.)

The volume of a single bin (cairn) compost processor is approximately 12.8 ft^3 (cubic feet). Galvanized 4 Gauge Welded Wire was used for its low cost, durability, ease of construction, and ability to allow ventilation, as well as for partial pest and vermin mitigation. The interior dimension of each bin is 11.9 ft^3 (cubic feet).

The bottom of each bin is constructed of a waterproof 12" (1') deep by 102" (9') long by 36" (3') wide trench (soak pit barrier) to avert transport of any compost liquid (leachate) into the environment. This soak pit is common to all three bins (cairns).

At the top of the cairns, a wooden, plywood roof structure is placed. The roof area can be easily removed during use, and has a slight slope to shed rainwater to the outside of the bin/cairn, which can be absorbed by the soak pit.

system design

(MORE) Design and Construction Details

The Role of Urine

Urine can be added without problem to commodes and to the compost processor. In fact, the high nitrogen content of urine can result in faster break down of carbon-based bulking material (composting). Approximately 75% of one's excreted nitrogen is found in urine. In addition, valuable potassium, phosphorus, and other minerals are excreted in urine in a form immediately usable by plants.

However, urine is generally pathogen free, odorless, and needs little further processing to enable the nutrients to be delivered to growing plants.

appendix

Find out more here...

Materials Cost

A breakdown of the approximate costs of materials for this eco-san compost processor system at the time of installation follows:

Nature's Head Toilet System

Nature's Head Toilet ~= $1,000
Peat moss = $45
Wood Shavings = $0

SUBTOTAL: $1,045

3 Bin Cairn Processor

Per 3 bin cairn, includes:

Exterior Walls: One roll, 14 Gauge Welded Wire 1" x 2" (galvanized) = $30
Interior Walls: Tree bark = $0
Roofing sheets: Two 3/4" plywood sheets @ $25/sheet = $50
Roof screws: 1 pack @ $7.5 = $7.5

SUBTOTAL = $87.50

Using the Nature's Head Toilet

See the next page.

References:

Humanure Handbook by Joe Jenkins
http://www.josephjenkins.com/

Glossary

Batching - Collecting and adding several containers of human excreta (humanure) all at one time.
Ecosanitary (Ecosan) - A sanitation toilet system designed to store and prepare human excreta (humanure) resource for use in agriculture by formation of humus.
Human excreta/Humanure (Human manure) - Feces/Faeces/Poop and urine
Humus - Biologically decomposed, soil-like, output of the compost processor
IAPMO - International Association of Plumbing and Mechanical Professionals
Thermophilic/Thermophile - An organism that can thrive at a high temperature between 106-252 °F (41-122 °C).
WE•Stand - Water Efficiency Sanitation Standard

Using the NATURE'S HEAD®

Self-Contained Composting Toilet

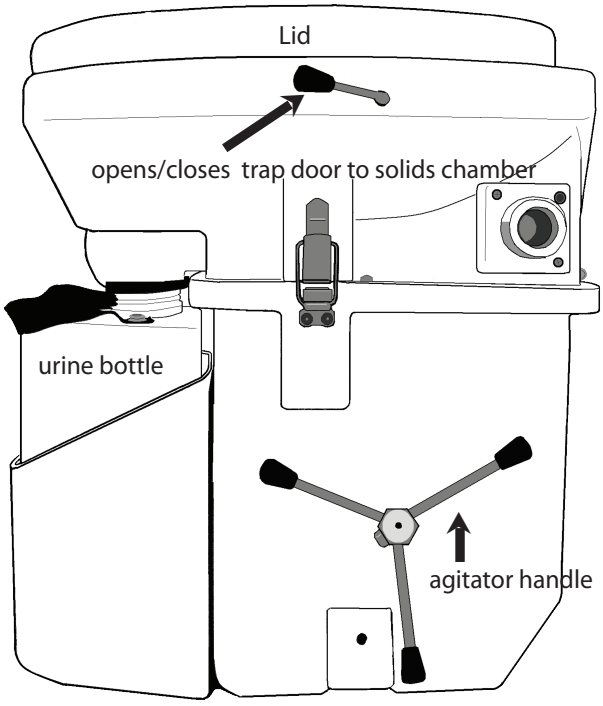
Open the lid.
Please be seated for all usage.

URINATION

Make sure trap door is CLOSED
(lever on the left side)
Go
Spritz the bowl with water
Close the lid

DEFECATION

Make sure trap door is OPEN
(lever on left side)
Go
Spritz any residue with water
Close the lid
Turn the agitator handle SLOWLY
for 3 or 4 revolutions



Check with hosts to get instructions on toilet paper disposal.
Do not place sanitary items or wipes in the solids bin.

SAVING OUR WATER FOR TOMORROW®

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appendix

Find out more here...

How to perform a soil test for fecal coliforms

See Colisan Easygel Instructions for guidance.

ONE. Draw compost samples from three representative points, 4 inches from the bin perimeter, and from a bin that has cured for at least four months. Place samples in a sterile container.

TWO. Determine moisture by subtracting dried weight from fresh weight samples of approximately 250 g after drying in a 171 °F (77 °C) oven.

THREE. Test samples using Coliscan Easygel test kits at the manufacturer's recommended dilution of 100. Thoroughly mix samples together in distilled water.

FOUR. Place samples into the bottles of Coliscan Easygel. Swirl the bottles to distribute the inoculum.

FIVE. Pour the medium/inoculum mixtures into the correctly labeled petri dishes. Place the lids back on to the petri dishes. Gently swirl the poured dish until the entire dish is covered with liquid.

SIX. Place petri dishes right-side-up in a warm (80-95 °F) level spot in the room while still liquid.

SEVEN. Incubate at 95 °F (35 °C) for 24 hours, or at room temperature for 48 hours.

EIGHT. Inspect the petri dishes for coliform forming units. (Refer to the Coliscan Color Guide card)

Aside: To report in terms of E. coli Fecal Coliform per 100 mL of water:

1. Divide 100 by the number of mL that you used for your sample.
2. Multiply the count in your plate by the result obtained from #1.

NINE. Dispose petri dishes. See Coliscan Easy Gel Instructions for proper disposal protocol.