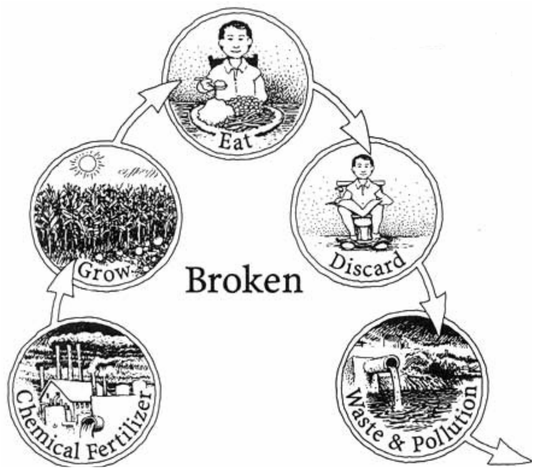
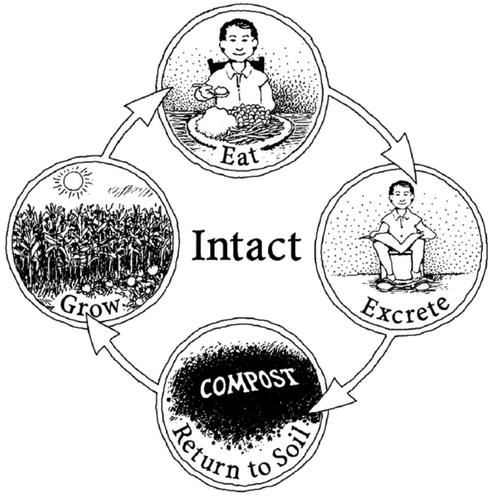
out think the box





CONTAINER-BASED ECOSANITARY (CBES) DRY TOILET COMPOST PROCESSOR SYSTEM TRAINING

Prepared for the California Environmental Health Association (CEHA) Annual Update Training | Track 2: Onsite Wastewater Treatment Systems (OWTS) Composting Systems

Wed, 1 October 2025

outthinkthebox

table of contents

Contact: Kimberly King, Container-Based Eco-sanitation Sanitation Expert, Renewable Energy Engineer
+1 415 832-9084
kimgerly@outthinkthebox.net

Presentation number: 03-2025
Oakland, CA USA

my story & experience

Kimberly (Kim) King *https://www.linkedin.com/in/kimgerly/*

Ecosanitation Expert

Renewable Energy Engineer

Applicable Credentials and Certifications

1994-1995 | Johns Hopkins University, Environmental and Health Engineering (Graduate Studies in Solid & Hazardous Waste Management)

2002-2003 | 40-Hour Hazardous Waste Operations & Emergency Response Operator

2015-Present | OSHA 30 Hour Training

2018-Present | Ecole Polytechnique Fédérale de Lausanne (EPFL), Planning and Design of Sanitation Systems and Technologies

2019-Present | Technical Advisor, US TAG to ISO/PC 318 Community scale resource oriented sanitation treatment systems

Industry Experts Letters of Recommendation | https://bit.ly/4il1jiv

01

my story & experience

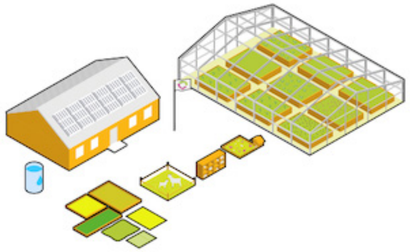
WHY DO I DO THIS?

THE CATALYST

I fell into the Activist role learning how to safely thermophilically compost humanure. I had an epiphany during the design phase of the 2014 Laney College SMUD Tiny Dwelling Design Team. When I raised that zoning and planning in California municipalities for dry compost toilet system processing is not supported, I commenced this ‘adventure’ to learn how to safely process humanure outside of a conventional, municipal waste treatment system.

1° | Ultimate aim is to...

...reside on a tax defaulted vacant lot and grow my own food, reside in a truly affordable autonomous, completely self-supporting tiny dwelling on wheels in the city.

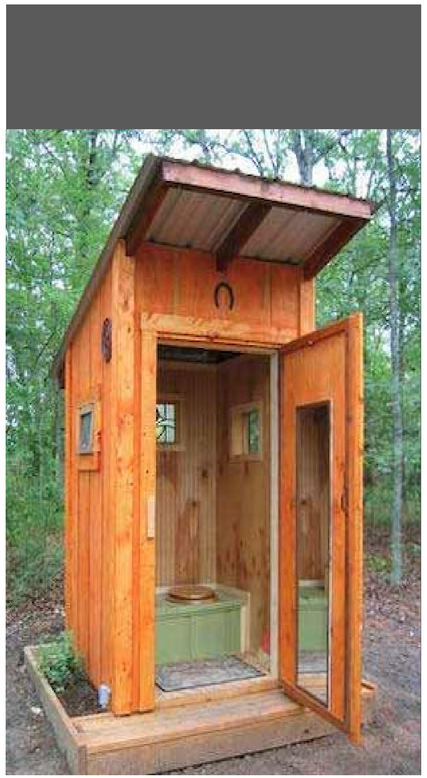


2° | Perform civic duty

Provide curbside communities a dignified, safe, accessible sanitation offering while they wait 6-48 months for truly affordable housing.

3° | Contingency plan

Provide an agile, adaptable, resilient disaster preparedness contingency toilet system when the municipal sanitation infrastructure is rendered inoperable.



my story & experience

TIMELINE

This is the time line of events that brought me into this space. A compendium of my efforts and events of consequence can be viewed here.

2014

Laney College SMUD Tiny Dwelling Competition | I was on the initial design team. I raised that the composting toilet installation included in the design is not permitted for use in the urban environment. This design achieve a number of awards.

2016-2017

Land-Action.org 100 Microfarms in 5 Years Campaign | I was the COO. The vacant lots were to be used for community farms with tiny dwelling residences for farm stewards. Legacy web site.

2018-2019

My colleage presented at the 6th International Dry Toilet Conference and were invited to submit a paper to IWA Blue-Green Systems. This permitted processor system located at the Kailash EcoVillage in Portland, OR was permitted on September 2019 using the 2018 IAPMO WE-Stand Green Building Code.

2022

On 2/2/2022, the City of Oakland Human Services Department provided me a Notification of Qualification in response to my RFQ for a Single User Pilot that included an eco-sanitary dry compost toilet system.

2023

The 2023 International Association of Plumbing and Mechanical Officials Water Efficiency and Sanitation Standard for the Build Environment (IAPMO WE-Stand) Chapter 6 includes best-practices copy from my Kailash EcoVillage O&M Manual.

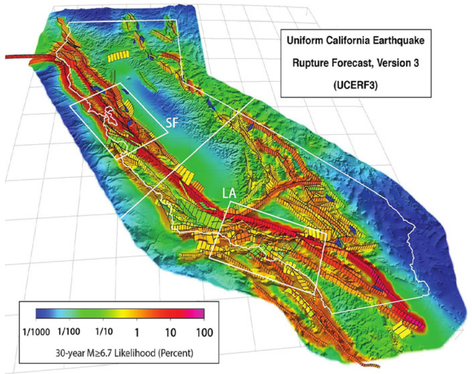
2024

Responded to the Notice of Funding Opportunity (NOFO) for the US EPA Community Change Grant. The aim was to provide eco-sanitation for curbside community inhabitants in W. Oakland, CA while they waited for affordable housing.

what will you do?

AFTER THE NEXT BIG ONE, WHAT WILL YOU DO?

Prior to the occurrence of a natural disaster, it has been demonstrated time and time again the citizens of the USA think little about the reliability and importance of uninterruptible power, sanitation, clean water or food access, until it's not there. Society is dependent on commodities over which individuals ultimately have minimal control. Whether it's electricity, gasoline, diesel, natural gas, buildings and communications devices that require constant access to energy. Without energy, or access to potable water and sanitation, the citizenry of the 21st century can barely survive.



California's major faults. The 3rd Uniform California Earthquake Rupture Forecast (UCERF3) estimated probabilities. The San Andreas Fault and Hayward Fault systems are red on the likelihood scale. Citation: USGS, https://on.doi.gov/2qVm5n0

02

what will you do?

SCENARIOS

Some scenarios to consider. The following scenarios are by no means comprehensive...

A major earthquake just hit your house. Thankfully you have prepared. You have a garden. You have drinking water stored. Everything in your residence is locked down. There is one thing you did not anticipate—the plumbing has been completely knocked out. You have two flushes, and that's it. Your toilet will clog up if you flush it again. Flush toilets everywhere will be out of commission for weeks, at best.

SCENARIO 1

So what are you going to do?

Imagine your neighborhood has never been or is no longer accessible for porta-potty delivery or pick up services. The roads and transportation infrastructure has been rendered inaccessible for an indefinite, protracted period of time.

SCENARIO 2

So what are you going to do?

Imagine your 50+ gallon curbside garbage bin is full with humanure you have been collecting for about one week.

SCENARIO 3

So what are you going to do?

A water-guzzling data center in your area is being used to power the AI and cryptocurrency networks. Your faucets and toilets stopped working.

SCENARIO 4

So what are you going to do?

what is eco-san?

VOCABULARY

Coliform Forming Unit per Gram (cfu/g)

A unit which estimates the number of microbial cells (bacteria, fungi, viruses, etc.) in a sample that are viable, able to multiply via binary fission under the controlled conditions. Reference: https://en.wikipedia.org/wiki/Colony-forming_unit

Compost

Decayed organic material that can be used as a plant fertilizer or soil amendment.

Dry Toilet

A dry toilet is a toilet that does not use water for flushing. Composting is the process used for managing the decomposition of humanure (feces and urine).

ETPA

ETPA - Excreta (feces+urine), Toilet Paper, and High Carbon Additive) AKA humanure.

Humanure

Excreta (feces and urine) from human beings.

Leachate

Liquid from a compost pile, usually dark brown and turbid with a high microbial content.

Soak Pit

A hole in the ground, filled in with granular material e.g. rocks or gravel, which allows liquid e.g. urine to infiltrate the granular material and be absorbed/soak way.

Themophilic

A process that uses high temperatures, typically between 131°F and 160°F (55°C and 70°C). These high temperatures rapidly decompose organic matter into a nutrient-rich soil amendment called humus. Bacterium or other organisms surviving these high temperatures are called thermophiles.

03

what is eco-san?

DEFINITION

Ecological Sanitation (Eco-san)

A sustainable sanitation approach that focuses on:

- Recovering humanure nutrients from thermophilic-/heat-composted human excreta from a dry toilet.
- Water conservation.
- Minimizing environmental impact.
- Improving public health by disease prevention reduction.
- Cost-effectiveness (especially for financially limited resource settings).

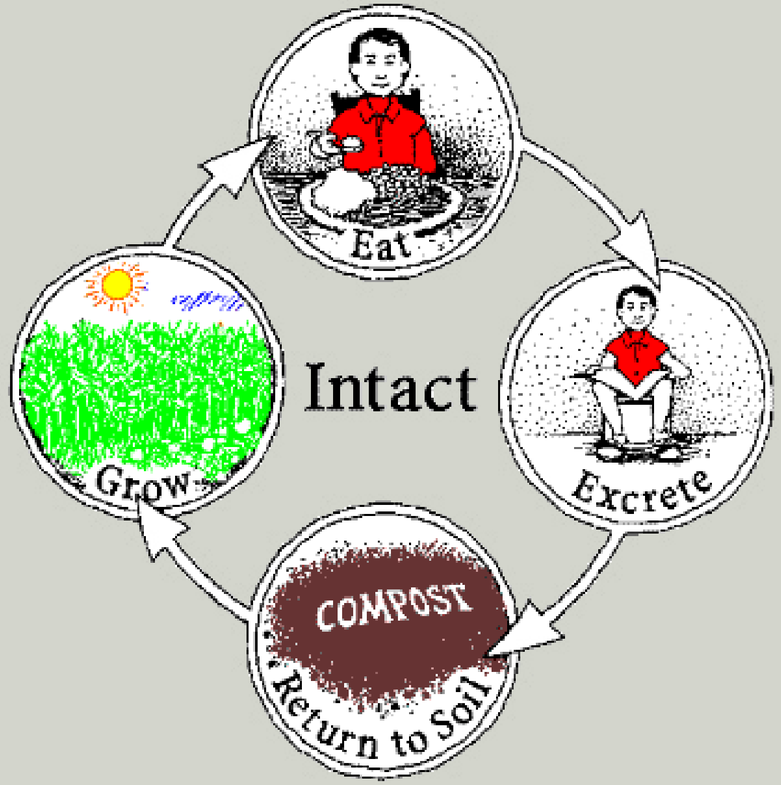


IMAGE: Jenkins, J., 1998. The Humanure Handbook, 2nd Edition, http://weblife.org/humanure/chapter2_1.html

COLLECT. COVER. COMPOST.

Poop needs to be in the loop!

what is eco-san?

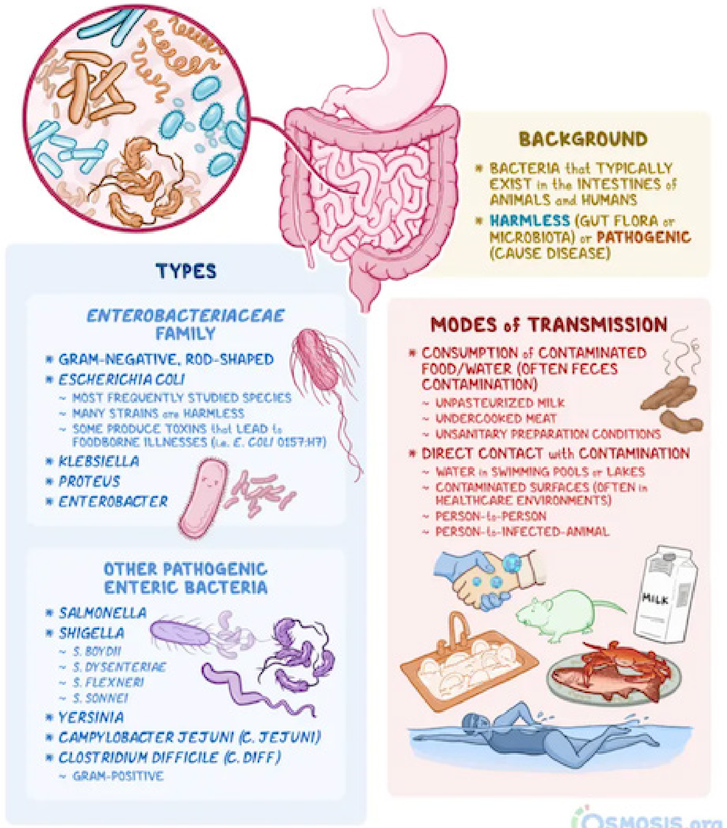
WHY ECO-SAN?

Public health

Public health concerns are a primary reason curbside community (homeless encampments) are swept.

Encampments will likely increase after a major earthquake and there will be:

- Escalating open defecation
- Increase pollution and pests
- Compromise human health, safety and the environment from an increase in pathogens



What are the different types of enteric bacteria?

IMAGE: Osmosis.org, https://www.osmosis.org/

Safe & secure

Destroys pathogens (eco-sanitary) and is free of odors & vermin.

Environmental benefits

Saves water and provides a soil nutrient opportunity.

Financial benefits

Ecosan is comparatively low in cost, and is a revenue generating opportunity i.e. operation & management service, compost/humus/soil amendment sales.

what is eco-san?

WHY ECO-SAN?

[MORE] Public health

Pathogen destruction is aided by microbial activity and diversity. No excreted pathogen can survive a temperature of 65°C (149°F) for more than a few minutes.

Table 7-14 from the *Humanure Handbook* provides survival times of pathogens:

- in soil
- anaerobic decomposition conditions
- composting toilets
- thermophilic compost piles

An aerobic (oxygen entrapped) compost pile may rapidly rise to a thermophilic temperature of 55°C (131°F) and 70°C (160°F) or above. Also, a compost pile will maintain a temperature hot enough for a long enough period of time destroying human pathogens beyond a detectable level.

Table 7.14
PATHOGEN SURVIVAL BY COMPOSTING OR SOIL APPLICATION

Pathogen	Soil Application	Unheated Anaerobic Digestion	Composting Toilet (Three mo. min. retention time)	Thermophilic Composting
Enteric viruses	May survive 5 mo	Over 3 mo.	Probably elim.	Killed rapidly at 60C
Salmonellae	3 mo. to 1 yr.	Several wks.	Few may surv.	Dead in 20 hrs. at 60C
Shigellae	Up to 3 mo.	A few days	Prob. elim.	Killed in 1 hr. at 55C or in 10 days at 40C
E. coli	Several mo.	Several wks.	Prob. elim.	Killed rapidly above 60C
Cholera vibrio	1 wk. or less	1 or 2 wks.	Prob. elim.	Killed rapidly above 55C
Leptospires	Up to 15 days	2 days or less	Eliminated	Killed in 10 min. at 55C
Entamoeba histolytica cysts	1 wk. or less	3 wks or less	Eliminated	Killed in 5 min. at 50C or 1 day at 40° C
Hookworm eggs	20 weeks	Will survive	May survive	Killed in 5 min. at 50C or 1 hr. at 45C
Roundworm (*Ascaris*) eggs	Several yrs.	Many mo.	Survive well	Killed in 2 hrs. at 55C, 20 hrs. at 50C, 200 hrs. at 45°C
Schistosome eggs	One mo.	One mo.	Eliminated	Killed in 1 hr. at 50°C
Taenia eggs	Over 1 year	A few mo.	May survive	Killed in 10 min. at 59°C, over 4 hrs. at 45°C

Source: Feachem et al., 1980

Table 7.15
THERMAL DEATH POINTS FOR COMMON PARASITES AND PATHOGENS

PATHOGEN	THERMAL DEATH
Ascaris lumbricoides eggs	Within 1 hour at temps over 50°C
Brucella abortus or *B. suis*	Within 1 hour at 55°C
Corynebacterium diptheriae	Within 45 minutes at 55°C
Entamoeba histolytica cysts	Within a few minutes at 45°C
Escherichia coli	One hr at 55°C or 15-20 min. at 60°C
Micrococcus pyogenes var. *aureus*	Within 10 minutes at 50°C
Mycobacterium tuberculosis var. *hominis*	Within 15 to 20 minutes at 66°C
Necator americanus	Within 50 minutes at 45°C
Salmonella spp.	Within 1 hr at 55C; 15-20 min. at 60°C
Salmonella typhosa	No growth past 46C; death in 30 min. 55C
Shigella spp.	Within one hour at 55°C
Streptococcus pyogenes	Within 10 minutes at 54°C
Taenia saginata	Within a few minutes at 55°C
Trichinella spiralis larvae	Quickly killed at 55°C

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

TABLE CITATION: Humanure Handbook, Table 7-14, Table 7-17, https://humanurehandbook.com/contents.html

A well-managed ecosan processor...

...destroys pathogens (eco-sanitary) and is free of odors & vermin.

The following temperatures will guarantee complete pathogen destruction:

- 62°C (143.6°F) for one hour
- 50°C (122°F) for one day
- 46°C (114.8°F) for one week
- 43°C (109.4°F) for one month

Worms/Vermi can aid in the sanitation of the compost over time.
Survival temperatures:

- Range | 5-29°C (41-84°F)
- Ideal | 13-25°C (55-77°F)

See presentation: Vermicomposting | Worms in Sanitation

what is eco-san?

WHAT CAN ECO-SAN PROVIDE?

Baseline production

Baseline produced per person per year
- ~500L (~132 gal) urine
- ~50L (13.2 gal) feces

Human urine releases

- 7-10 times more Nitrogen (N)
- 2-3 times more Potassium (K)
- 2-3 times more Phosphorus (P)

than feces.

CITATION: Drangert, J.O., 1998. Fighting the urine blindness to provide more sanitation options. Water SA 24, 157–164

IMAGE: Basics on how a dry, composting toilet works https://preppersportal.com/best-composting-toilet/

The following info-graphic 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..

Odor & vermin free

If managed properly, thermophilic decomposition is odor free and vermin free.

Soil nutrients

Nutrients from humanre can be recovered and applied as a soil amendment.

Revenue generation

The operation & management can provide a service, and sales of decomposted humaure can be sold as humus/soil amendment.

what is eco-san?

WHAT ELSE CAN ECO-SAN OFFER?

Ecosan Improves

- Curbside community access to dignified & safe sanitation
- Economic viability & empowerment
- Job opportunities
- Resiliency

Ecosan Reduces

- Dependency on social services agencies
- Outdoor defecation
- Stress on municipal H_2O and sanitation infrastructure
  - Stop defecating in water and compost instead
  - Retrain thinking—a drain is not a waste disposal site
  - Recover household ('new water' supply) greywater:
    - 42% - 79% shower and bathtub
    - 5% - 23% laundry facilities
    - 10% - 17% kitchen sink/dishwasher
    - 5% - 6% bathroom sink
    - 38% - 45% flushing of blackwater from toilet

CITATION:: Karpiscak, Martin M. et al. Residential Water Conservation: Casa del Agua. Water Resources Bulletin. Dec. 1990, p. 945-946. American Water Resources Association. (1990)

Instead of being disgusting, humanure is a/an:

- Resource opportunity (instead of a threat)
- Excreta-To-Energy (E2E) opportunity
- Opportunity to reduce stress on water infrastructure
- Way to transform filth into food (Close the nutrient cycle loop)
- Way to replace chemical fertilizers
- Soil amendment
- NOT a 'waste'

IMAGE: Nature Commode Nutrition Loop, http://naturecommode.com/ (RIP)

what is eco-san?

WHAT ARE ECO-SAN CHALLENGES?

Container-based ecosanitary dry compost systems, while offering water conservation and sustainability benefits, also present some challenges. These include increased maintenance requirements, potential odor issues, and the need for a greywater system. There may also be limited capacity for handling large amounts of humanure, and necessitate the removal of the finished compost.

Potential challenges

- More frequent and involved maintenance; tasks include:
  - Adding bulking agents.
  - Removing excess liquids.
  - Manually excavating composted material.
- Odor problems if not properly maintained.
- Health hazards due to inadequate maintenance, if not properly thermophilically treated before using as a soil amendment.
- Capacity limitations if not sized properly for peak usage.
- Freezing issues of liquids in cold climates.
- Separate greywater system for handling wastewater from sinks and showers.

IMAGE: Nature Commode Nutrition Loop, http://naturecommode.com/ (RIP)

use cases

04

RURAL & URBAN EXAMPLES

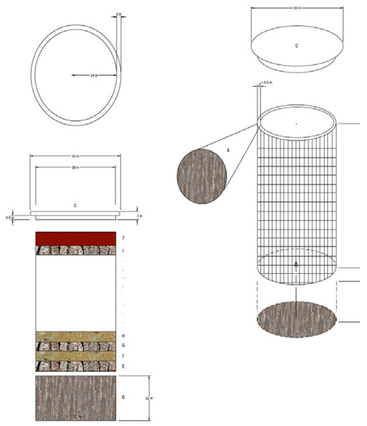
The Use Cases in this section span 2014 to the present...

out think the box

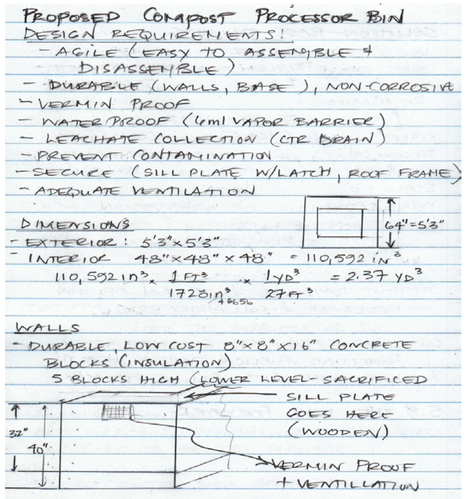
use cases

IN OPERATION & CONCEPTUAL EXAMPLES

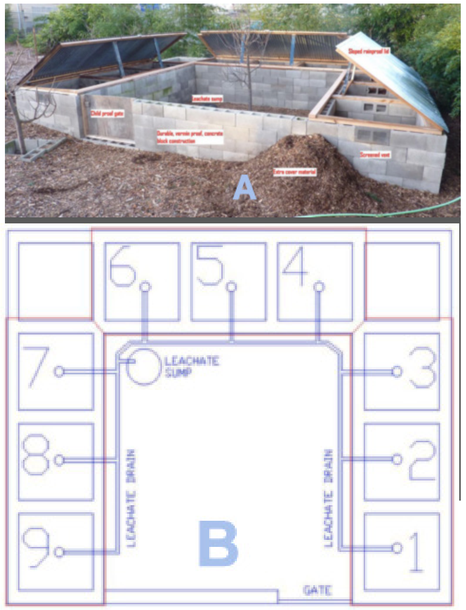
Kelseyville, Lake County, CA



Berkeley, CA



Portland, OR



1 Person - Kelseyville, CA

Since 2019, a single user Lovable Loo was installed with a novel compost processor system brought to the attention of the CA Water Board.

20 Persons - Berkeley, CA

This conceptual offering was envisioned for implementation in 2018 at the Here/There Encampment with Adeline Neighborhood support.

50 Persons - Portland, OR

Since March 2014, this experimental compost toilet system modeled after the WE-Stand) set out by IAPMO. Permitted in September 2019.

COLLECT. COVER. COMPOST.

use cases

1 USER

COLLECT. COVER. COMPOST.

Kelseyville, Lake County, CA

This system was brought to the attention of the CA Water Board as a suggested pilot for eventual use consideration in the built/urban environment at a future date. Cover material used in the Loveable Loo™ is a combination of readily available materials including wood chips, saw dust, and coconut coir.

Description

This system has been used by the primary caretaker at a monastery in Lake County since September 2019. Submitted to the CA Water Board in January 2019, this novel Eco-sanitary (Ecosan) Dry Toilet System Bioretention Cairn can be viewed here.

Supporting documentation

OPERATION & MAINTENANCE MANUAL Single User Dry Toilet System Using IAPMO WE•Stand © 2018 Lake County, CA, USA 1 October 2019

use cases

20 USERS

Berkeley, CA

In late-2017 a temporary, modular concrete blocks construction processor system with a leachate collection assembly was proposed. This movable processor was sized to service the humanure of 20 curbside community activists and inhabitants on Adeline St in South Berkeley. To be located at 100 ft above sea level on Adeline St, as well as another lot close by proposed by the Adeline Neighborhood.

Description

Similar to the Kailash Ecovillage Processor, an agile, modular, moveable processor was proposed to safely manage the humanure of up to 20 persons. The system design reduces the need to access municipal water, sewer, and electrical infrastructure, enhancing emergency preparedness.

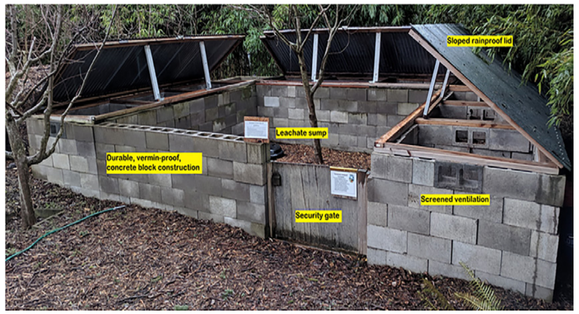
Supporting documentation

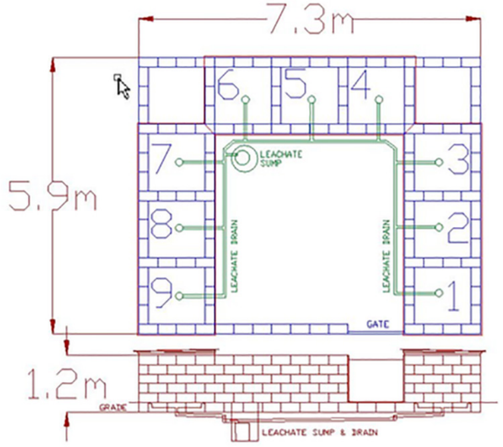
TBD

COLLECT. COVER. COMPOST.

use cases

50 USERS





COLLECT. COVER. COMPOST.

SE Portland, OR

This system located at the Kailash EcoVillage in SE Portland is the first of its kind in an urban environment in the USA to receive a permit by a municipality in September 2019. This system exceeds performance for US EPA Biosolids 503 A and ANSI/NSF-41 Non-Liquid Saturated Treatment Systems for safety.

Description

This system has been used by the inhabitants of the Kailash Ecovillage since 2014 and can safely manage the humanure of up to 50 persons. The system design reduces the need to access municipal water, sewer, and electrical infrastructure, enhancing emergency preparedness.

Supporting documentation

IWA Blue-Green Systems *The Kailash Ecovillage project converting human excreta into organic foodstuffs and sanitized compost using new international building codes for compost toilet and urine diversion systems* , 1 January 2019

use cases

ECOSAN GONE WRONG

COLLECT. COVER. COMPOST.

PHOTO: Outhouse (inside and outside) and compost tumbler at a farm in Brentwood, CA

Brentwood, CA

2019 | Sawdust was used as carbon cover material in the Loveable Loo™. This system was poorly maintained. Mildew had accumulated over the period of a month, emitting an intense, noxious odor that could be smelled 1/4 mile away due to the wet, matted sawdust not receiving proper aeration.

Kingsbury, TX

2020 | The three stall system used a wood chips, leaves, sawdust for cover material. Frequent management was required especially after high visitor traffic. Users were not properly educated on how to use the system and often over wetted the contents of the commode failing to add enough cover material after each use.

Santa Cruz, CA

2024 | Attempts were made to provide the survivors of the CZU Complex Fire with an ecosan pilot. The municipality hampered bringing the system online in a timely fashion, so ~25 participants tossed their untreated toilet contents into 55 gallon trash wheelie bins that were picked up and dumped at the local municipal landfill.

toilet options

05

COMMODES & CABANAS

Curbside community activists and inhabitants were an integral part of the stakeholder engagement process when developing a list of design requirements for commodes/toilets and cabanas. The aim was to provide confidence that designs selected would meed expectations and requirements.

toilet options

DESIGN REQUIREMENTS - USER INTERFACE

The information in this section involved direct stakeholder engagement in 2017-2018 with the Here/There Encampment activists, inhabitants and Adeline Neighborhood representatives. The aim was to adhere to the International Association of Plumbing and Mechanical Officials Water Efficiency and Sanitation Standard (IAPMO WE•Stand) building code design standard and also empower users ensuring their needs and requirements would be satisfactorily addressed. Since the commodes/toilets reside inside the cabanas, cabana design requirements are also included in this section.

See: IAPMO WE•Stand Chapter 6
https://epubs.iapmo.org/2023/WESTAND/

Commode/Toilet

The agile, robust, high performing, low-cost Loveable Loo™ is the designated commode/toilet to be installed in the cabanas.

- Odor-free
- Clean
- Comfortable
- Timely collection
- Easy to maintain
- Accessible hand washing
- Timely collection

Cabana

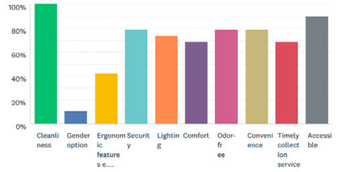
All cabanas are to be outfitted with Loveable Loos, cover material with scoops, and handwashing station access.

- Cleanliness
- Accessible
- Safe and secure (locks, lighting)
- Odor-free
- Accessible hand washing
- Ergonomic features/ADA
- Easy to maintain
- Gender option

19 out of 20 responses from the September 2018 Here/There Encampment Survey

How important are the following to you when using the toilet? Check all that apply.

Answered: 19 Skipped: 0



ANSWER CHOICES	RESPONSES	
Cleanliness	100.00%	19
Gender option	10.53%	2
Ergonomic features e.g. stability bar(s)	42.11%	8
Security	78.95%	15
Lighting	73.68%	14
Comfort	68.42%	13
Odor-free	78.95%	15
Convenience	78.95%	15
Timely collection service	68.42%	13
Accessible	89.47%	17
Total Respondents: 19		

toilet options

COMMODES

Nature's Head

$1,065 - $1,299

Loveable Loo™

$40-$50

Luggable Loo Seat Cover & 5gal Container

$20-$22

Depending on one's comfort zone and budget, there are a number of options to consider. These toilets do offer water conservation and sustainability benefits, but have increased maintenance requirements compared to water flush toilets e.g. adding bulking agents, removing excess liquids, and manually removing the semi-composted material.

toilet options

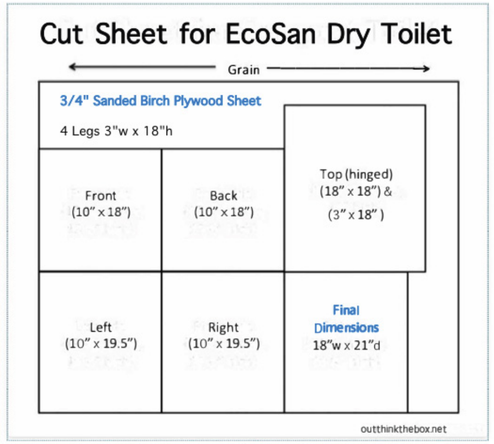
COMMODES

BOM (Bill Of Materials) for the Ecosan Dry Toilet Loveable Loo

Standard toilet seat lid
Two 2 1/2" standard brass door hinges

Cut sheet for one half sheet of sanded Birch Plywood follows:

Two 3/4" x 10" x 18"
Two 3/4" x 10" x 19.5"
Four 3/4" x 3" x 18"
3/4" plywood 18" x 18"
3/4" plywood 3" x 18"



Cut Sheet

Loveable Loo™

$40-$50

This single user Loveable Loo™ toilet/commode was constructed for a livestock manager's use in Big Sur, CA in 2021.

Cabinet | Waterproof sealed Fir Plywood 15" (38 cm) wide, 20" (51 cm) deep, 15" (38 cm) high capable of holding a 5 gal (19 litres) container/receptacle
Toilet Seat | Compression molded, plastic standard (height from floor is 16")
Receptacles/Containers (Excreta collection device) | 5 gal (19 litres) with lid
Materials Cost | ~$20
Labor | $30

toilet options

CABANAS

Most portable toilets use a chemical-based deodorant which can include formaldehyde to keep odors at a minimum. Both Nature Commode and Natural Event use modular, temporary cubical units with ADA option. These units are suitable for adults and children.

Nature Commode

Nature Commode

Natural Event

Natural Event

Nature Commode

Originally out of Portland, OR, Nature Commode uses locally-sourced sawdust to neutralize odors - one scoop for urine, two scoops for poop. https://www.instagram.com/naturecommode/

Natural Event

Changing the World from the Bottom Up, Natural Event is the world leader in waterless, odour free, composting toilet solutions for festivals, events and gatherings where people poo. https://naturalevent.com/

Give Love

GiveLove is a skills training organization dedicated to the teaching and promotion of Ecological Sanitation and composting. https://givelove.org/

processor options

POST-CONTAINER PROCESSING

After a collection container is filled, secondary treatment/post-container processing is needed.

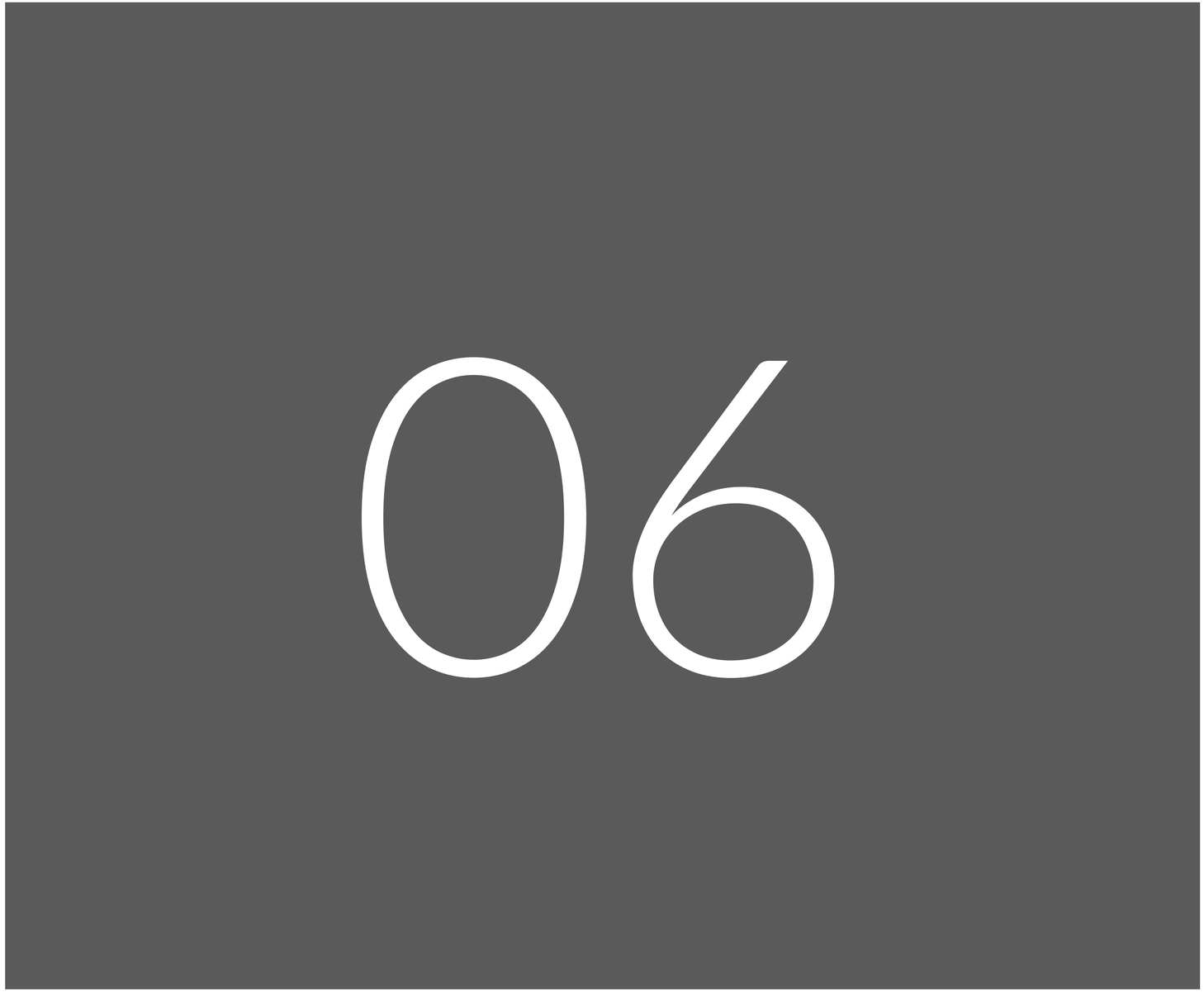
After the processor systems are filled with humanure collected from the commode collection containers, processor contents need to achieve thermophilic composting temperatures 55ºC (131º F) for ten weeks.

List of processor inputs

- Human excreta (feces, urine)
- Cleansing material (toilet paper)
- Carbon cover material (wetted wood chips, dry oak leaves, pine and oak bark)
- Recycled leachate
- Vermi Eisenia fetida/foetida (Red Wiggler Worms)

The most important characteristics of this performance-based composting dry toilet (and urine diversion, where applicable) requires adherence to IAPMO WE•Stand building code design standard. See: IAPMO WE•Stand Chapter 6, https://epubs.iapmo.org/2023/WESTAND/

Best-Practices Rule Of Thumb (ROT) Capacity Minimum |
1 cubic meter (1 m^3) ~= 1.3 cubic yard (yd^3) ~= 35.3 cubic feet (ft^3)



processor options

DESIGN REQUIREMENTS

IAPMO WE•STAND

The most important performance characteristics of this performance-based composting toilet (and urine diversion, where applicable) requires adherence to the International Association of Plumbing and Mechanical Officials Water Efficiency and Sanitation Standard (IAPMO WE•Stand) building code design standard. IAPMO WE•Stand does not require thermophilic composting, but it does prevent contamination of the soil with pathogenic material, such as leachate and compost less than one year old. Jurisdictional adoption of WE•Stand provides an opportunity for building code officials to approve performance-based composting dry toilet systems that have all these and other specified advantages. Go to Chaper 6.

Design Constraints

- ANSI/NSF listed materials
- Licensed/Registered professional sign of
- Permits
- Authority Having Jurisdiction (AHJ), licensed professional
- Owner's Manual required
- **Toilet**
  - Corrosion-resistant
  - Odor & vermin/vector prevention (during operation <= 1/2" mesh)
- **Processor**
  - Maintain aerobic, unsaturated composting conditions
  - Leachate drainage system
  - Openings screened
  - Water tight
  - Hold min. of 10 gal material/person/yr
  - Primary and secondary testing i.e. if primary inputs are moved to a windrow

Processor Inputs

- Human excreta (feces, urine)
- Cleansing material (toilet paper)
- Carbon cover material (wetted wood chips, dry oak leaves, pine and oak bark)
- Recycled leachate
- Red Wiggler Worms (Eisenia fetida/foetida)

Performance Characteristics

- Tested primary & secondary composted material must be <1,000 fecal coliform (cfu/g) for compost safety without fluid
- Cannot visually discern initial inputs
- End result volume ~1/2 initial inputs
- Average moisture content of ~33%
- Humanure from ~20 persons produced 4.3 m^3/year
- Product characteristics must be considered in terms of additional treatment required or beneficial use:
  - Nutrients
  - Pathogen content
  - Volume

processor options

PERMEABLE SOAK PIT 1

COLLECT. COVER. COMPOST.

Description | Big Sur, CA

Constructed in 2021, this compost processor constructed with concrete blocks was sized to service the humanure of 1-2 ranch hands for a one year period. Constructed 1,300 ft atop a ridge in a Redwood Pine Grove 0.25 mile away from the closest ground water source. The blocks were offset when assembled, to allow easy disassembly and reassembly for unloading compost, and if relocation is needed.

Features

Single bin dimensions

- Exterior | 5’3” W x 5’3” L -> 27.56 square feet (ft²)
- Interior | 4’ H x 4’ W x 4’ D -> 64 cubic feet (ft³)

Construction materials

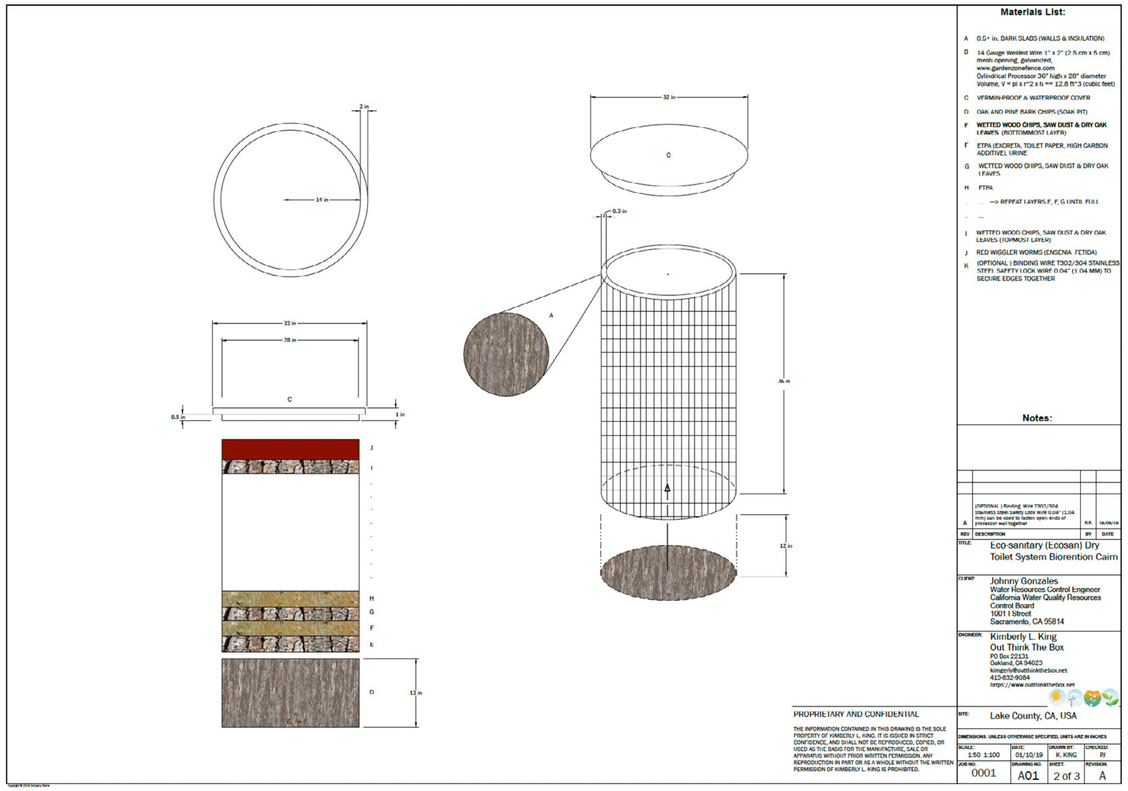
- Modular, offset 8”x8”x16” and 8”x8”x8” concrete blocks
- 3 ft deep soak pit base filled with layers of sand (bottom), gravel (middle), and wood chips (top)
- Sill plate cover was constructed with 2”x4” pine frame beams, corrugated aluminum, heavy duty fixtures, and secured with latches
- Ventilation portals fitted with 1/4” hardware cloth to keep out pests/vermin

Operation & Maintenance (O&M)

The batch loading method is used to add humanure. Concrete blocks are temporarily removed from the front of processor to unload finished, cured compost. Once emptied, blocks are replaced.

processor options

PERMEABLE SOAK PIT 2



COLLECT. COVER. COMPOST.

Description | Kelseyville, CA

In 2019, this modular, movable compost Bio-retention Cairn processor was constructed with welded wire mesh, wooden slab top, tree bark, fitted with a wooden cover and sized to service the humanure of 1 monastery steward for a one year period. Constructed 3,100 ft atop a ridge in a Pine Grove over 1 mile away from the closest ground water source.

Features

Cylindrical Processor Bins (3-count)

- Dimensions for a single bin | 36” H x 28” Diameter
- 3-Bin Capacity (External) | ~21 cubic feet (ft^3)

Walls

- Exterior | Durable, galvanized, low cost 14 Gauge Welded Wire 1” x 2” mesh opening close-fastened with wire wrapping
- Interior | 0.5+” tree bark lines the inside of the wire walls

Base

- 12+” layered tree bark (pine, oak) soak pit
- Subterranean

Fitted Wooden Cover Top

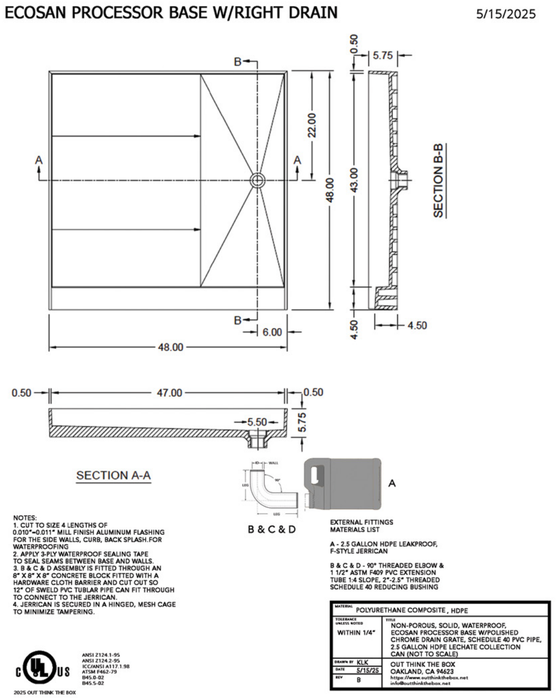
- Vermin mitigation
- Rain accumulation prevention

Operation & Maintenance (O&M)

The batch loading method is used to add humanure. Red Wiggler Worms (Ensenia fetida) were added to facilitate complete curing process. The wooden cover top is temporarily removed and wire mesh unhinged to unload finished, cured compost. Once emptied, wire is re-secured and top replaced.

processor options

MOVABLE BASE



COLLECT. COVER. COMPOST.

Description | Berkeley, CA

In late-2017 construction of a 5-bin temporary/movable, modular concrete block processor system with a leachate collection assembly was under consideration by the Here/There Encampment the system was sized to service the humanure of 20 curbside community activists for a one year period. To be located on Adeline St in South Berkeley at 100 ft above sea level.

Features

Single bin dimensions and requirements

- Exterior | 5’3” W x 5’3” L -> 27.56 square feet (ft^2)
- Interior | 4’ H x 4’ W x 4’ D -> 64 cubic feet (ft^3)
- Real Estate | 12’3” x 11’3” permitter fence -> ~ 140 square feet (ft^2)

Construction materials

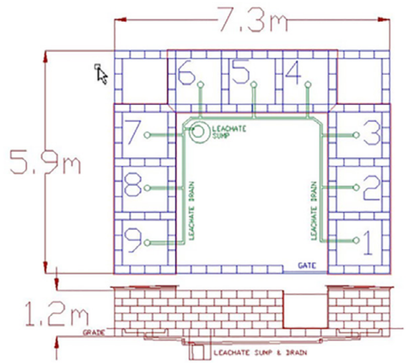
- Modular, offset 8”x8”x16” and 8”x8”x8” concrete blocks
- 2”x4” pine frame beam sill plate, corrugated aluminum/heavy-duty plastic, heavy duty fixtures, and secured with latches
- Ventilation portals fitted with 1/4” hardware cloth to keep out pests/vermin
- Pre-sloped, reinforced edges, moisture barrier augmented right drain shower pan base for leachate collection and recycling into bin
- Load support of rocks and gravel underneath shower pan

Operation & Maintenance (O&M)

The batch loading method is used to add humanure. Concrete blocks are temporarily removed from the front of processor to unload finished, cured compost. Once emptied, blocks are replaced.

processor options

STATIC BASE



Composting Processor	Features
Bins (9 count, 3 modules)	**DIMENSIONS** • Exterior (~25' x 19') • Interior (48" x 48" x 48" ~=2.4 yards³ **WALLS** • Durable, low-cost, 8" x 8" x 16" concrete blocks (insulation) • Vermin proof • Wooden sill plate for roof support (located on top of walls) **BOTTOM** • Sloped concrete pad (4" above pad perimeter lip) • Waterproof • Center drain grate (leachate collection) **ROOF ASSEMBLY (sloped)** • Corrugated, galvanized steel • Rain accumulation prevention • Vermin mitigation • Hinged • 3-bin module shares a common roof • No electricity, water, plumbing connections required
Sump Area (Plumbing)	Leachate collection includes drain grate, sump barrel, sump lid; 2" ABS piping with 1/4" per foot slope, 2" ABS fittings; Contamination prevention of local soil and groundwater
Ventilation	Wire mesh screen air vent (hardware cloth); Vermin and insect management; ~70 in²
Security	Gated courtyard (hinged and latched)

COLLECT. COVER. COMPOST.

SEE: Community Dry Toilet and Urine Diversion System Using IAPMO WE•Stand © 2018

IWA Blue-Green Systems Research Article 1 Jan 2019 | The Kailash Ecovillage project converting human excreta into organic foodstuffs and sanitized compost using new international building codes for compost toilet and urine diversion systems

Description | Inner SE Portland, OR

First of it's kind in an urban environment is an experimental community dry compost toilet system modeled after the Water Efficiency and Sanitation Standard (WE•Stand) set out by the International Association of Plumbing and Mechanical Officials (IAPMO)—the first comprehensive codified requirements for compost and urine diversion toilet fixtures. This system services 20-50 persons in a year. Processor is constructed with low cost, drystack concrete blocks. Permitted in September 2019 in Portland, OR. 160 ft above sea level, and ~2 miles from the Willamette River.

Features

IAPMO WE-Stand requirements

- Separate collecting devices (commodes) & compost processor
- Material construction (durable, non-corrosive)
- No environmental composting leachate discharge
- Covered (rain prevention)
- Enclosed, ventilated (vermin prevention)

Compare to flush toilets

- Destroys pathogens
- Safe and secure
- Odor-free
- Vermin-free
- Retains nutrients
- Conserves water

Operation & Maintenance (O&M)

The batch loading method is used to add humanure. Concrete blocks are temporarily removed from the front of processor to unload finished, cured compost. Once emptied, blocks are replaced.

load flow calculation

07

THE FUN STUFF!

Let’s perform some cursory calculations for sizing a Container-Based ecoSanitary (CBeS) Dry Compost Toilet Processor.

load flow calculation

BASELINE

ONE PERSON

5 gal bucket/container/commode @ 75% full (3.75 gal)

URINE

~ 500L (~132 gal) urine produced/person/year=~+ 11 gal/mo ~= 0.367 gal/day (wet) x 365 days = 133.955 gal/year produced —> 0.367 gal/day x 3.785412 L /1 gal = 1.39 L/day

FECES

~50 L (13.2 gal)/person/year ~= 1.1 gal/mo /30 days = 0.0367 gal/day x 8.32 lb/1 gal = 0.3058 lb/day —> 1.1 gal/mo x 8.34 lb/gal = 9.174lb/mo x 12 mo = 110.088 lb/year produced

ESTIMATES PER MONTH

FECES

13.2 gal x (254 in^3/1.1 gal) = 3048 in^3 x (1 ft^3/12^3 in^3) = 3048 in^3 x (1 ft^3/1728 in^3) = 1.76ft^3 (liquid)

2.05 ft^3 (dry) --locate this conversion reference!

COVER MATERIAL NEEDED

Carbon-Nitrogen Ratio (C:N) for compost processor | 6:1

6 x 110.088 lb/yr = 660.528 lb/yr/person cover material needed

660.528 lb/12 mo = 55.044 lb/mo —> 55.044 lb/30 days = 1.835 lb/day

55 lb/mo x (1 gal/8.34 lb) = 6.59 gal/mo/5 gal container = 1.32 container fills/mo —> 2 containers/mo/person (overbuild)

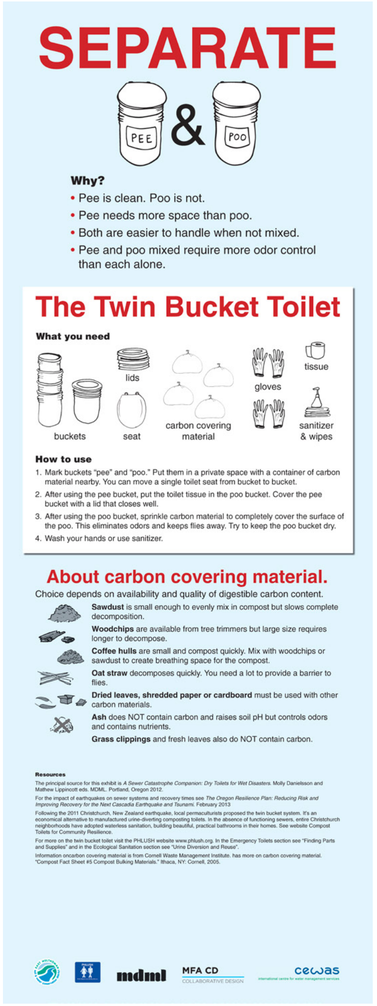
URINE

11 gal x 12 mo = 132 gal/yr

132 gal x (1 ft^3/7.48 gal) - 17.65 ft^3

Assume 50% evaporation —> 8.825 ft^3 processor size needed for 1 year (Minimum)

INFOGRAPHIC: PHLUSH ©Public Hygiene Lets Us Stay Human, 2013. https://phlush.org/



PHLUSH

The Disaster Sanitation Planning Guide on this page was presented at the World Toilet Summit in Stockholm, Sweden by Carol McCreary, PHLUSH Co-Founder.

Temporary Processor

50-gallon rolling bin can hold...

- An 8-week emergency supply of wood chips, sawdust or other carbon material.
- 9 weeks of urine
- 5 weeks feces and carbon material

...for four adults.

Don't Build a Dump. Build Compost.

- *Carbon materials make up about half of the pile.*
- *Construct a bed of carbon at the bottom.*
- *Choose good wood.*
- *Compost needs to breathe.*
- *Bugs volunteer for vital jobs.*
- *Compost is moist but not wet.*
- *Covered compost piles don't smell.*

load flow calculation

METHOD 1 | VOLUME OF COMPOSTING CHAMBER

SIX PERSONS (e.g. RESIDENTIAL HOUSEHOLD)

V = N * P * R (m^3)
N - Emptying interval (years)
P - Average number of users
R - Sludge produced/person (annum)

Assume - 0.05 m^3/person/yr
0.05 m^3 = 1.765 ft^3

Recall 1 m^3 = 35.314 ft^3

Given: 10.88 ft^3 container volume required x 1 m^3/35.314 ft^3 = 0.308 m^3/yr == 0.403 yd^3/person/yr

Interior of one concrete compost processor == 64 ft^3 x 1 yd^3/1728 ft^3
== 2.37 yd^3

2.37 yd^3/0.403 yd^3/person/yr
== 5.88 persons/bin/yr
== 6 persons/bin/yr

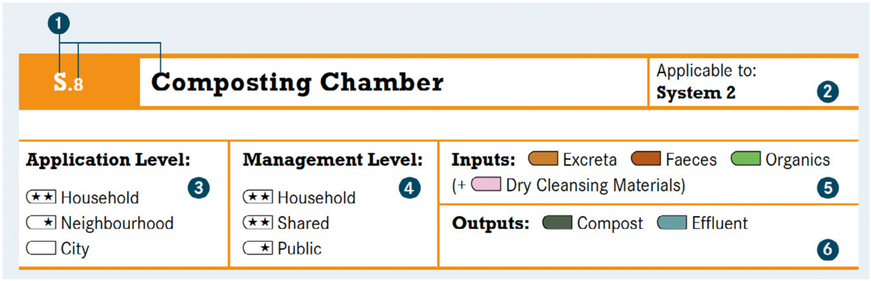


IMAGE: System 2 | Waterless Pit System without Sludge Production
CITATION: Compendium of Sanitation Systems and Technologies, 2nd revised edition, Swiss Agency for Development and Cooperation SDC pp. 25

User Interface

Loveable Loo™ Toilet.

Inputs

Human excreta (feces, urine)
Cleansing material (toilet paper)
Carbon cover material (wetted wood chips, dry oak leaves, pine and oak bark)
Small amount of water (anal & container cleansing)
Recycled leachate
Red Wiggler Worms (Eisenia fetida/foetida)

Organic Loading

Processor acts similar to a planted drying bed. Can withstand high organic loading rates, since the hydraulic loading rate is comparatively low —> carbon cover material absorbs urine and cleansing water.

load flow calculation

METHOD 2 | ORGANIC LOADING

SIX PERSONS

Assumptions:
- Water loading urine and feces with 60% moisture content
- Drawn every 6 months
- Drying surface 643 cm^2/person (0.692 ft^2)

2.22 ft^2 bin/person/yr = 4.928 ft^2

0.692 ft^2/4.928 ft^2 = 14.04%

Compost height 36 cm (14.4 in) and 63 cm (24.8 in)

2.22 ft x 12 in/1 ft = 26.64 in

26.64 in - 24.8 in = 1.84 in
Design estimate overbuilt to allay load flow management concerns

Safety Factor - 26.64/24.8 = 1.074

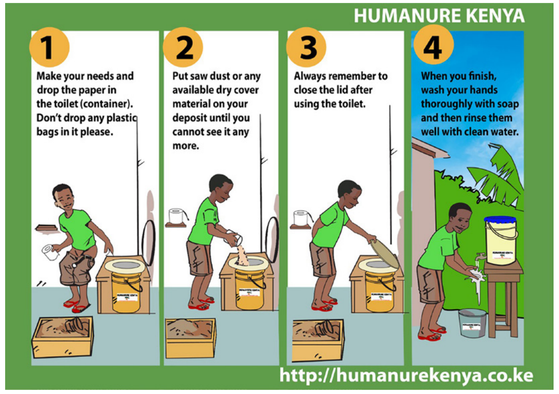


IMAGE: *Jenkins, J., 1998. The Humanure Handbook, 2nd Edition, http://weblife.org/humanure/chapter2_1.html*

User Interface

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Small amount of water (anal & container cleansing)
Recycled leachate
Red Wiggler Worms (Eisenia fetida/foetida)

Organic Loading

Organic loading rate (OLR) is the amount of organic waste fed per unit volume of the processor per day.

The processor acts similar to a planted drying bed. It can withstand high organic loading rates, since the hydraulic loading rate is comparatively low —> carbon cover material absorbs urine and cleansing water.

testing

FIRST TEST | COLISCAN® EASYGEL® #25001

NSF-41. Working with the National Sanitation Foundation (NSF) International, an independent, nonprofit, organization, ANSI developed ANSI/NSF-41: Non-Liquid Systems (NSF 2018). It is a standard allowing testing and certification for commercially available dry toilets. NSF-41 certification of commercially available devices insures:

- Compliance with construction, manuals, and performance standards.
- Six months of performance testing, both in the laboratory and in a mature field setting.
- The 'humus' product has <200 mpn E coli per gram and no objectionable odor.
- E. coli testing of initial compost output of a system <200 cfu/g.

Micology Labs Coliscan Test Kit for initial test for E. coli coliform bacteria after bin temperature was under the mesophilic temperature range 20 °C to 45 °C (68 °F to 113 °F),

https://www.micrologylabs.com/product/coliscan-water-monitoring-kit/

For each bin:

- Test 5 collected samples each weighing 10 grams.
- Evenly distribute sample collection points from throughout the bin are representative of the contents of the entire bin.
- Thoroughly mix together the 5 samples prior to testing.
- Test using Coliscan Easygel test kits using the manufacturer's recommended dilution of 100×.
- Incubate samples at 40–44 °C for 48 hours per manufacturer's recommendation.

08

resources & references

RECOGNIZED & RESPECTED BEST PRACTICES RESOURCES & REFERENCES

- Container Based Sanitation Alliance (CBSA) - Provides aid to strengthen government leadership, regulation, and incentives to encourage adoption.
- Humanure Handbook - The definitive guide on how to safely compost humanure.
- 2023 International Association of Plumbing and Mechanical Officials Water Efficiency and Sanitation Standard (IAPMO WE•Stand) for the Built Environment | Chapter 6
- NSF/ANSI 41: Non-Liquid Saturated Treatment Systems - Certifies composting toilets and similar treatment systems that do not use a liquid saturated media as a primary means of storing or treating wastes.
- OPERATION & MAINTENANCE MANUAL | Single User Dry Toilet System Using IAPMO WE•Stand © 2018 - Part of the IWA Blue-Green Systems Research Article
- Public Hygiene Lets Us Stay Human (PHLUSH) | Helps local governments and citizen groups to provide equitable public restroom availability and to prepare for sanitation disasters with appropriate ecological toilet systems.
- The Poop Project - Peoples' Own Organic Power (POOP) | The POOP Project uses art, theater, and education to promote critical conversations about sustainable sanitation for the person, planet, and world community.
- Restorative Sanitation Panels - Infographic from the 2012 *A Sewer Catastrophe Companion* by Molly Danielsson and Mathew Lippincott editors MDML. Portland, Oregon 2012.
- Sustainable Sanitation Alliance (SuSanA) | The SuSanA Alliance is a global network of individuals and organizations united by a common goal: advancing sustainable sanitation.
- US Composting Council (USCC) - The USCC doesn't specifically address humanure, but they acknowledge that human waste can be composted under controlled conditions, and when performed correctly, can convert human 'waste' into a nutrient-rich soil amendment.
- US EPA Biosolids 503 Subpart A

09

contact

KIMBERLY (KIM) KING

kimgerly@outthinkthebox.net
+1 415 832 9084
https://www.outthinkthebox.net/projects/topsoilfactory.html
EcoSan Oakland Blogspot - https://kimgerly.wixsite.com/ecosanoakland/blog (TEMPORARY)

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