out think the box

REST* in Urban Agriculture — Humanure

* REST - Renewable Energy Systems Technology

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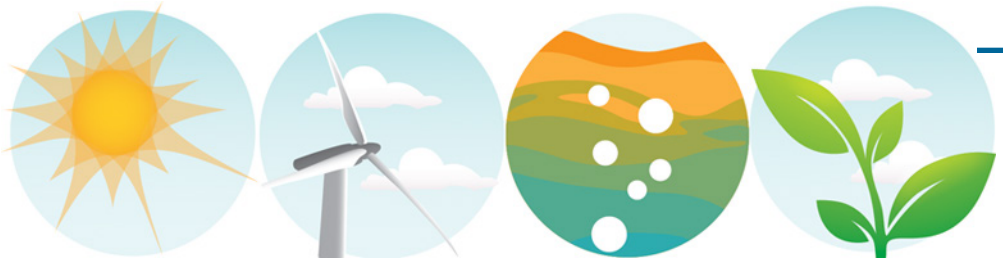
Kimberly King
Renewable Energy Engineer
Email: kimgerly@kimgerly.com
Mobile: +1 415 832 9084
Skype: kimgerly



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out think the box

Contact: Kimberly King, Renewable Energy Engineer
+1 415 832-9084
kimgerly@kimgerly.com

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anatomy of disgust

Compost toilet adoption problems:

- Mass and energy balance of compost toilet load stream not available
- Lack of standards
- Lack of established design guidelines
- Disposal and maintenance challenges
- Monitoring process factors (see slide 5)

(re)branding humanure

Instead of being disgusting, humanure is:

- Resource opportunity (instead of a threat)
- Excreta-To-Energy (E2E) opportunity
- Opportunity to reduce stress on water infrastructure
- A way to transform filth into food
- NOT a 'waste'

why do this?

Reduce water consumption due to increased unavailability of this precious resource

- 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 toilets

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)

process factors

Composting process factors:

- Aeration
- Temperature - 40°C - 65°C (104°F - 149°F)
- Bulking agents (Carbon, C : Nitrogen, N ratio)
- pH (5.5 - 8.0)
- Porosity/Particle size
- Moisture content (50%-60%)

Citation: Chirjiv K. Anand, Defne S. Apul, Composting toilets as a sustainable alternative to urban sanitation – A review, Waste Management, Vol 34 (2014)

process factors (cont'd)

Complete pathogen destruction via well-managed thermophilic composting:

- 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

Citation: Joseph Jenkins, Humanure Handbook, 3rd Edition (2005)

baseline production

Baseline produced per person per year

- ~500L (~132 gal) urine
- ~50L (13.2 gal) faeces

Human urine releases

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

than faeces.

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

benefits

Urine-separating vermicomposting toilets w/ combined collection composting toilets :

- ↑ Mass reduction
- ↑ Pathogen destruction
- ↑ Compost quality
- ↑ Operational cost

Citations: Hill, G.B., Baldwin, S.A., 2012. Vermicomposting toilets, an alternative to latrine style microbial composting toilets, prove far superior in mass reduction,pathogen destruction, compost quality, and operational cost. Waste Manage. (Oxford) 32 (10), 1811–1820.

Huasi is vermi-composting faeces with subsequent solar drying in the same compartment in El Alto, Bolivia (photo: H. Hoffmann, 2012).

plant application

Compost can:

- Close the nutrient cycle loop
- Replace chemical fertilizers
- Act as a soil amendment

USEPA Windrow Compost of Class A Biosolids*:

- 55°F (minimum) for 15 days or longer
- 5 turns of compost pile (minimum)
- If Rule 503 is met, qualifies as Exceptional Quality (EQ) biosolids

*Citation: *USEPA,Water Efficiency Technology Fact Sheet: Composting Toilets. http://water.epa.gov/aboutow/owm/upload/2005_07_14_comp.pdf (accessed January 2016).*

stability & maturity tests

A combination of tests can be used:

- Physical (change in physical properties) e.g.
  - pile temperature
  - color
  - odor
- Biological (living organisms distribution) e.g.
  - respiratory
  - phytotoxicity
  - enzyme activity
- Chemical (composition, matter changes) e.g.
  - C:N ratio
  - pH
  - organic matter, etc.

design criteria

Design criteria should include:

- Safety
- Functionality
- Economy
- Aesthetics
- Social and environmental affordability

(Some) Design considerations:

- Compost chamber size
- Ventilation
- Carbon supply
- Access

guidelines & regulations

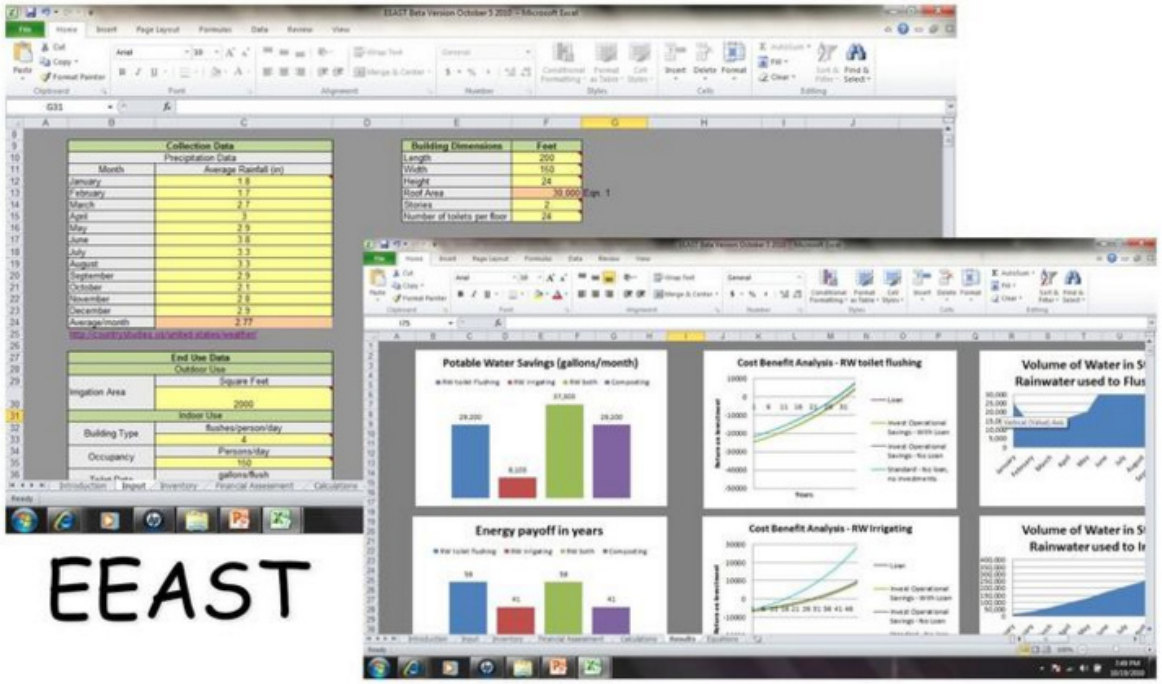
National Sanitation Foundation recommends:

- Toilet seat & riser
- (In some cases) Removal when tank ~75% full
- Continuous ventilation
- Health endangerment avoidance
- Biosolids 503 Rule (extended to composting)

design criteria (more)

EEAST Model developed for comparing water and sanitation systems e.g. composting toilets.

Economic and Environmental Analysis of Sanitation Technologies (EEAST)



Citation: http://defneapul.wikispaces.com/Water+Sustainability

design criteria (more)

Method 1 - Volume of composting chamber

- $V = N*P*R\ (m^3)$
  - N - emptying interval (years)
  - P - average number of users
  - R - sludge produced/person (annual), ~0.05 m^3/year/person

Cistation: Pickford, J., Reed, R., 1992. A Guide to the Development of On-site Sanitation. (accessed January 2016).

Method 2 - Organic loading

- 'H_20' loading urine + faeces 60% content moisture
- Drawn every 6 months
- Drying surface 643 cm^2/capita (0.692 ft^2/capita)
- Compost height 36 cm (14.1") & 63 cm (24.8")

Citation: Zavala, M.A.L., et al 2006. Design and operation of the bio-toilet system. Water Sci. Technol. 53, 55–61.

urine management

On-site Urine Treatment

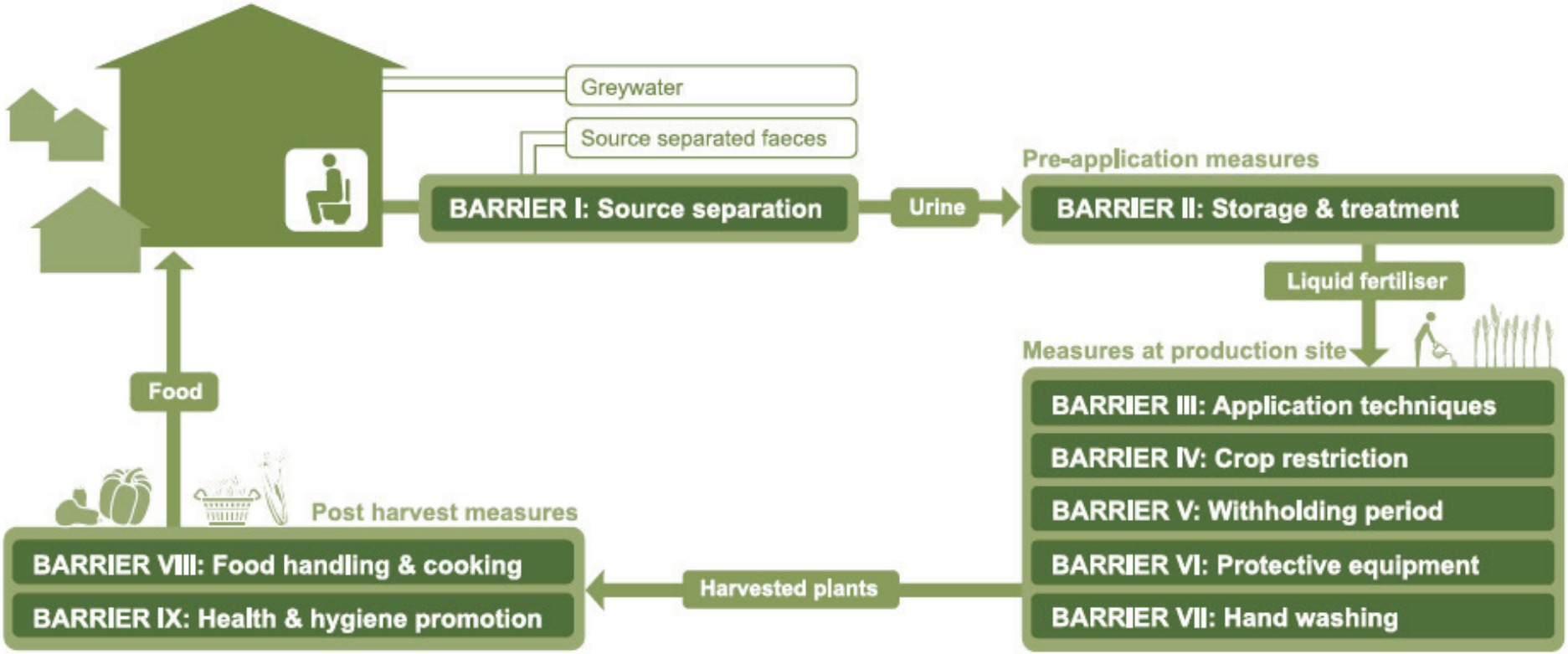
- Soak Leach/Pit
- Anaerobic Storage conditions decreasing pathogens
  - 1-2 week storage time
  - Temperature > 68°F (20°C)
  - pH 9+
  - High NH_3 concentration (also kills pathogens)

Reuse of Urine

- Stimulate plant growth w/ P, N, K, S, micronutrients
- Safest when applied to fruit trees
- Most effective:
  - Immediately before sowing
  - During the plants' vegetative growth period

(more) urine management

Multi-barrier Concept for Urine

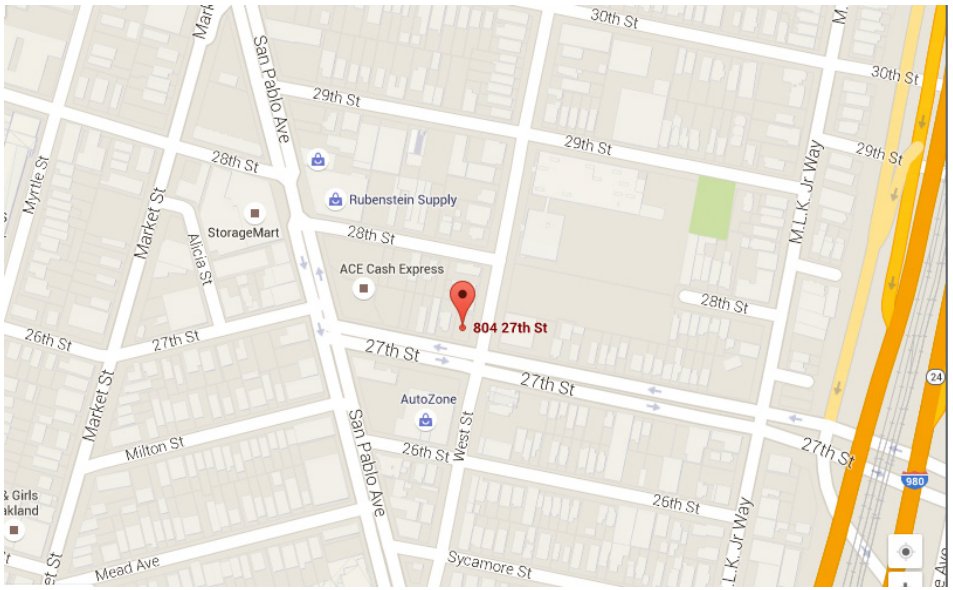


Citation: Richert et al., Multi-barrier concept for safe use of urine as a fertiliser (2010)

the proposition

Pilot project 804 27th St

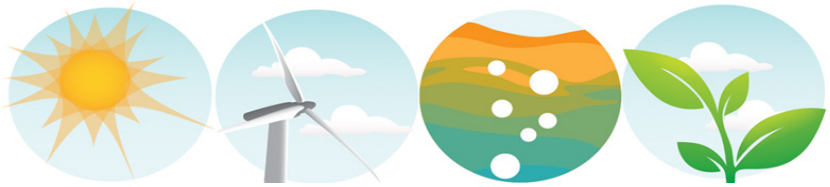
- Tiny S.E.E.C. Houses
- On-site Compost (Humanure & Urine)
- Greywater Treatment
- Solar PV & Thermal
- AD for CH_4 production
- AWG for drip irrigation
- Produce Garden
- Fruit Tree Orchard
- Chickens & Bee Hive



the proposition

Pilot Project REST & Community Offerings:

- Produce compost human excreta & food waste
- Biofuel/gas generation from waste stream using AD
- PV and solar thermal for electricity and hot water
- Condense H_2O vapor in the air -> H_2O mgt (IP)
  - No ground water drilling
  - No surface water pumping
- Community engagement/education/services
  - Composting 101
  - Build raised beds from re-purposed shipping palates
  - Leafy greens seed give-away
  - Produce market sales



benefits

- ↑ Economic viability & empowerment
- ↑ Job opportunities
- ↑ Healthy communities
- ↑ Healthy, fresh, nutritious food access
- ↑ Resilience
- ↑ Food security
- ↓ Homelessnesses
- ↓ Dependency on social services agencies
- ↓ Stress on municipal H_2O infrastructure
- ↓ GHG emissions e.g. locally grown produce

parting thoughts

Out think the box.
Prepare. Respond. Adapt.

People who compost humanure are recycling—there is no waste in nature.

We need to S.E.E.C. out everyday brilliance for disaster resilience.