Public Sanitation Using Hot Composting

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Most Sanitation Systems Create Pollution

- Dirty water is the world's biggest health risk.
- When we use a flush toilet, we intentionally defecate into drinkable water, thereby polluting it.
- Pit Latrines pollute ground water and water wells.
- Open defecation pollutes soil and spreads disease and parasites.

Beaches are closed when bacteria levels are too high.

The largest known contributor to beach closings is storm water pollution and untreated sewage spills.

There were 5,725 beach closings or advisories in the US during the 2012 swimming season.

Polluted Water is a Serious Health Hazard Worldwide

- 88% of all diarrhea cases are caused by polluted drinking water, resulting in 1.7 million deaths annually world-wide.
- WHO states that fecal pathogens contaminate water through sewage systems, flush toilets and latrines.
- By 2015 there will be 2.7 billion people without access to basic sanitation.

Here are some viruses that can be transmitted by feces:

Table 7.3

POTENTIAL VIRAL PATHOGENS IN FECES

Virus	Disease	Can Carrier Be Symptomless?
Adenoviruses	varies	yes
Coxsackievirus	varies	yes
Echoviruses	varies	yes
Hepatitis A	Infectious hepatitis	yes
Polioviruses	Poliomyelitis	yes
Reoviruses	varies	yes
Rotaviruses	Diarrhea	yes

Rotaviruses may be responsible for the majority of infant diarrheas. Hepatitis A causes infectious hepatitis, often without symptoms, especially in children. Coxsackievirus infection can lead to meningitis, fevers, respiratory diseases, paralysis, and myocarditis. Echovirus infection can cause simple fever, meningitis, diarrhea, or respiratory illness. Most poliovirus infections don't give rise to any clinical illness, although sometimes infection causes a mild, influenza-like illness which may lead to virus-meningitis, paralytic poliomyelitis, permanent disability, or death. It's estimated that almost everyone in developing countries becomes infected with poliovirus, and that one out of every thousand poliovirus infections leads to paralytic poliomyelitis.

Source: Feachem et al., 1980

Here are protozoa that can be transmitted by feces:

Table 7.5

POTENTIAL PROTOZOAN PATHOGENS IN FECES

Protozoa	Disease	Symptomless Carrier?
Balantidium coli	Diarrhea	yes
Entamoeba histolytica	Dysentery, colonic ulceration, liver abscess	yes
Giardia lamblia	Diarrhea	yes

Source: Feachem et al., 1980

Parasites that can be spread via fecal contamination:

Table 7.6

POTENTIAL WORM PATHOGENS IN FECES

Note: hum. = human; intes.=intestinal; Chin.=Chinese; Vietn=Vietnam

Common Name	Pathogen	Transmission	Distribution
1. Hookworm	*Ancylostoma doudenale* *Necator americanus*	Hum.-soil-human.	Warm, wet climates
2. ----------	*Heterophyes heterophyes*	Dog/cat-snail-fish-hum.	Mid. East/S. Eur./Asia
3. ----------	*Gastrodiscoides*	Pig -snail- aquatic vegetation-hum.	India/Bangla./Vietn./ Philippines
4. Giant intes. fluke	*Fasciolopsis buski*	Human/pig-snail- aquatic vegetation-human	S.E. Asia/China
5. Sheep liver fluke	*Fasciola hepatica*	Sheep -snail - aquatic vegetation -human	Worldwide
6. Pinworm	*Enterobius vermicularis*	Human-human	Worldwide
7. Fish tapeworm	*Diphyllobothrium latum*	Human/animal-copepod - fish-human	Mainly temperate
8. Cat liver fluke	*Opisthorchis felineus* *O. viverrini*	Animal-aquatic snail- fish-human	USSR/Thailand
9. Chin. liver fluke	*Chlonorchis sinensi*	Animal/human-snail-fish- human	S.E. Asia
10. Roundworm	*Ascaris lumbricoides*	Human-soil-human	Worldwide
11. Dwarf tapeworm	*Hymenolepsis* spp.	Human/rodent-human	Worldwide
12. ----------	*Metagonimus yokogawai*	Dog/cat-snail-fish-hum.	Jap./Kor./Chi./ Taiw./Siberia
13. Lung fluke	*Paragonimus westermani*	Animal/human-snail - crab/crayfish-human	S.E. Asia/Africa/ S. America
14. Schistosome, bil.	*S. haematobium*	Human-snail-human	Africa, M. East, India
----------	*Schistosoma. mansoni*	Human-snail-human	Afr., Arabia, Ltn. Amer.
----------	*S. japonicum*	Animal/hum.-snail-hum.	S.E. Asia
15. Threadworm	*Strongyloides stercoralis*	Hum.-hum. (dog-hum.?)	Warm, wet climates
16. Beef tapeworm	*Taenia saginata*	Human-cow-human	Worldwide
Pork tapeworm	*T. solium*	Human-pig-human or human-human	Worldwide
17. Whipworm	*Trichuris trichiura*	Human-soil-human	Worldwide

Source: Feachem et al., 1980

Disease bacteria that can be in feces:

Table 7.4

POTENTIAL BACTERIAL PATHOGENS IN FECES

Bacteria	Disease	Symptomless Carrier?
Campylobacter	Diarrhea	yes
E. coli	Diarrhea	yes
Salmonella typhi	Typhoid fever	yes
Salmonella paratyphi	Paratyphoid fever	yes
Other *Salmonellae*	Food poisoning	yes
Shigella	Dysentery	yes
Vibrio cholerae	Cholera	yes
Other *Vibrios*	Diarrhea	yes
Yersinia	Yersiniosis	yes

Source: Feachem et al., 1980

Sanitation systems that destroy pathogens are needed.

- Composting destroys pathogens.
- Composting is not based on water use.
- Composting does not create waste or pollution.
- Composting recycles soil nutrients and yields a valuable byproduct.

What is Compost?

- Compost is the controlled, aerobic, biological degradation of organic material - a process which produces internal biological heat.

Composting Kills Disease Germs

- Research has shown that thermophilic (hot) composting is deadly to human pathogens.
- Researchers include Gotaas, (1956 W.H.O.); Feachem, et al. (1980 World Bank). Franceys, R. et al. (1992 W.H.O.) and others.

Hookworms die rapidly in compost.

Table 7.16

HOOKWORMS

Hookworm larvae develop outside the host and favor a temperature range of 23°C to 33°C (73°F to 91°F).

Temperature	Survival Time of: Eggs	Larvae
45°C (113°F)	Few hours	less than 1 hour
0°C (32°F)	7 days	less than 2 weeks
-11°C (12°F)	?	less than 24 hours

Both thermophilic composting and freezing weather will kill hookworms and eggs.

Parasitic worm eggs die rapidly in compost.

Table 7.13

PARASITIC WORM EGG DEATH

Eggs	Temp.(°C)	Survival
Schistosome	53.5	1 minute
Hookworm	55.0	1 minute
Roundworm	-30.0	24 hours
Roundworm	0.0	4 years
Roundworm	55.0	10 minutes
Roundworm	60.0	5 seconds

Source: Compost, Fertilizer, and Biogas Production from Human and Farm Wastes in the People's Republic of China, (1978). M. G. McGarry and J. Stainforth, editors, International Development Research Center, Ottawa, Canada. p. 43.

Ascaris eggs develop at temperatures between 15.5° C (59.9° F) and 35° C (95° F), but the eggs disintegrate at temperatures above 38° C (100.4° F). The temperatures generated during thermophilic composting can easily exceed levels needed to destroy roundworm eggs.

Pathogens in general die in compost.

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.

- Complete pathogen destruction is guaranteed by arriving at a temperature of 62° C (143.6° F) for one hour, 50° C (122° F) for one day, 46° C (114.8° F) for one week or 43° C (109.4° F) for one month. It appears that no excreted pathogen can survive a temperature of 65° C (149° F) for more than a few minutes.

How Compost Kills Pathogens

- Biological Heat generated by compost microorganisms
- Competition for food from compost microorganisms
- Inhibition and antagonism by compost microorganisms
- Consumption by compost organisms;
- Antibiotics produced by compost microorganisms

Compost is teeming with beneficial microorganisms.

Table 3.6

MICROORGANISMS IN COMPOST

Actinomycetes	Fungi	Bacteria
Actinobifida chromogena	*Aspergillus fumigatus*	*Alcaligenes faecalis*
Microbispora bispora	*Humicola grisea*	*Bacillus brevis*
Micropolyspora faeni	*H. insolens*	*B. circulans* complex
Nocardia sp.	*H. lanuginosa*	*B. coagulans* type A
Pseudocardia thermophilia	*Malbranchea pulchella*	*B. coagulans* type B
Streptomyces rectus	*Myriococcum themophilum*	*B. licheniformis*
S. thermofuscus	*Paecilomyces variotti*	*B. megaterium*
S. thermoviolaceus	*Papulaspora thermophila*	*B. pumilus*
S. thermovulgaris	*Scytalidium thermophilim*	*B. sphaericus*
S. violaceus-ruber	*Sporotrichum thermophile*	*B. stearothermophilus*
Thermoactinomyces sac chari		*B. subtilis*
T. vulgaris		*Clostridium thermocellum*
Thermomonospora curvata		*Escherichia coli*
T. viridis		*Flavobacterium* sp.
		Pseudomonas sp.
		Serratia sp.
		Thermus sp.

Source: Palmisano, Anna C. and Barlaz, Morton A. (Eds.) (1996). Microbiology of Solid Waste. Pp. 125-127. CRC Press, Inc., 2000 Corporate Blvd., N.W., Boca Raton, FL 33431 USA.

- Humanure contains up to a trillion (1,000,000,000,000) bacteria per gram.
- There are 10 times as many bacteria in our bodies as there are human cells.
- Beneficial microorganisms keep us alive.

How can toilets make hot compost?

- 1) Collect the toilet material
- 2) Add carbon
- 3) Compost aerobically

- COLLECT-COVER-COMPOST

Sugar cane bagasse, an industrial by-product in Haiti, is a carbon source.

Sawdust is another product free for the hauling.

“Collection” Toilets simply collect toilet materials before they come in contact with the environment.

HAITI

A 20 liter receptacle inside the toilet collects feces and urine.

Urine separation is not required and is counter-productive to thermophilic composting systems.

The contents are covered with a carbon-based material. The receptacle is easily removable.

A 60 liter receptacle is about the maximum size that can be easily handled without machinery.

The toilets are inexpensive to construct.

These humanure toilets in Haiti are based on the Loveable Loo® design.

They can be located inside an existing building. No special infrastructure is needed: no drains, no electricity, no vents, no pits, no pipes, no plumbing.

Or they can be in their own building.

This Haitian toilet utilizes a chute through the floor.

Sixty liter recycled drums collect the toilet material underneath the stalls.

One drum is being filled while an empty one waits to replace it.

Compost toilets at this school were designed by Architecture for Humanity.

Inside the toilet building.

Inside a stall.

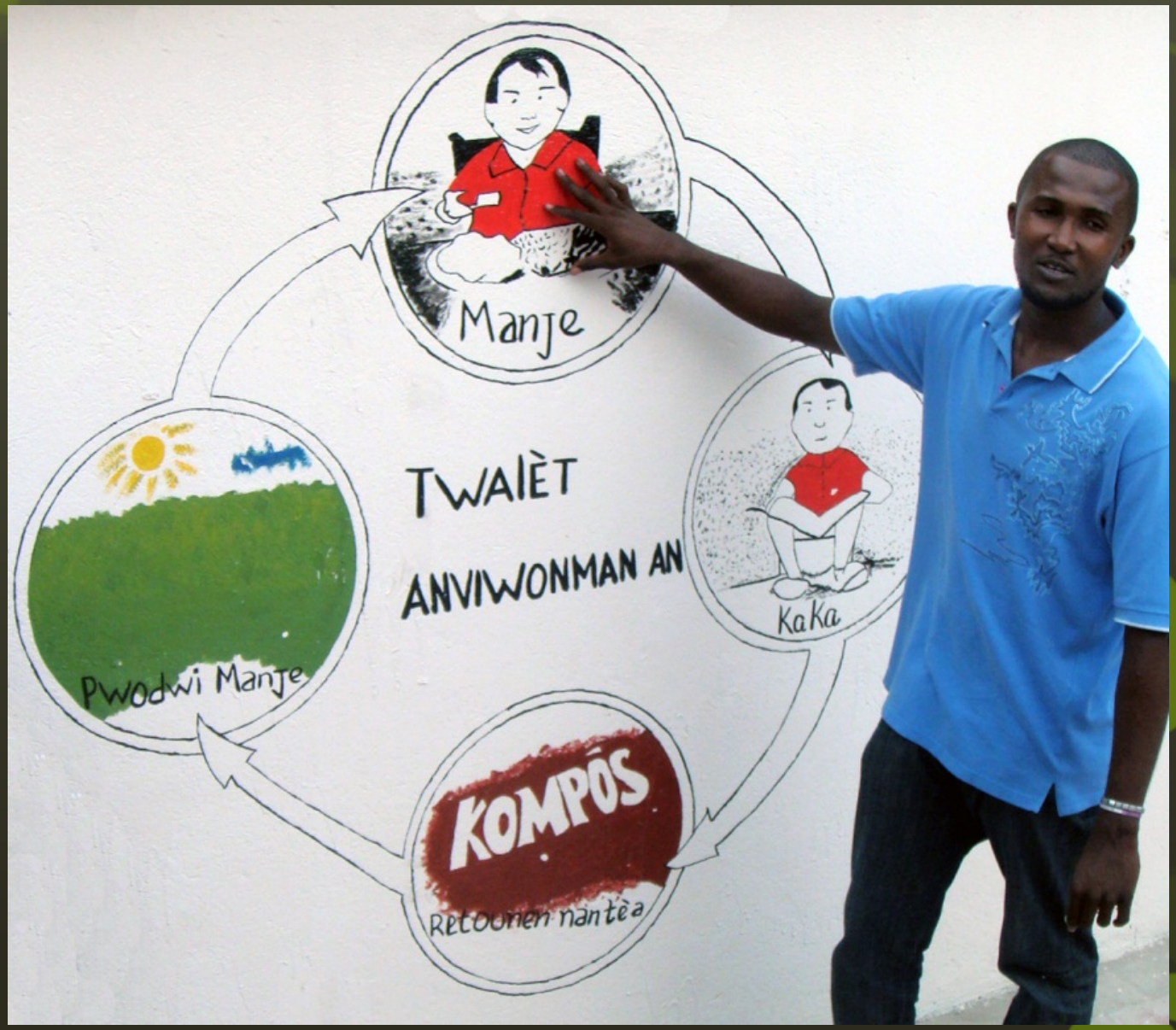
Access to the organic material is behind the building.

Instructions should be posted inside each toilet.

Hand washing stations are located at every toilet.

The toilets can be painted with ecological messages.

These toilets recycle. There is no waste, no pollution, and no disposal.



The collected material can be composted near the toilet. It is always covered.

The toilet contents are added to a depression in the compost pile.

The new material is covered with clean bagasse. No flies, no odor.

Thermophilic conditions are consistent and prolonged.

After 6 months, this compost was still at 131F. The US EPA requires 3 days at 131F for hygienic safety.

Food scraps are also added to the compost bins. A variety of organic materials can be recycled using this system, even animal mortalities.

Public education helps to improve acceptance of this revolutionary sanitation system.

Compost training in Haiti

After a year of aging, the finished compost is suitable for food gardens.

These trees are being planted in humanure compost.

What would have been sewage and pollution and a threat to public health is now clean compost.

“Human Waste” creates pollution and threatens public health.

“Humanure” creates compost and enhances public health.

Any Questions?

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Haiti toilets were set up by GiveLove.org:

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Also contact: SOIL (OurSoil.org)