

Faecal composting – how to build and maintain a compost for faeces from dry urine diverting toilets



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Introduction

Sanitation of toilet waste is one of the most important health factors. A sustainable sanitation toilet system means a system that prevents disease and promotes health, protects the environment and conserves water, and recycles nutrients and organic matter. The main challenge is to develop sustainable sanitation systems which give effective pathogen removal. One person leaves about 60 litres human excreta and toilet paper per year, which corresponds to a nutrient amount of 0,55 kg nitrogen (N) and 0,18 kg phosphorus (P). Around the Baltic Sea live about 20 million people with on-site sanitation for single family households or with no treatment at all.

Urine diverting dry toilets

Urine diverting toilets with dry handling of faeces are often a cost-efficient, hygienic and environmentally friendly alternative to water closets. Urine diverting dry toilets also facilitates recovery of plant nutrients present in toilet waste. After storage, urine can be used as fertiliser. Faeces can be used as fertiliser and soil conditioner after composting. This handbook describes mainly how the composting of faeces is done.



Figure 1. Example of a urine diverting dry toilet in porcelain.

Nutrient content in urine and faeces

Most of the nitrogen and about 2/3 of the phosphorous in the toilet waste is present in the urine, see table below. The concentrations in human urine from urine-diverting toilets, including some flush water, is similar to that of cow manure, about 3 g N/l urine and 0,2 g P/l urine. Urine is a good nitrogen fertiliser, with similar effects as chemical fertilisers, and should be used for leafy vegetables and other nitrogen demanding plants.

Table 1. Nutrient content in urine and faeces.¹

Fraction	Amount (kg/person, year)	N (kg/person, year)	P (kg/person, year)	K (kg/person, year)
Urine	550	4	0,37	1
Faeces + toiletpaper	60	0,55	0,18	0,36
Total	610	4,55	0,55	1,36

The faecal fraction has a lower nutrient content than urine, and has also a lower plant availability, as the nutrients mainly are organically bound and therefore latent. The organic matter can contribute to the soil by e.g. improving soil structure and increasing water holding capacity.

Use of urine

Before using the urine from a public toilet or a larger system of toilets, as a fertiliser, it needs to be hygienically safe. This is done by storage for a certain period of time, see table below. If the collected urine is coming from a family and will be used in their own garden, storage is not needed.

The urine should be applied to the plants during the growing season, when the plants can use the nutrients, and not during late autumn or winter.

¹ Jönsson et al. Guidelines of the use of urine and faeces in crop production. EcoSanRes Report 2004-2.

Table 2. Recommended storage times for urine mixture^a based on estimated pathogen content^b and recommended crops for larger systems^c

Storage temperature	Storage period	Possible pathogens in the urine mixture after storage	Recommended crops
4 °C	≥ 1 month	Viruses, protozoa	Food and fodder crops that are to be processed
4 °C	≥ 6 months	Viruses	Food crops that are to be processed, fodder crops ^d
20 °C	≥ 1 month	Viruses	Food crops that are to be processed, fodder crops ^d
20 °C	≥ 6 months	Probably none	All crops ^e

a) Urine or urine and water. When diluted, it is assumed that the urine mixture has a pH of at least 8.8 and a nitrogen concentration of at least 1 g/l.
b) Gram-positive bacteria and spore-forming bacteria are not included in the underlying risk assessments, but are not normally recognized as a cause of any infections of concern.
c) A larger system in this case is a system where the urine mixture is used to fertilize crops that will be consumed by individuals other than members of the household from whom the urine was collected.
d) Not grasslands for production of fodder.
e) For food crops that are consumed raw, it is recommended that the urine be applied at least one month before harvesting and that it be incorporated into the ground if the edible parts grow above the soil surface.

(Table from WHO guidelines for the safe use of wastewater, excreta and greywater. Volume 1.)

Collection of dry faeces

Before starting to use the urine diverting dry toilet, cover the bottom of the collection container with litter material. A biodegradable bag, e.g. paper bag, can also be used for easier handling and to keep the collection container clean.

Depending on how often the toilet is used, and the size of collection container, the interval of emptying the faecal container varies. It is recommended to empty at least once a month in a household, to make the procedure smooth.



Figure 2. Useful barrow for easy transport of faeces to the compost

Faecal composting

Before starting to compost your faecal material, contact the local authorities to check if a registration or permission is needed.

Why composting?

By composting the faecal material from the toilet, pathogens are killed and the material is safe to use as a soil conditioner in the garden for e.g. berry bushes, trees and flowers. Moreover the material is reduced in volume and weight, have no odour, and can be manageable.

Composting process

Composting is a degradable process where the temperature increases in the organic material. Temperatures above 50 °C are needed to sanitise the material. However, faecal composting based entirely on faeces is often not enough to achieve high temperatures. Co-composting faeces with organic food waste can enhance the temperature development and its stability and may be necessary when faeces have been collected during a long period. But even if the temperature is not increased some sanitisation occurs. The high microbial activity kills many pathogens even if the temperature is low but the result is of course a less safe compost product. Since it is difficult to ensure that the temperature has risen above 50 °C in the whole volume, a long composting/storage period is generally recommended.

Composting is an auto-heated, aerobic decomposition process. Organic matter is partially oxidized and through biological and chemical processes converted to residues with increased resistance to biodegradation. As a result, heat and water are evolved together with a variety of gaseous

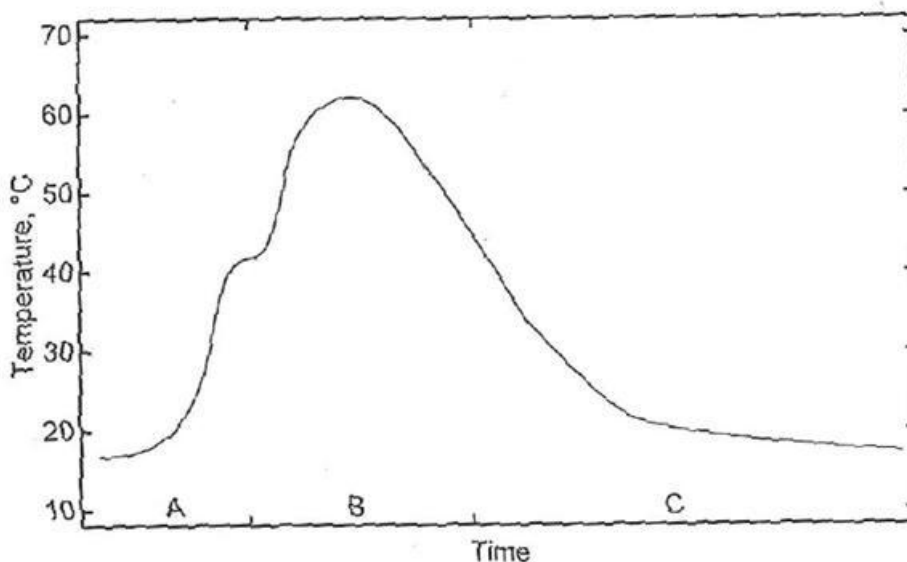


Figure 3. Typical temperature development during composting showing the mesophilic (A), thermophilic (B) and cooling (C) phases.

products such as carbon dioxide and ammonia. The process involves microbial succession characterized by a mesophilic phase (25- 45°C) and a thermophilic phase (45-80°C). Thereafter composting is characterised by a cooling phase (Fig. 2). Composting is run by microorganisms and therefore the process is basically dependent on air, water and nutrient supply.

Sanitation

Pathogens are inactivated in the environment over time depending on a combination of factors such as moisture, temperature, pH, carbon content and nutrient availability. Microbial competition for nutrients and antagonistic behaviour may also contribute to the reduction of pathogenic microorganisms. To assure a hygienic compost product, the temperature increase is very important. Almost all pathogens are killed above 50°C. The compost material must reach 50°C during one week. To be sure all organic material is safely treated, the compost heap has to be turned carefully **three times** during this week. To be able to reach a high temperature the heap has to be big enough to create heat and the compost box efficiently insulated and ventilated. The temperature increase is favoured by adding organic household waste, called co-composting.



If 50°C is not reached during one week the process is regarded as storage, and the human excreta needs a long storage period to be safe. This means **at least one year** before the material can be used in the garden as soil improver. Long storage is not as safe as composting and the sanitation process is uncontrolled.

Compost container

A compost batch must rest for at least one year which means two containers are needed for acceptable handling. There are several human excreta compost containers on the market. A compost container should fulfil the following construction demands:

- Two containers, separated from each other
- Water tight floor
- Tight-fitting lid
- Good ventilation
- Protected from birds, rats or insects (insect nets)
- Robust



Figure 4. Prefabricated compost container.

Measures and material

The required size of the compost containers is dependent on how much the toilet is used. Below is a table with volumes needed for summer houses and permanent-living.

Table 3. Recommended compost volumes* for one family-households.

Summer houses	Permanent houses
Latrine composting Two containers taking 350 liters each	Latrine composting Two containers taking 680 liters each or three containers taking 500 liters each
Co-composting Two containers taking 500 liters each	Co-composting Two containers taking 750 liters each or three containers taking 500 liters each

*When calculating on the volume, the inner volume of the container should be used.

The container can be made of wood, plastic or other robust material. If wood is used, it must be free from toxic wood impregnation chemicals, such as arsenic.

Location of compost

When choosing the place of your compost, the following aspects should be considered:

- Placed above the ground in the garden
- The place should not be covered with water at any point during the year
- The place should be warm and wind protected, rather in shade than in direct sunlight
- At close distance to the toilet
- Easy to reach also during winter time
- Not too close to neighbours (>5 m) without asking them
- No closer than about 20 m from a water supply, e.g. a groundwater well

Build your own compost container

By building your own compost containers you can reduce the costs and adapt the system to local conditions in your garden. The compost can be built in wood, and it can be built with prefabricated parts. If using planks the following standard measures can be used:

Planks e.g. 21 x 120 mm

Crossbars e.g. 45 x 95 mm

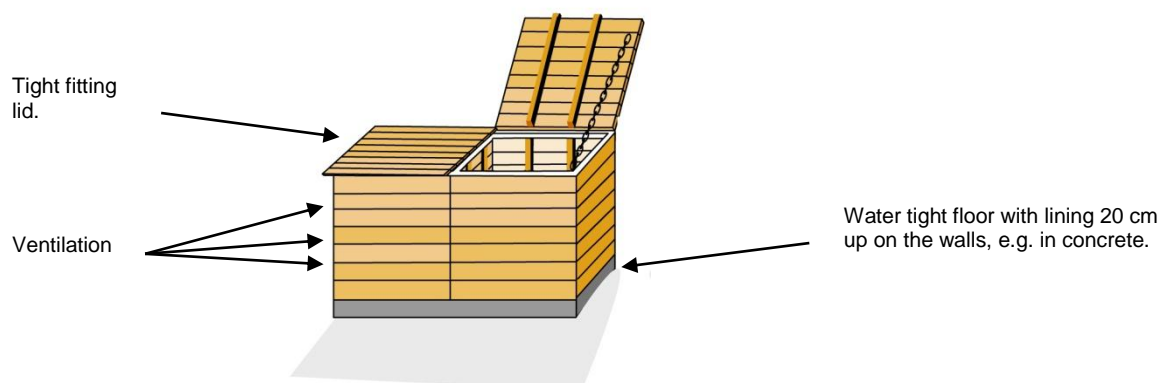


Figure 5. Example of a simple design for a faecal compost.

The **size required** is dependent on how much the toilet is used, see *Measures and material* above. Below are examples of minimum measures for two different sizes of compost.

350 liters (one chamber)	Cylinder (cm)	70 in diameter, 90 height
	Square(cm)	60 length*60 width*100 height
500 liters (one chamber)	Cylinder (cm)	80 in diameter, 100 height
	Square (cm)	70 length*70 width*100 height

A **water tight floor** is needed to avoid pathogens from the compost reaching the ground by leaching. The most permanent, e.g. for a bigger compost, is to build the floor in concrete. A simpler solution is to line the floor with a thick plastic sheet. Either way, the water tight lining should cover about 20 cm up on the walls.

The lid should be tight fitting and rodent safe to stop rats and birds from getting in. The lid can be made of planks of a smaller dimension than the rest of the container or in a lighter material, to make it easier to lift.

To **facilitate emptying** of the compost container, the front wall can be fastened to the other walls by hasps, or wing nuts. In that way the wall can easily be detached and the composted material can be removed with little effort.

The compost **container should be ventilated**, to enable air to enter to the compost material. If the container is built with planks, the slots between the planks will be enough to aerate the compost. Ventilation holes can also be drilled into the walls. If the holes or slots are too wide, they should be covered by a net, to prevent rats or birds to enter.

A simple way to build a compost is to screw together four pre-fabricated duckboards (e.g. 80*80 cm) from the building store, put a thick plastic sheet on the bottom, cover the container with net and isolate it during the cold months.

Another example is taking a plastic cylindrical container with a lid, drill small ventilation holes in the upper half, and start using it! To mix and oxygenate the material, the barrel can be tipped over and rolled a few turns. Just make sure the lid is fastened. When the first barrel is full, put it aside to rest and start with a new one.



Figure 6. Plastic barrels are used for different liquids. Used barrels can often be bought cheaply.

Maintenance

How to start the composting?

Start with covering the container bottom with at least 10 cm of peat moss or similar litter material. The peat helps to avoid leaching and ventilation. Fill with faeces and toilet papers. For better composting mix the faeces with dry and energy rich organic material. Co-composting with organic food waste is improving the compost process.

How to run your compost?

The faecal matter has a water content of about 80 %, ideal compost condition is 50-60 % water content. The compost must be mixed up with drier material, see examples of adding materials in table 4. The adding material volume can be about a third of the faecal matter volume. The right water content is when the compost material is moist, but not so wet that it is leaching.

The faecal matter has low carbon content and the compost needs extra energy rich material for efficient degradation. Many of the suggested adding materials are both dry and energy rich (table 4).

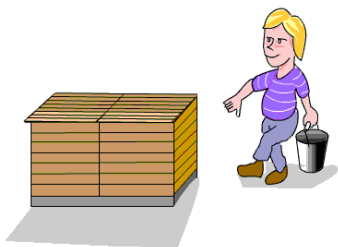


Figure 7. Good increase in temperature is achieved when faecal matter and food waste is co-composted with old compost, straw or chopped twigs.

To avoid the compost material becoming a compact mass, a structure material is needed. Mixing in chopped twigs, straw or sawdust is excellent for obtaining a porous material where air can enter.

Table 4. Examples of adding material and their functions in a compost

Adding material	Dry material	Energy rich material (carbon rich)	Structure material
Old compost	x		
Paper	x	x	
Grass cut	x		
Straw	x	x	x
Food waste		x	
Saw dust	x	x	x
Chopped twigs			x
Peat	x		x

To spread the material evenly in the compost, and to get a better oxygenation of the compost, the compost can be turned a few times during the compost period. Turning can be done with a spade or a manure fork. It is enough if only the upper layer is turned.



Figure 8. A manure fork is useful for turning the compost.

Composting period

When the container is filled to two thirds, it is full. If the faeces are wet put extra litter material and to avoid flies put peat moss on the compost top. The compost heap must rest (sanitise) **at least one year** without adding new faeces, before use as soil improver. If needed for use in soil with growing vegetables two years rest is needed. WHO guidelines for safe use of excreta recommend **1,5-2 years of storage** before use of faeces at household and municipal levels.

After composting

Handling of compost soil

Use gloves and boots when handling the compost material, even after the composting period. Wash your hands afterwards. It is important to cover the compost material with soil directly after spreading to avoid contact with people and animals.

Use as fertilizer on edible and non-edible crops

Faecal compost has a lower nutrient value than urine, but still has a rather high content of phosphorous (P) and potassium (K). The faecal compost is valuable to crop production both for its fertilising effect and its effect as a soil conditioner.

The mature compost product can be spread and used in the garden, for example when establishing a lawn or in a flowerbed. It can also be used when planting trees. Dig a hole, put compost in the bottom of the hole, place the tree-plant, and cover with soil. This will stimulate the early growth of the tree.

Recommended area is about 10 m² per person and year for spreading the composted faecal material (from permanent-living). It is important not to over-fertilize, because of the risk of nutrient leaching.

If the compost soil is used for growing vegetables meant to be eaten fresh, like carrots and lettuce, two growing seasons should pass between spreading the compost and harvesting. This means that where compost is spread autumn 2012, growing carrots can earliest be done 2014. For e.g. potatoes, fruit trees and berry bushes, one growing season should pass between application of composted material and harvest. Flowers and other plants not meant for human consumption need shorter time between spreading of compost and harvest, so they can be fertilized with composted faeces also during the growing season.

FAQ (Frequently asked questions)

- *How safe is faecal composting?* After excretion, the concentration of enteric pathogens usually declines with time by death or loss of infectivity of a proportion of the organisms. Protozoa and viruses are unable to grow in the environment outside the host, thus their numbers will always decrease, whereas bacteria may multiply under favorable environmental conditions. Helminths may need a latency period after excretion before being infective. That means faecal composting is not 100 % safe regarding infectious matters and it's important to use long sanitation time before growing vegetables on the compost. An efficient pathogen reduction need compost temperature over 50°C during one week with several turnings.
- *Are there any chemical sanitation?* Sanitation of faeces can be achieved by mixing them with urea. Urea is degraded to ammonia which is toxic to microbes. Adding ash and lime increase pH which also means higher concentration of ammonia. This treatment need to be performed in a closed container.
- *What is the best faecal mixture?* To include kitchen waste is a good way to optimize the compost process. Be aware of the fact that

the volume of the containers must be bigger when extra waste is included.

- *What are the environmental problems?* Odour, flies and rats can give problems. To avoid odour – have no standing water in the compost. For less flies - put peat moss on the material to keep the surface dry. Cover the container with a net to avoid rats.
- *Which litter material shall I use?* Material that are dry and can keep water like peat moss and chopped straw are good examples.
- *Must the two containers be similar?* No, but about the same size. It is good if both containers are insulated as the sanitation period is at least one year before use.

References:

Avloppsguiden (2011) <http://husagare.avloppsguiden.se/ta-hand-om-urin-latin-och-slam-på-din-egen-tomt.html>.

Beck-Friis, B. (2001) Emissions of ammonia, nitrous oxide and methane during composting of organic household waste. Doctoral thesis, SLU.

EcoSanRes (2004) Guidelines for the safe use of urine and faeces in ecological sanitation systems. Report 2004-1.

EcoSanRes (2004) Guidelines on the use of urine and faeces in crop production. Report 2004-2.

Jönsson, H., et al. (2005) Composition of urine, faeces, greywater and biowaste for utilization in the URWARE model. In Urban water Rapport Chalmers University of Technology.

Nordin, A. (2010). Ammonia sanitisation of human excreta. Doctoral thesis, SLU.

Norrtälje kommun (2011) Eget omhändertagande av toalettavfall. Bygg- och miljökontoret. www.norrtalje.se

WHO (2006) Guidelines for safe Safe Use of Wastewater, Excreta and Greywater, vol 4. Geneva: World Health Organisation.

Vinnerås B., (2002) Possibilities for sustainable nutrient recycling by faecal separation combined with urine diversion. Doctoral thesis, SLU.