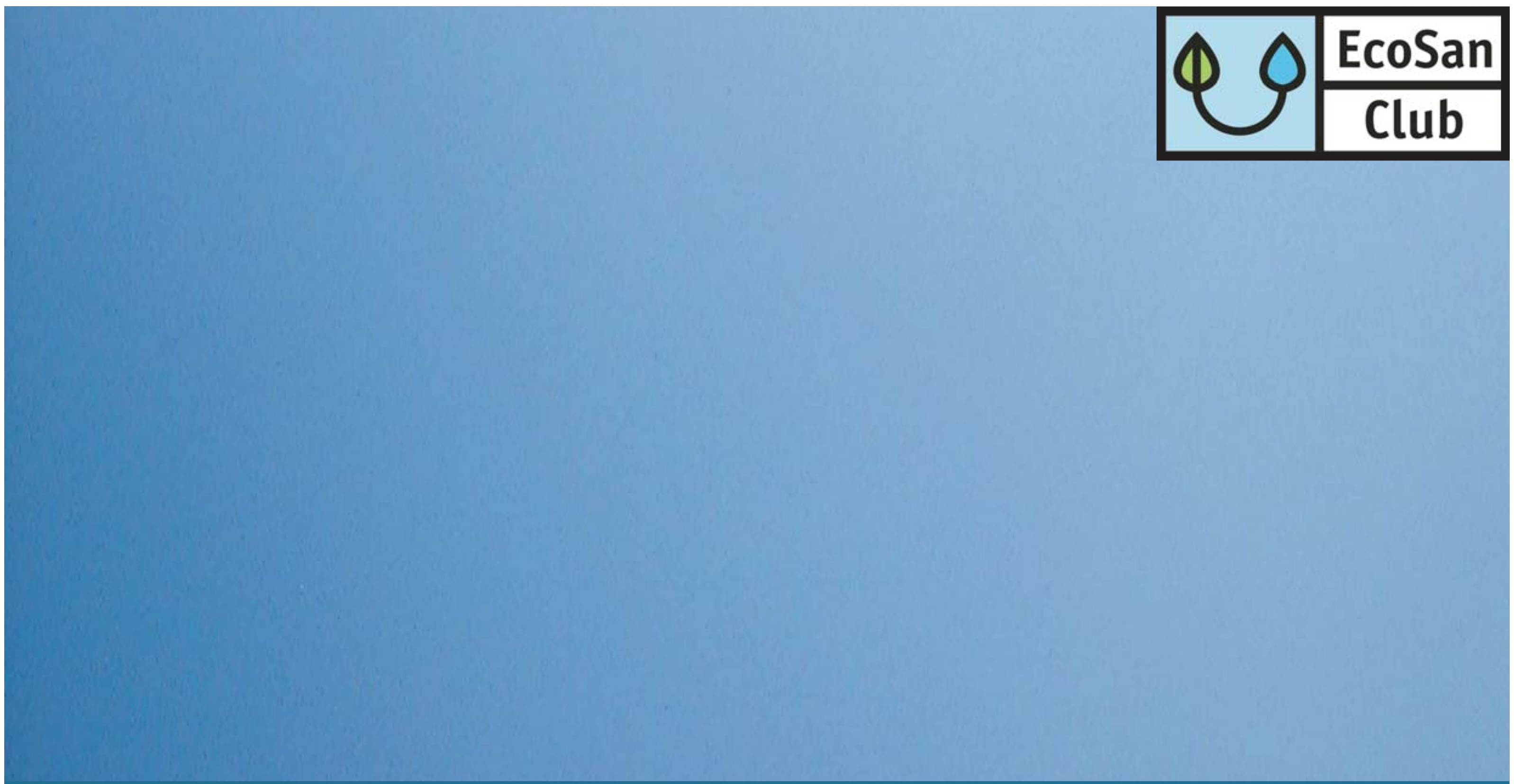

Dry Toilets

EcoSan Club Manuals - Volume 2

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This manual can be downloaded from www.ecosan.at

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0 Foreword

This series of manuals was initiated in 2003 when the EcoSan Club was contracted to carry out training workshops for hospital and health centre technical staff in Uganda. The objective of these workshops was to create a certain understanding of the problems associated with water supply and sanitation infrastructure at these institutions and enable their technical staff to operate and maintain existing infrastructure as well as participate closely in the technical design of new units or even design them by themselves.

Consequently these manuals are meant to provide guidelines for practical implementation. In addition to providing an overview on the theoretical background the emphasise lies on the demonstration of practical solutions.

This particular manual deals with two types of dry toilets – urine diversion and composting. The motivation behind this choice of topic was that even though, in particular in Uganda, a substantial number of dry toilets are being constructed but still an unnecessary high percentage of those toilets are not functioning properly. In many cases, apart from improper use, the reason can be found in simple mistakes in design and construction. In this sense this manual aims at people designing, constructing and operating dry toilets. It summarises own experience with dry toilets as well as experiences from other organisations and individuals involved in dry toilet design, construction and use.

1 Introduction

1.1 Human Excreta Management

Generally the main purpose of human excreta management is to avoid spreading of diseases and mitigate environmental pollution. Any practice which does not perform well with regard to these objectives must not be considered proper management of human excreta (see Picture 1).

The sanitation practices that are promoted today fall into two broad categories: 'flush and discharge' and 'drop and store'. Flush and discharge is still regarded as the ideal technology especially for urban areas. For those who cannot afford the flush and discharge, the conventional alternative is the drop and store, which is usually a pit latrine working on the principle of "indefinite" storage of human excreta. Drop and store is usually regarded as a temporary, inferior solution compared to the flush and discharge. Flush and discharge approaches can work well and under ideal conditions achieve a certain level of pathogen destruction. However it is being estimated that only app. 5% of the sewage from cities in the Southern Hemisphere is treated in any way.

Although drop and store technologies can prevent pollution in some places, very often they are not feasible because of lack of space for digging deep pits, difficult soil and ground water conditions, destabilisation conditions of nearby houses and odours.

Picture 1: Wastewater discharged from houses onto road (Gulu, Northern Uganda)

Nutrients, pathogens and other pollutants seeping from poor flush toilets, pit latrines and septic tanks have been documented as a cause of contamination to ground water and nearby surface waters throughout the world.

1.2 The Water & Nutrients Cycles

Human settlements are points were the water cycle gets in contact with other material flows, among others nutrients but also pollutants from human excreta and other human activities. Talking about human excreta management in relation to the water cycle the main aim must be to

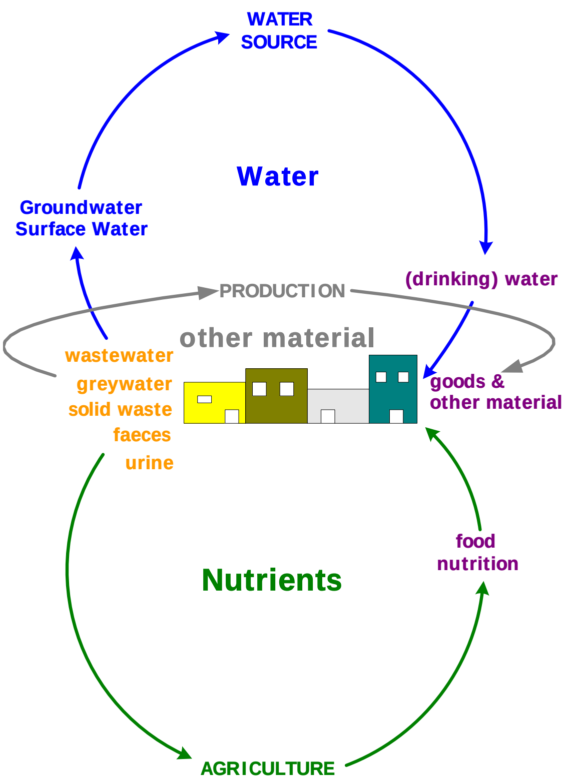


Figure 2: The Water and Nutrient Cycles

assure that the pollution of the water cycle by human excreta is as much reduced as possible. Ideally the contact between the two cycles is avoided at all. As soon as the two cycles carrying water and human excreta are mixed, technologies to separate the two fractions at a later point will have to be implemented. A high performance of such separation technologies goes hand in hand with an exponential increase in investment as well as operation and maintenance cost.

1.3 The Planning Process

It is believed that the main problems in sanitation are not so much caused by a lack of appropriate, affordable, manageable and acceptable technical solutions but rather a lack of (applying) suitable planning approaches. A technical solution which may be ideal from a technical point of view does not necessarily fulfil the requirements of the users. Therefore at this point it must be emphasised that the implementation of dry toilets does not start with the technical design. A planning process will be required which allows to define the future users' priorities. These priorities are

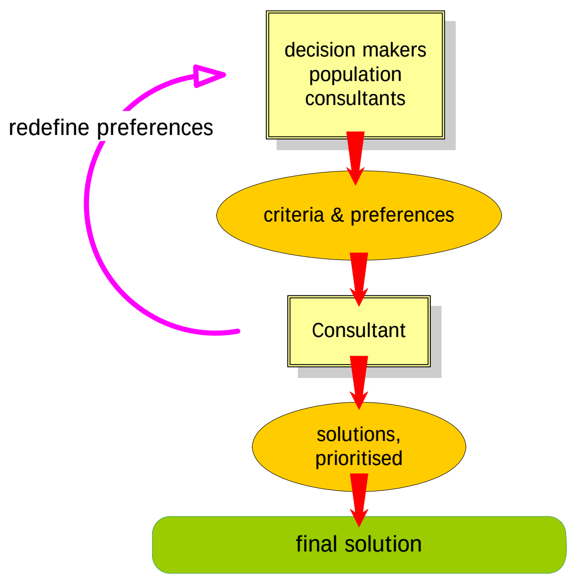


Figure 1: Participatory Planning

the framework conditions within which the technical design must be placed. Consequently, although there are general principals to be followed in designing a dry toilet, copying of standard designs is not recommended. Different facilities and designs need to be:

- acceptable,
- affordable and
- manageable,

and therefore consider local conditions. This is done by following the above described planning process.

Although this manual only serves to summarise information on the technical design of dry toilets the importance of a preliminary planning process must not be neglected.

2 Definition

2.1 Toilet, Latrine, Bathroom, etc.

From out of the numerous terms used to describe both the room and the device used for easing oneself for the purpose of this manual the following terms are used:

- the room where one urinates/defecates
  - bathroom
- the actual mechanism you sit down on or squat
  - toilet
- a hole in the ground
  - latrine

Bear in mind that different people may use different words to describe the above functions, in particular when referring to the room:

bathroom	little boys'/girls' room
bog	khazi
can	John
cloakroom	ladies'
convenience	ladies'/ men's room
toilet	ladies'/ men's lounge
facility or facilities	lavatory
loo	gentlemen's
men's	washroom
place of easement	gents
powder room	necessary
privy	throne
restroom	water chamber
smallest room	water closet (or WC)

2.2 Dry Toilet

Following the above definition a dry toilet is a device used in a bathroom (substitute with one of the words above which suits you best) for easing oneself. It is a device which does not use any fluids (water) thus remaining "dry". A pit latrine, though not using water, does not use any device and can therefore not be considered a dry toilet.

In addition and contrary to other types of toilets, below the immediately visible part of the dry toilet (partial) treatment of the human excreta takes place "on site". These compartments, including all installations, are therefore to be considered an integral part of the dry toilet.

3 Types of Dry Toilets

3.1 Urine Diversion Dehydration Toilet

A urine diversion dehydration toilet is based on

1. the diversion of urine and faeces,
2. separate collection and storage of the two fractions and
3. pathogen destruction by dehydration/drying of faeces (primary treatment).

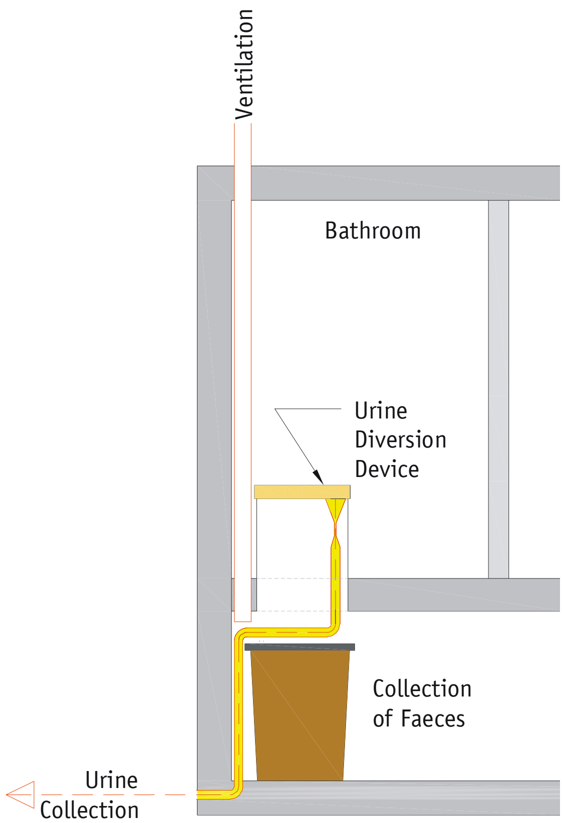


Figure 3: Dry Toilet

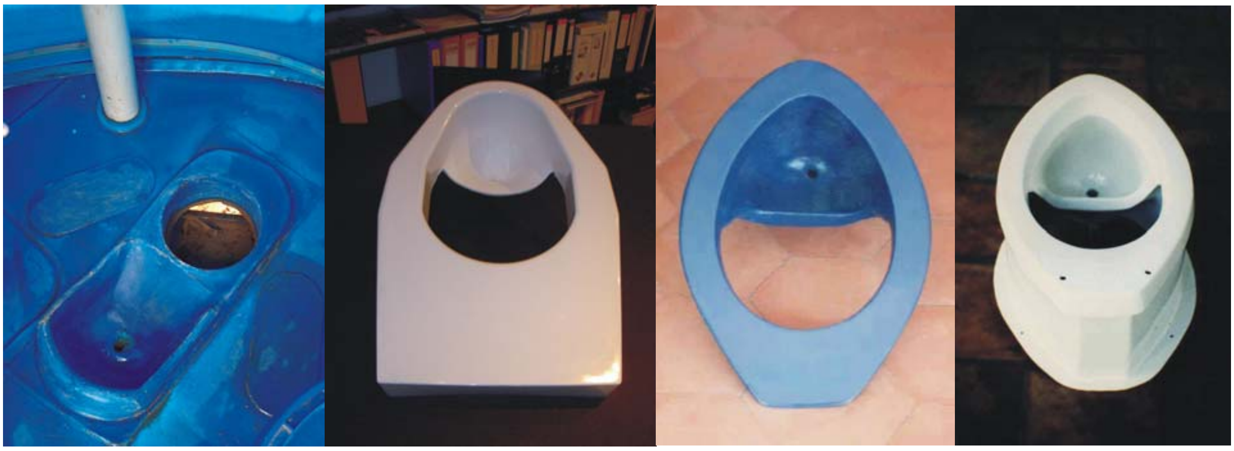
The separate collection of urine and faeces will result in the following advantages:

- urine under normal circumstances contains few pathogenic micro-organisms and does therefore not require extensive treatment before disposal/reuse
- the water content of the separately collected faeces is strongly reduced which facilitates the drying process and significantly reduces the volume which has to be dealt with
- the low water content of the faeces will facilitate aerobic conditions thus minimising the creation of smell

3.1.1 Diversion

A urine diversion toilet requires a specially designed squatting pan or toilet seat (compare Picture 2). Common to all designs is a dividing wall, to allow the separate collection of urine and faeces. Urine passes in front of the wall, faeces behind the wall. Various different types are readily available or can be locally constructed.

It must be taken into consideration that the seat, resp. the squatting pan is the only visible part of the toilet thus being an important factor for acceptability. For this reason special attention must be given to the design, construction / manufacturing and installation of this part of the dry toilet.



Picture 2: Different types of urine diversion devices

3.1.2 Storage

Both fractions – urine and faeces – have to be stored before further treatment, reuse or disposal.

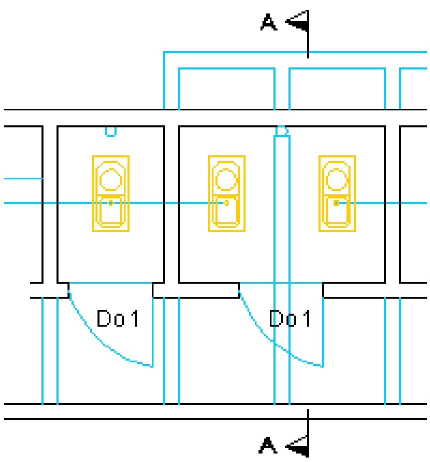
The type of containers used for storage of urine will have to be selected according to how the urine will later be transported and/or used further. Everything from a jerry can, which can simply be carried, to a big tank, which may require a cesspool emptier, can be used. Generally it is assumed that no particular conditions have to be met when storing urine. Obviously longer storage periods will result in increased pathogen die off and higher loss of Ammonium although available experience suggests that the losses are usually low. Disinfection of human urine by storage is mainly due to a combination of low content of organic matter, high amount of free ammonia and high pH. After six months of storage at ≥20°C, the urine can be used as a fertiliser even for foods consumed raw by humans. Direct infiltration of urine, although possible and usually related with comparatively low risk for the environment, is not recommended.

Faeces will be collected either directly in the chamber or in a container beneath the

Picture 3: Basket for collection and storage of faeces (Naggalama Hospital, Uganda)

bathroom. The number of pathogens is reduced as a consequence of the storage time, dehydration and increase in pH value (by adding lime or ash). Generally dry urine diversion toilets are designed to store faeces for a period of 6 to 12 months before faeces may be moved to a secondary treatment step (e.g. composting), depending on the required quality of the final product. Urine diversion toilets therefore require one compartment to collect faeces and a separate compartment to store them for a period of 6 to 12 months.

Therefore with regard to storing faeces dry urine diversion toilets can be divided into single and double vault systems. Double vault systems use two separate chambers



Picture 5: Single (l.) and double (r.) vault toilet – plan view

below the bathroom. While one is being used to collect faeces the other stores faeces for the required period of at least 6 months. As soon as the second chamber is filled up the first chamber is emptied and used again. Obviously the fixed volume of the chamber is a limit to the number of users. Too many users might require the chamber to be emptied before the required storage period ends. Single vault systems therefore use a container to collect faeces and a separate place for

Picture 4: Covered Area for further storage of dried faeces

storage. The container can be replaced any time by a new one. Often a plastic sack inside the container is used which can easily be replaced and furthermore minimises the risk of getting into contact with faeces while emptying the toilet.

The use of more containers, resp. plastic sacks allows the adjustment of the storage volume to the actual use. Adequate room for storage may be provided at any appropriate location.

Additionally equipping the storage compartment with a (solar) heating system may be considered to increase the temperature.

3.1.3 Pathogen destruction

Pathogenic organisms' die off rates are increased by:

- high temperature (commonly micro-organisms survive at low temperatures while higher temperatures (>40° C) increases die-off rates)
- high pH values (high pH values will inactivate micro-organisms; pH can be increased by adding lime or ash)
- low humidity (high humidity favours the survival of micro-organisms)
- UV radiation (pathogens, e.g. when faeces are reused on soil surfaces will die-off by UV radiation)
- presence of other organisms (die-off rates of micro-organisms can be increased by the presence of other organisms due to e.g. by predation, release of antagonistic substances or competition for nutrients)
- oxygen (enteric bacteria are mostly anaerobic)

Therefore the storage conditions of faeces have to be adjusted accordingly.

3.2 Composting Toilet

Composting is the decomposition of plant remains and other once-living materials to make an earthy, dark, crumbly substance which is called humus. In composting toilets human faeces with or without urine are collected and stored in a processing chamber along with organic household wastes and garden refuse and bulking agents (straw, twigs, etc) and composted. Good composting is a matter of providing the proper environmental conditions for microbial life. The process of decomposition reduces the heap to less than 10% of the original volume. The amount of humus produced varies from 10 to 30 litres per person per year.

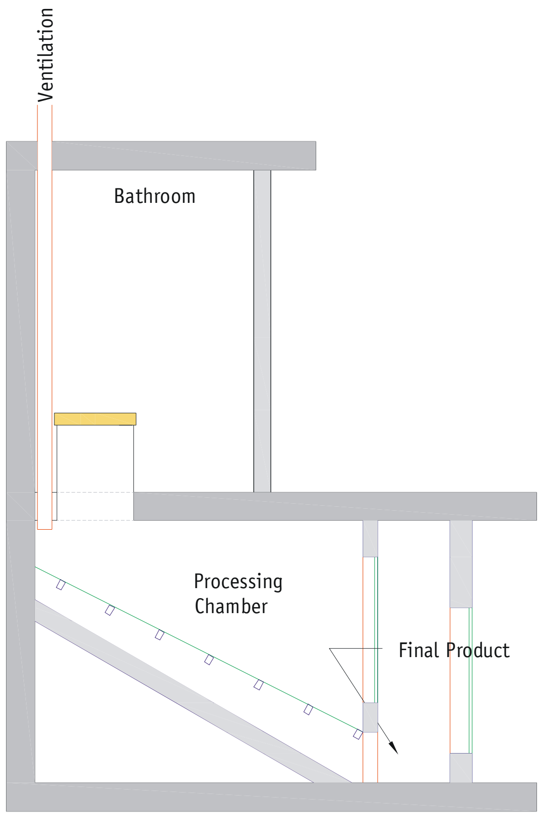


Figure 4: Composting Toilet

3.2.1 Environmental conditions

Composting is a biological process which occurs under special conditions:

- moisture content app. 60%

  By adding bulking agent like dry grass, clippings, sawdust or kitchen refuse the water content can be adjusted. High water content will result in anaerobic conditions while low water content will slow the composting process. In dry climates, it may be necessary to water the pile occasionally to maintain proper water content. The addition of layers of finely chopped carbon-rich material also helps to provide oxygen to the pile and to achieve rapid and complete decomposition.

- increasing of the pH

  Adding ash can raise the pH value.

- high temperatures

  Biological activity will increase as temperature increases. Generally it can be assumed that increasing the temperature by 10° will double the biological activity.

- adequate aeration

  When there are high moisture content and insufficient bulking materials to increase pore space, oxygen is restricted to the outer surface of the heap. Thus, stirring or turning over the compost heap is important to encourage growth of aerobic biodegradation microbes.

- ratio carbon to nitrogen 15:1 to 30:1

  The carbon to nitrogen ratio in human excreta is normally too high in relation to the required optimum. Therefore the addition of bulking agents does not only help to adjust the water content but also reduce the carbon to nitrogen ratio.

- adequate storage period (6-8 month)

  When composting human excreta the required storage time is not defined by the question when the compost is finished but rather the complete destruction of pathogens. A storage period of 6 to 8 months is considered appropriate, higher temperatures, as can be observed under ideal composting conditions, will increase the pathogen die-off rates.

3.2.2 Storage

Depending on whether a urine diversion is used, the two fractions – urine and faeces – are either stored separately or together in the storage chamber. With regard to the separate storage of urine it is referred to section 3.1.2.

The storage of faeces, resp. the mixture of faeces and urine has to assure ideal environmental conditions for the composting process.

- ratio carbon to nitrogen 15:1 to 30:1

  Sufficient volume must be foreseen to allow the addition of carbon rich material (up to 5 times the weight of excreta), particularly if urine is not collected separately. Regular mixing assures good mixing of carbon rich material and faeces. Mixing can be done by manual turning. Another possibility is to equip the storage chamber with a sufficiently sloping floor which will cause the pile to move slowly downwards. This downward movement results also in a certain mixing of the pile.

- adequate aeration

  Regular mixing of the pile also increases the pore volume (comp. above). Additionally sufficient aeration of the storage chamber and the compost pile (by perforated air pipes) should be considered.

- storage period

  The volume of the storage chamber should be designed assuming that huge amounts of carbon rich material has to be mixed with the faeces and still a storage period of 6 to 12 months kept.

- high temperature

  Equipping the storage chamber with a solar heating system may be considered to increase the temperature.

3.2.3 Pathogen Destruction

Destruction of pathogens in composting toilets is a function of temperature and storage time. The temperature of the pile depends, apart from external sources, e.g. solar heating, on the microbiological activity. The addition of large amounts of carbon rich material (up to 5 times the weight of excreta) and sufficient provision of oxygen will increase the biological activity. Since practical experiences show that keeping sufficiently high temperatures (above 60°) is rarely achieved in composting toilets, a sufficiently long storage period should be considered. Keeping a storage time of 6 to 12 months will allow for pathogen die-off also at lower temperatures.

Although as mentioned earlier the ideal water content is around 60% investigations show that in many cases the water content of composting toilets, in particular if equipped with urine diversion, is below 40%. Therefore in many cases the main reason for pathogen die-off, although not planned, is desiccation of the excreta.

4 Technical Design

4.1 Design Data

4.1.1 Quantity of human excreta

Each person produces <u>within one year</u> app.:

Urine

volume....................500 liters

Faeces

volume..................... 50 liters

dry mass...................... 11 kg

water content ....80 %

4.1.2 Quality of human excreta

The sections below give a brief overview on the composition of human excreta, With regard to more details it is referred to the Manual "Reuse of biosolids in Agriculture".

<u>Nutrients</u>

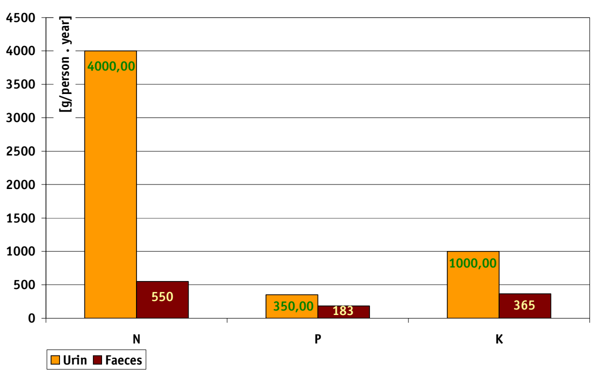


Figure 6: Nutrients in Urine and Faeces

The largest nutrient and smallest heavy metal contents are found in

urine, the second most nutrient-containing fraction is the faecal matter. The nutrient content depends on the diet. Therefore the values given in Figure 6 will vary, depending on the actual diet.

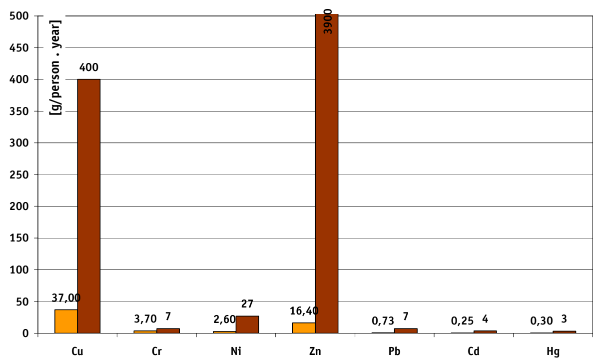


Figure 5: Heavy Metals in Urine and Faeces

Studies showed that for, e.g., Uganda the nutrient contents can be up to 40%.

<u>Pathogens</u>

The urine in a healthy person's bladder is usually sterile. Only when transported out of the body different types of dermal bacteria are picked up. Therefore fresh urine may contain <10 000 bacteria per ml. Infections of the urinary tract naturally result in significantly higher amounts of bacteria. The pathogens known to be excreted in urine (Leptospira interrogans, Salmonella typhi, Salmonella paratyphi and Schistosoma haematobium) are rarely sufficiently common in urine to constitute a significant public health problem in temperate climates. An exception in tropical areas is Schistosoma haematobium, although it's lifecycle implies a low risk (a freshwater snail is needed as an intermediate host).

The majority of pathogens can be found in faeces. A long list of bacteria, viruses, worms and protozoa can eventually be present in human excreta. Primary and secondary treatment before reuse is therefore mandatory contrary to urine where storage is usually sufficient.

Heavy Metals

Essential heavy metals like Cu, Cr, Ni and Zn are present in the diet and consequently can be found in human excreta. Non essential heavy metals, like lead (Pb), Cadmium (Cd) or Mercury (Hg) find their way into human excreta through polluted food.

Hormones and pharmaceutical residues

A large proportion of the hormones produced by our bodies and the pharmaceuticals that we consume are excreted with the urine. Although detailed studies on the fate of these substances when being applied with human excreta as fertiliser still show a significant knowledge gap it can be assumed that for both hormones and pharmaceutical substances, it seems far better to recycle urine and faeces to arable land than to flush them into recipient waters.

4.2 Storage & Treatment

4.2.1 Urine

Urine needs to be stored a) to await further use and b) to inactivate pathogens. While a) is defined by the demand for urine, b) depends on whether urine is reused within a single household or larger systems. For single households urine can be used without storage for all type of crops, if the last application of urine is done at least one month before harvesting.

The general recommendation of storage is mainly aimed at reducing the risks from consuming urine-fertilized crops. It will also reduce the risk for the person handling and applying the urine.

Specific recommendations for large-scale systems may need to be adapted, based

Storage time	Possible pathogens in the urine after storage	Recommended crops
≥1 month	Viruses	Food crops that are to be processed, fodder crops
≥6 months	None	All crops

Table 1: Recommended storage time for urine (adapted from Schönning and Stenström 2004)

on local conditions. Nevertheless general recommendations for a storage temperature $\geq$ 20°C are summarised in Table 1.

Such the required urine storage volume can be calculated using the formula below:

$$V_{urine} = {}^{500}\!/_{12} \times n \times t \quad \text{Formula 1}$$

where:

V_{urine}....minimum storage volume [litres]
n........number of users
t ....minimum storage period [months]
The storage volume can be divided onto more than one tank / container.

4.2.2 Faeces

Natural die-off of pathogens in faeces with time requires a certain storage period under suitable conditions (low humidity, high temperature, high pH) of faeces before further safe use/disposal. Simple storage at ambient temperature, pH and moisture is therefore not considered safe practice except if the storage time is for years. Therefore storage will have to be considered as primary treatment only whereas in order to make human excreta sufficiently safe for reuse secondary treatment is required.

<u>Primary Treatment</u>

In addition to a certain degree of pathogen reduction, storing faeces will also reduce the volume of the faeces to help facilitate transport. Faeces are normally collected in a compartment beneath the toilet seat. The required volume for storage can also be located beneath the toilet seat (e.g. double vault systems) or elsewhere (single vault, container systems). The storage volume is designed to allow for a min. storage period of 6 months. Formula 2 considers a factor 2 for ash added to the faeces. For composting toilets the additional volume due to added bulking material must be considered.

$$V_{faeces} = {}^{50}\!/_{6} \times n \times t \quad \text{Formula 2}$$

where:

V_{faeces}...minimum storage volume [litres]
n........number of users
t ....minimum storage period [months]
In the case of a double vault system this volume must be available twice, once for collecting fresh faeces and once for storing them for the required period.

For a container system the volume of one container in relation to the total required storage volume defines the total required number of containers (if the contents of individual containers are stored separately).

Generally the bottom of the collection compartment beneath the toilet seat should be sloped to allow water (rainwater from ventilation pipe, excess water due to improper use, etc.) to flow outside. For composting toilets, where excess water may be highly polluted, connecting this flow to a treatment system should be considered.

Secondary Treatment

Secondary Treatment may be required to make human excreta sufficiently safe for application in agriculture. Although composting toilets are assumed to achieve an increased pathogen die-off rate due to the composting process, practice shows that rather than an ideal composting process, storage, desiccation or alkalisation occur. In such cases secondary treatment may be required.

Possible secondary treatment options are

- heating (e.g. thermophilic digestion, high temperature composting, solar heating,
- composting (comp. Manual ""Reuse of biosolids in Agriculture"),
- alkaline treatment / pH increase (addition of lime, ash, ...),
- additional storage (up to 18 months),
- incineration.

4.3 Ventilation

If human excreta are stored under the above described conditions there is nearly never a problem with smell. Still in case of excess humidity (faeces) or reducing conditions (urine) problems with smell may occur. Humans are generally very sensitive to bad smell; therefore special care must be given to the design of the ventilation system of the dry toilet.

The general aim is to assure airflow from the bathroom through the toilet to the vent pipe and above the roof.

Forced ventilation and natural ventilation must be differentiated. While forced ventilation requires less engineering skills, due to the additional cost and the introduction of an additional source of failure natural ventilation is to be preferred wherever possible.

4.3.1 Forced / mechanical ventilation

Forced ventilation is achieved by the use of fans, radial blowers, etc.. The advantage is that the direction of the airflow remains predictable under all circumstances. The obvious disadvantage is higher cost for installation and operation. The systems can generally be divided into exhaust only / supply only / balanced ventilation.

4.3.2 Natural ventilation (thermal duct ventilation)

The aim of the ventilation is to create airflow from the bathroom through the toilet seat / the squatting pan into the vent pipe and above the roof.

The thermal duct ventilation works due to outdoor and indoor temperature differences. Therefore, a vertical movement upwards is only possible if the indoor air temperature is higher compared with the ambient temperature. An inverted temperature ratio would be counterproductive and would cause a downward stream.

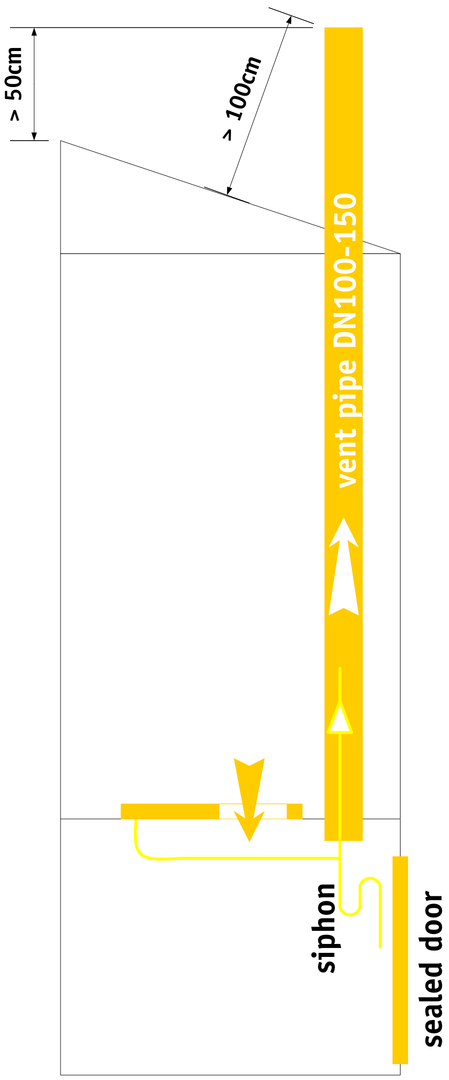


Figure 7: Ventilation

The following factors need to be taken into consideration when designing a natural ventilation system:

1. To reduce the possible causes for undefined airflow at first it has to be assured that there are only the two openings mentioned above to the collection chamber – the toilet seat/squat hole and the vent pipe. This can be achieved by a completely sealed collection chamber. Special care has to be taken when a collection chamber serves more than one toilet. In this case the airflow is undefined and measures must be taken to assure a sufficiently strong draught through the vent pipe upwards.

2. Wind – direction of main wind flow.

3. In the absence of wind airflow can only be caused by convection, i.e. flow of air due to differences in temperature. Having the vent pipe passing outside the building may result in the room temperature rising above the temperature in the vent pipe causing airflow into the wrong direction. Having the vent pipe passing through the bathroom at least assures equal temperature in the vent pipe and the bathroom. Painting the part of the vent pipe which protrudes above the roof black helps to absorb sunlight and increase the temperature.

4. Convection creates a rather small force, therefore the reduction of friction losses must be aimed at. Reasons for high losses are small diameter of the pipe, bends and too

closely covered vent pipes. With regard to the necessity to cover vent pipes it is referred to section 0.

5. Wind will cause a draft pulling air out of the pipe. For proper performance the vent pipe must extend sufficiently long above the roof. The longer distance, either defined by min. 50cm above the highest point of the roof or min. 100cm perpendicular distance from the pipe's top to the roof, should be chosen.
6. To eliminate potential smell problems caused by backflow of air from the urine tank a ventilated siphon may be foreseen. In most cases a siphon only without ventilation has proven sufficient to eliminate such problems.

4.3.3 Air-duct dimensioning

The stream equation represents the relation between the,

- air volume stream,
- the air duct cross-section and
- the stream velocity

$$V = A \times w$$ *Formula 3*

where:

V........Air volume stream [m³/s]
A........Air duct cross section [m²]
w ....Stream velocity [m/s]

The actual air volume stream is a function of the thermal buoyancy and the pressure loss in the air-duct.

The external pressure loss describes the pressure loss in air channels. Responsible for this losses are the,

- Resistance due to friction (pipe-friction)
- Resistance due to shaped pieces (bows, T-peaces..)
- Resistance due to components (supply air openings..)

The thermal buoyancy increases according to the temperature difference between outside and inside and the difference of height between inlet and outlet openings. Another operative parameter represents the density of the air. It varies according to temperature and therefore generates different pressure conditions.

Generally the following recommendations shall be observed:

- the diameter of the ventilation pipe should be > 100mm,
- bends, elbows, T's and other fittings shall be avoided,
- vent pipes shall not be covered,
- one vent pipe per toilet.

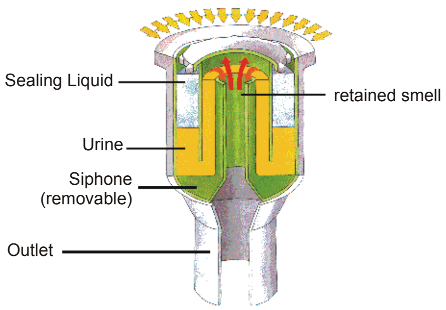
5 Urinals

One of the most common reasons for the malfunctioning of dry urine diversion toilets is excess humidity in the faeces compartment caused by misuse (insufficient separation). To reduce the risk it is recommend installing waterless urinals for men wherever possible.

The most common options for eliminating smell from waterless urinals (which can also applied for the urine diversion toilet) are

- oil seal

  A siphon is filled with a biologically degradable liquid with a density lower than water/urine. The liquid will always float on top of the urine. A siphon with a high cross section to reduce the flow velocity is preferable. The liquid will have to be topped up regularly.



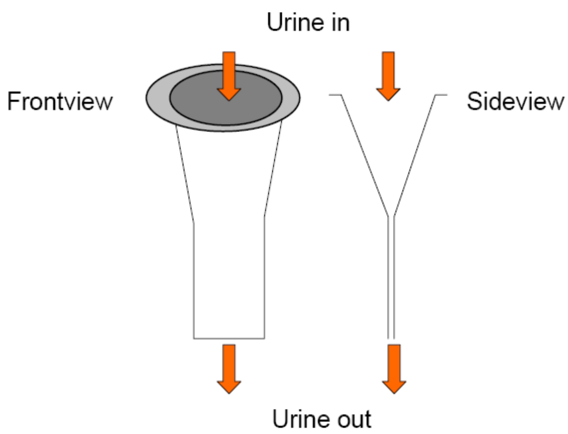
Picture 7: Trap with floating liquid

- air flush

  Either the urine pipe directly or before the inlet side of an ordinary siphon is connected to a vent pipe assuring airflow into the urine diversion. The only disadvantage is risk of reverse airflow.

- rubber seal

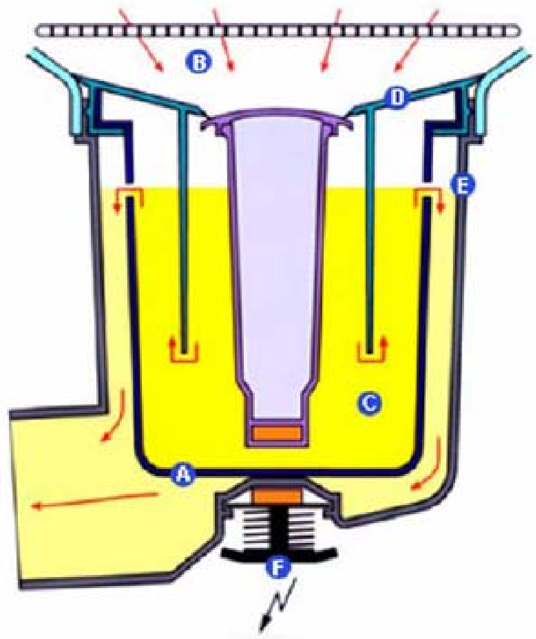
  At the outflow of the urinal (urine diversion) a plastic pipe is connected which ends in a flat section. Urine can pass by gravity, and then the flat end of the pipe (the trap) closes due to it's form. The main disadvantage is the need for regular cleaning and replacement after a certain period of use.



Picture 6: Trap with rubber seal

- Trap with a buoyancy body

  This patented system consists of one cylindrical plastic container with overflow outlets along its circumference, a buoyancy body, and a rubber cuff with a sealing lip. The buoyancy body, floating in water or urine is lifted upwards towards the rubber cuff and thereby seals the inlet opening. A sensor below the urinal detects the user. Subsequently an electromagnet moves the buoyancy body - before, during, and after use – downwards. As a result urine can flow from the urine collection point into the trap.



Picture 8: Trap with buoyancy body

6 Management, Operation and Maintenance

The major common element in the maintenance of dry toilets is that the user must ensure that the system is working properly. However, it is important to note that many operation and maintenance activities, such as emptying of toilet vaults, transport and secondary treatment, can be carried out by special service providers, either as a public service or through private enterprise. Service contracts will minimize the burden on households and also enable municipal administrations to guarantee a satisfactory standard of operation and maintenance.

In addition to general o&m activities relevant for any type of buildings the following main activities will have to be carried out.

6.1 Urine Diversion

- Monitor urine collectors, pipes and containers/tanks for blockage.
- Flush urine pipes periodically to avoid accumulation of deposits, which can block the flow and generate unpleasant odours.
- Check, clean or replace the smell trap, if present.

6.2 Dehydration

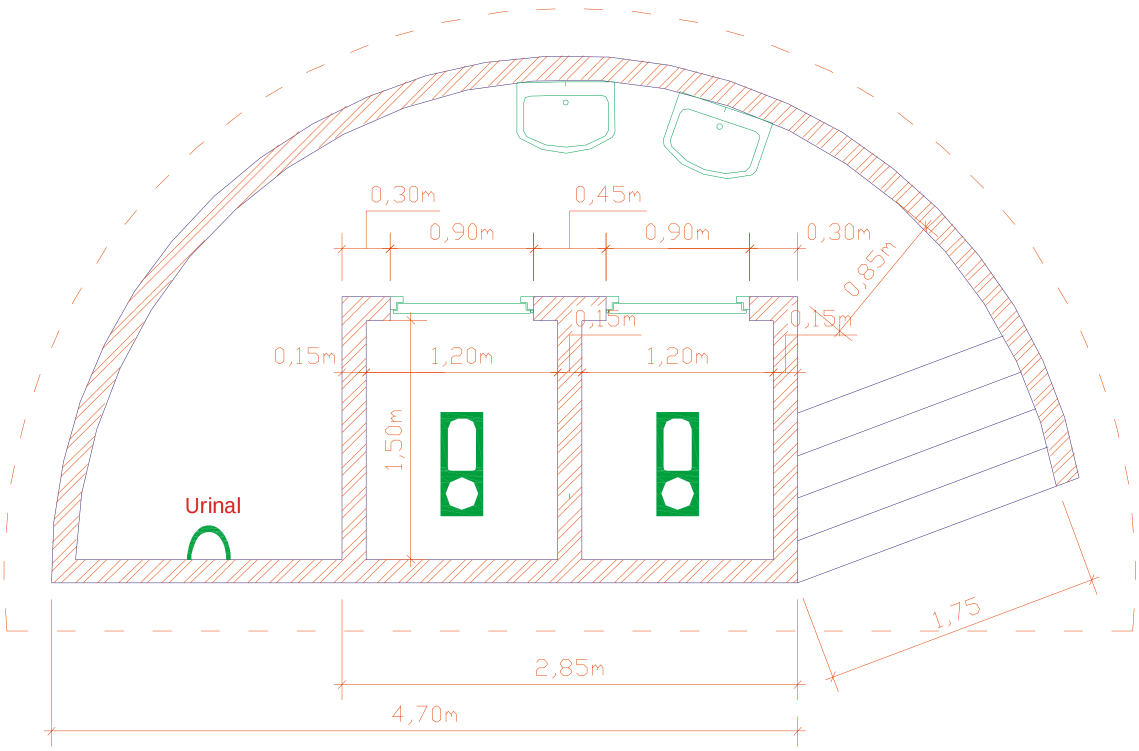
- Check water content and correct if required (by adding drying agents)
- Empty when full and
- assure sufficient additional storage period when necessary and/or
- secondary treatment.

6.3 Composting

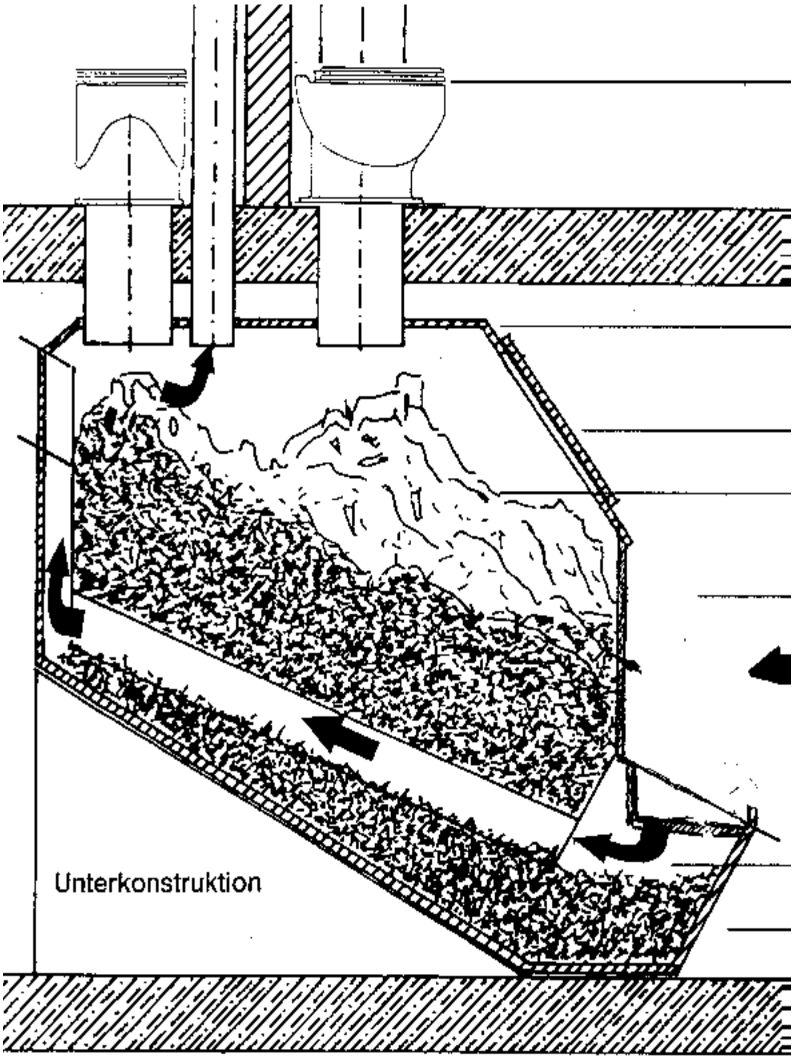
- Control and adjust water content,
- Add carbon rich material,
- Empty regularly.

7 Examples

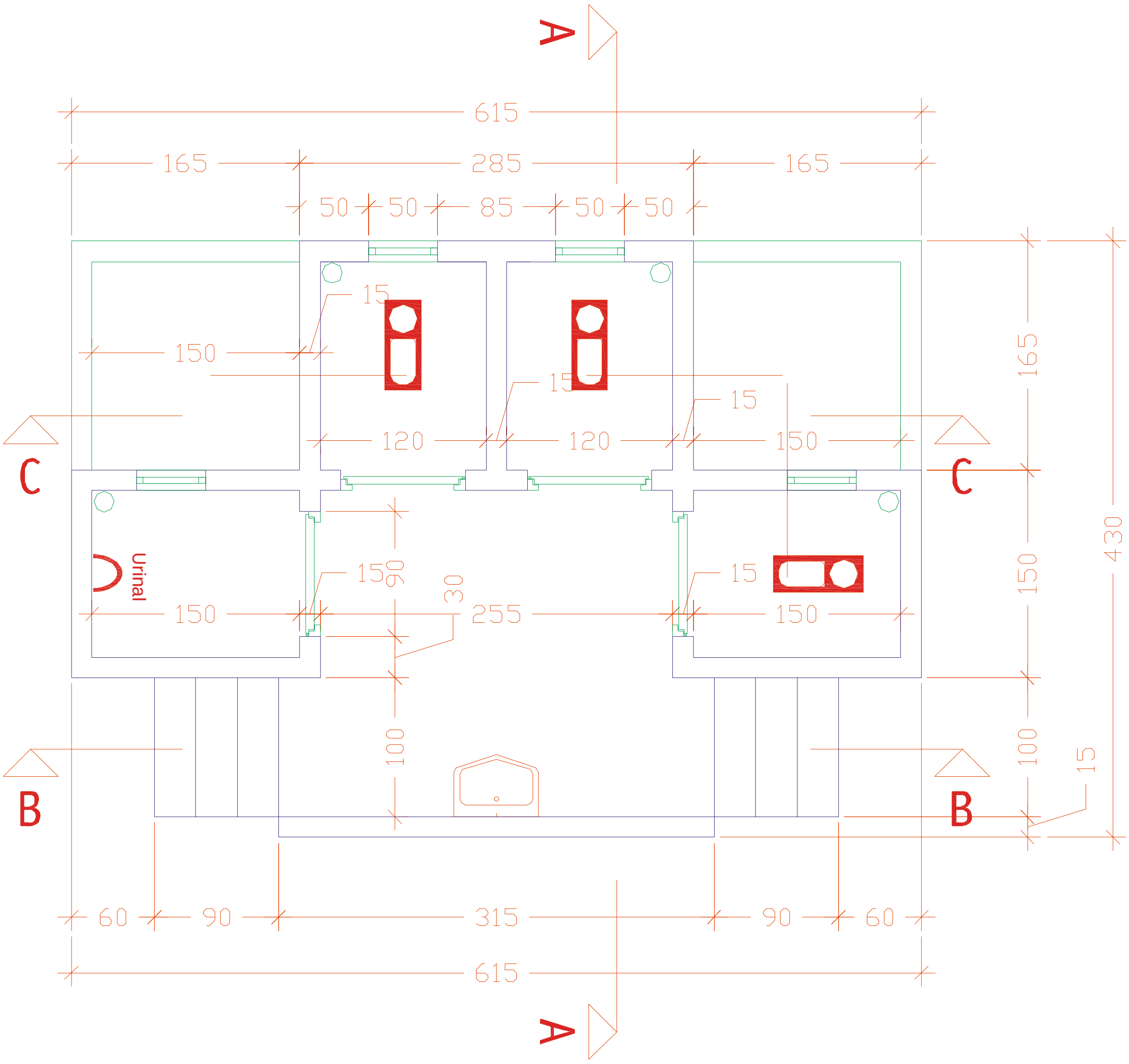
7.1 Dry urine diversion toilet Kalungu Girls Secondary School, Masaka, Uganda

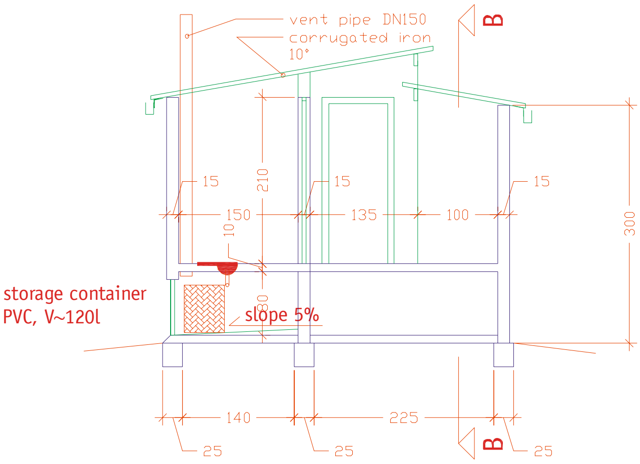


7.2 Composting Toilet Bielefeld, Germany (Source: Berger Biotechnik)

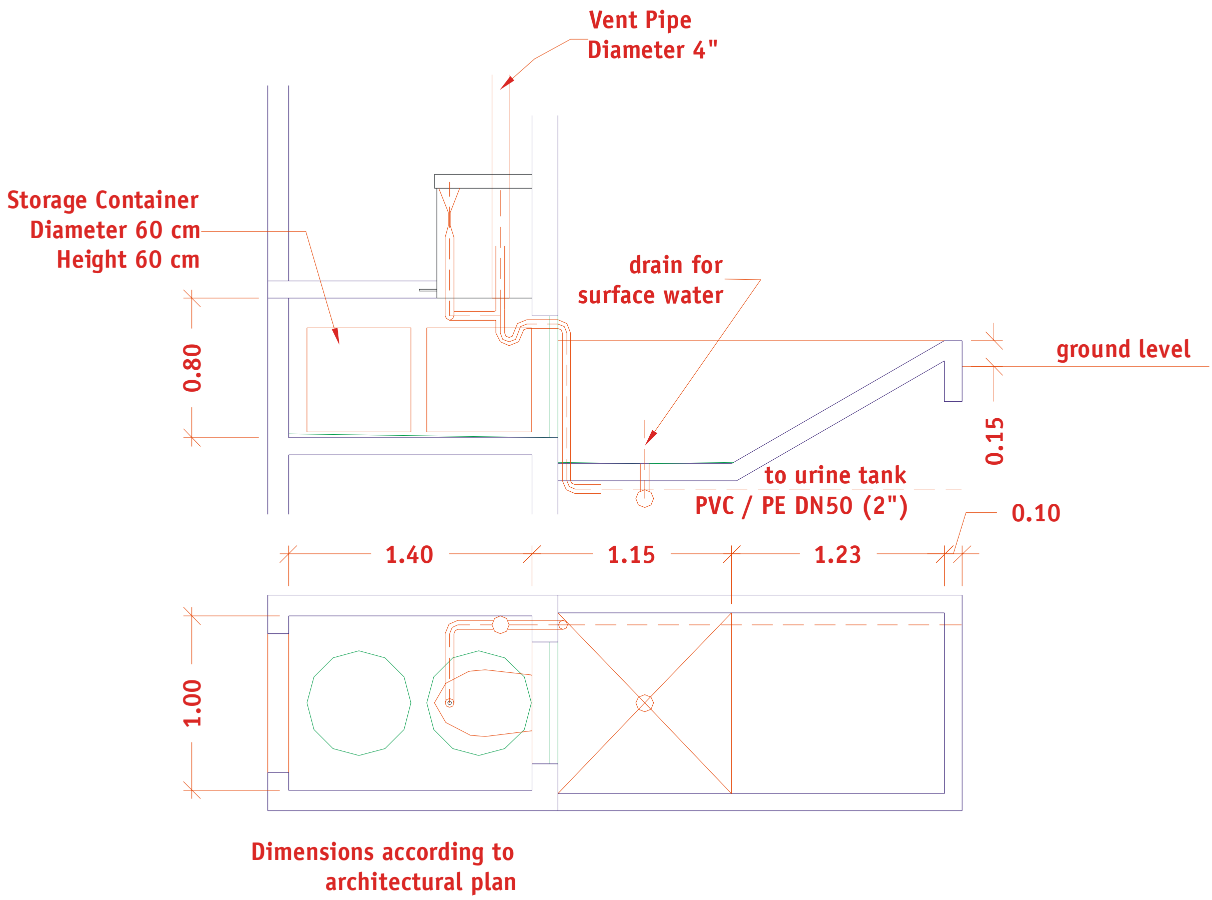


7.3 Dry Urine Diversion Toilets, Naggalama Hospital, Uganda

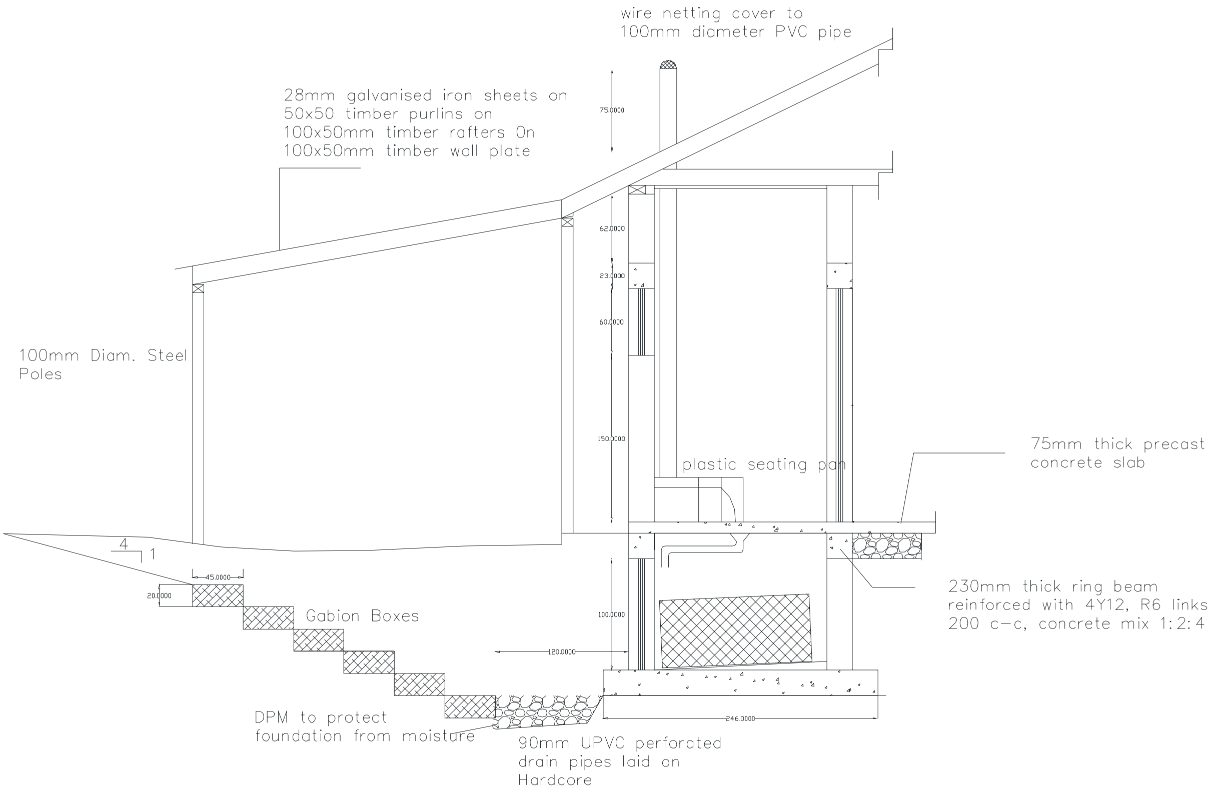




7.4 Dry Urine Diversion Toilet, Balit Hospital, Philippines



7.5 Dry Urine Diversion Toilet, Arua, Uganda



8 Mitigation of common problems

8.1 Smell

8.1.1 Urine diversion toilet

If a urine diversion toilet is properly cleaned, smell can only be caused by two main reasons:

- high water content in faeces combined with wrong/uncontrolled ventilation

  reduce water content by adding drying agent (dry soil, ash, etc.), identify and eliminate cause (wrong use, surface/ground/rainwater intrusion), optimise ventilation system (compare section 4.3)

- air flow from urine pipe/tank back into bathroom

  introduce smell trap according to section 5

8.1.2 Composting toilet

The main cause for smell is a too high water content which leads to anaerobic instead of aerobic decomposition. Adding a sufficient amount of dry, carbon rich organic material will help to minimise this problem. If the smell is not reduced within a short period the problem is normally caused by improper design and/or construction.

8.2 Blockage of urine pipe

Dilution of urine with water increases the tendency to precipitate with Ca+, Mg+ and PO_4^{3-} ions which can cause blocking of the urine pipe. Regular flushing of the urine pipe may be required.

8.3 Liquids accumulate at the lower end of the composting vault

Surplus liquids in composting toilet vaults will accumulate at the lower end of the composting vault. These liquids will carry pathogens from fresh faeces at the top of the pile and contaminate old, already decomposed material at the bottom. Therefore these liquids will have to be collected and treated before being disposed or reused. If this problem persists the installation of a urine diverting seat-riser might help.

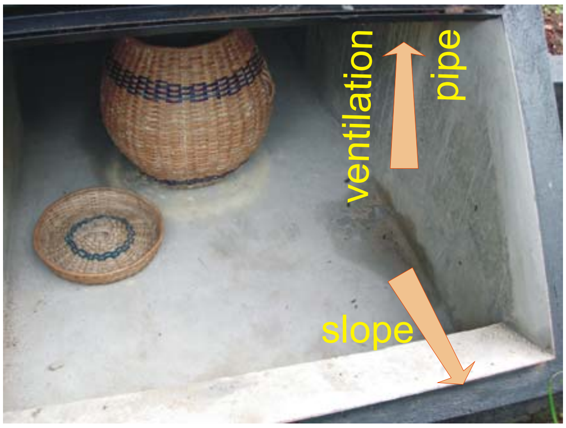
8.4 Surface water entering the storage chamber

Surface or groundwater intrusion into the storage compartment is caused by inappropriate design and/or construction. Generally, if built below ground, the walls of the storage chamber have to be water tight, special attention has to be given to the joints between the floor and the walls. The terrain has to have a slope leading away from the building. Should this not be possible or in case of a high groundwater table a state of the art drainage system will have to be installed to keep the storage chamber dry.

8.5 Rainwater entering the storage chamber

Generally the same considerations as in section 8.4 above apply. In addition a small amount of rainwater might enter the storage chamber through the ventilation pipe. As mentioned in section 4.3 covering the ventilation pipe is not recommended when using natural ventilation only. To mitigate the risk of a too high water content in the storage chamber the floor of the chamber has to have a slope towards a drain and the ventilation pipe should be installed above the lower section of the floor.

Generally the quantity of rainwater entering the storage chamber through the vent pipe is small.



Picture 9: Dealing with rainwater

9 Annex 1 - Example of pathogens possibly excreted in faeces

(can be transmitted through water and improper sanitation) and related diseases, including examples of symptoms they may cause (Schönning and Stenström, 2004)

Bacteria		
	Aeromonas spp.	Enteritis
	Campylobacter jejuni/coli	Campylobacteriosis - diarrhoea, cramping, abdominal pain, fever, nausea; arthritis; Guillain-Barré syndrome
	Escherichia coli (EIEC, EPEC, ETEC, EHEC)	Enteritis
	Pleisiomonas shigelloides	Enteritis
	Pseudomonas aeruginosa	Various; bacteraemia, skin infections, ear infections, meningitis, pneumonia
	Salmonella typhi/paratyphi	Typhoid/paratyphoid fever - headache, fever, malaise, anorexia, bradycardia, splenomegaly, cough
	Salmonella spp.	Salmonellosis - diarrhoea, fever, abdominal cramps
	Shigella spp.	Shigellosis - dysentery (bloody diarrhoea), vomiting, cramps, fever; Reiter's syndrome
	Vibrio cholerae	Cholera - watery diarrhoea, lethal if severe and untreated
	Yersinia spp.	Yersinioses - fever, abdominal pain, diarrhoea, joint pains, rash
Virus		
	Adenovirus	Various; respiratory illness. Here added due to the enteric types (see below)
	Enteric adenovirus 40 and 41	Enteritis
	Astrovirus	Enteritis
	Calicivirus (incl. Noroviruses)	Enteritis
	Coxsackievirus	Various; respiratory illness; enteritis; viral meningitis
	Echovirus	Aseptic meningitis; encephalitis; often asymptomatic
	Enterovirus types 68-71	Meningitis; encephalitis; paralysis
	Hepatitis A	Hepatitis - fever, malaise, anorexia, nausea, abdominal discomfort, jaundice
	Hepatitis E	Hepatitis
	Poliovirus	Poliomyelitis - often asymptomatic, fever, nausea, vomiting, headache, paralysis
	Rotavirus	Enteritis
Parasitic protozoa		
	Cryptosporidium parvum	Cryptosporidiosis - watery diarrhoea, abdominal cramps and pain
	Cyclospora cayetanensis	Often asymptomatic; diarrhoea; abdominal pain
	Entamoeba histolytica	Amoebiasis - Often asymptomatic, dysentery, abdominal discomfort, fever, chills
	Giardia intestinalis	Giardiasis - diarrhoea, abdominal cramps, malaise, weight loss
Helminths		
	Ascaris lumbricoides	Generally no or few symptoms; wheezing; coughing; fever; enteritis; pulmonary eosinophilia
	Taenia solium/saginata	
	Trichuris trichiura	Unapparent through vague digestive tract distress to emaciation with dry skin and diarrhoea
	Hookworm	Itch; rash; cough; anaemia; protein deficiency

10 Further Reading

Dranger, Jo (1998). Fighting the urine blindness to provide more sanitation options, in Water SA Vol. 24 No. 2 April 1998

Schönning, C. (2001).Hygienic aspects on the reuse of source-separated human urine, Paper prepared for NJF Seminar no. 327, Copenhagen 20-21 August 2001

Groth, Felix (2005): Ventilation of Dry Toilets, Diploma Thesis for Building Technology and Management, Pinkafeld 2005

GTZ: Technical Data Sheets for EcoSan Components