Urine Diverting Dry Toilets

Principles, Operation and Construction

MANUAL FOR DESIGN, CONSTRUCTION, OPERATION AND MAINTENANCE

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Urine Diverting Dry Toilets

Principles, Operation and Construction

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1| Why safe and environmentally friendly toilets?

All over the world many communities or houses are served by de-centralized water supplies such as standpipes, wells or springs. In many places, even if a centralized water supply system is in place, the system may be regularly interrupted and/or the sewage system may be lacking. These circumstances make the selection of a safe, comfortable and environmentally friendly waterless toilet a nice alternative for many households and communities.

Disadvantages of pit latrines
In communities where no access to central water or sewage systems exists, people often use pit latrines. Pit latrines are in general a source of nuisance: they smell bad and attract flies, and are also unattractive to see and use. Hence, pit-latrines are mostly located far from houses.

Flies are not only attracted by the latrines, but also by food. Therefore, after flies have been in the latrine they can infect food with pathogens (bacteria or other microorganisms which cause illness). In addtion nitrates and faecal bacteria leaching from latrines into the soil can pollute the groundwater supply, which is often used as drinking water. In case piped water is available, households may wish to have a flush toilet, whereas in rural areas piped water is limited and the treatment of wastewater is often not adequately solved.

Disadvantages of flush toilets
One person produces around 500 litres of urine and 50 kilograms of faeces during the period of one year. A flush toilet uses on average 12,000 litres of water per year to flush away these excrements. This not only means large amounts of (drinking) water are severely contaminated with faecal pathogens by rather small amounts of human waste, but nutrients valuable for growing food are wasted in wastewater streams. To collect and clean the polluted wastewater, expensive sewage and treatment systems are needed.
For many communities and households in rural areas where there is no reliable water supply and sewerage system, a good alternative to pit latrines and flush toilets could be the ***urine diverting dry toilet.***

1| Why safe and environmentally friendly toilets?

Urine diverting dry toilets are an ecological sanitation solution, that is why they are often called Ecosan toilets.

Urine diverting dry toilets (UDDT) don't pollute ground or surface water nor waste drinking water by flushing; by using these specially designed toilets, human feacal matter is diverted from urine and is sanitised and recycled in a safe way. Human fecal matter and urine are considered a valuable resource which can be reused for food production or gardening. No central water supply or sewage system is needed for the proper functioning of these toilets.

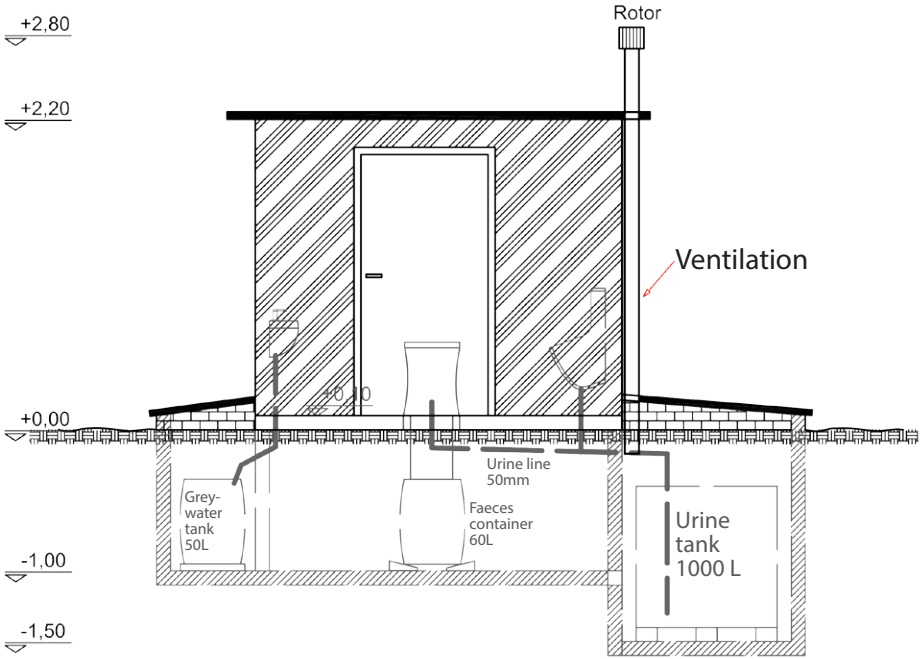
The design of the toilet makes it easily adaptable to different types of communities, can be constructed with cheap and locally produced materials and can even be constructed inside the house or adjacent to the house. According to the wishes or habits of the users, UDDTs can be designed as a sitting or a squatting toilet as seen on the right. The design can be adapted to the needs of handicapped people as well.

Bench toilet model

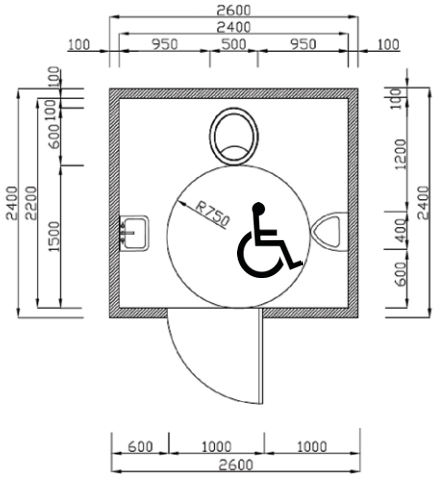
Sitting toilet model

Squatting toilet/slab model, made in China

2 | How does a urine diverting dry toilet function?



UDDT schematic cross section plan



UDDT handicapped accessible ground plan

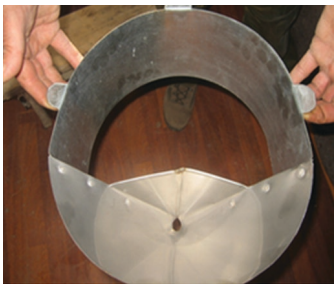
Urine and faeces leave the human body in two seperate out flows; the UDDT makes use of this natural condition, it does not mix urine and faeces at source.

2 | How does a urine diverting dry toilet function?

Human bodies are made in such a way that faeces and urine are stored separately in the intestines and bladder, and leave the human body in two separate outflows. Faeces always contain microorganisms (bacteria), which endanger human health in case of intake. In contrast, the urine of a healthy person is sterile and does not contain micro-organisms. It is important to realise the volume production difference between faeces and urine; on average a person excretes 50 kg of faeces per year while producing 500 liters of urine, which is nutrient rich and optimal for fertilising plants.

Special toilets make use of this natural condition: they do not mix the urine and faeces at source. Urine diverting dry toilets separate, collect, store and treat these two products.

Well-constructed and well-maintained UDDTs don't develop bad odours, or attract flies. After sanitising the urine and faeces, these nutrient rich products can be used in agriculture or in the garden.



Metal diverting device, made in Georgia

Diverting devices

The most important feature of a UDDT is the diverting device. Depending on the budget available, wishes or habits of the user, there are different designs of urine diverting equipment possible:

- Prefabricated squatting slabs made of fiberglass, plastics or porcelain
- Locally-made squatting slabs made of concrete, tiles or high quality metal
- Prefabricated toilet seats made of fiberglass, plastics or porcelain
- Locally-made toilet seats made of concrete (using a mould)
- Locally-made toilet seat or bench made of wood, using a prefabricated diverting device made of plastics or metal

2 | How does a urine diverting dry toilet function?

Example of a toilet mould

Plastic urine diverting device

Concrete toilet constructed from a mould

Squatting toilet/slab model

Facilities for the collection of faeces and urine

The UDDT can be constructed as a single vault or a double vault toilet. In other words, it can have one or two separated toilet. In other words, it can have one or two separate compartments for collecting and storing faeces. In both designs, urine flows into a storage tank where it is collected.

Double vault system

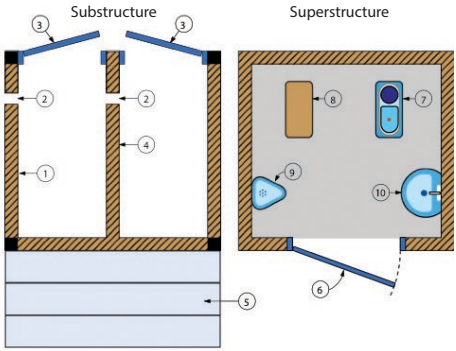
With double vault UDDTs, faecal matter is collected and stored in two vaults, which are used alternately. Daily deposits are made into one of the vaults. When one vault is full (which should take at least one year), the respective vault is sealed while the other vault is put in use. The storage time is counted from the date of the last faecal matter

contribution to a vault, and should be at least one year to provide sufficient time for desiccation and hygienisation.

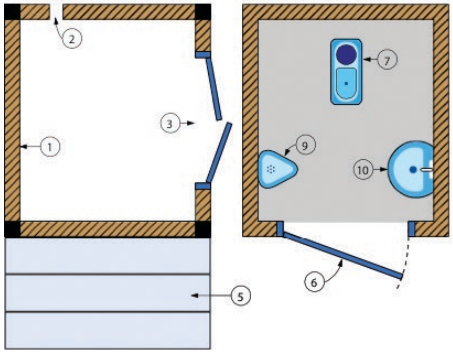
The first vault containing the desiccated feces should be emptied as soon as the vault is full. The material should be co-composted in a conventional compost heap and can then be used as normal compost in agriculture.

Single vault system

Single vault UDDTs, unlike double vault UDDTs, provide only one collection storage vault for the containment of faeces. Therefore, only little desiccation and hygienisation takes place in the vault. Emptying and further treatment (e.g. composting) have to be done very carefully (see pp. 15-16) as recommended. The most practical design of single vault UDDTs is the one that provides at least two moveable containers. Such containers allow removing the faeces easily once the container is full, without disrupting the functionality of the toilet.
In both systems it is necessary that after each defecation, a handful of cover material (dry soil, sawdust,



Double vault system. Figure from (Wisdom, 2010, p. 4).



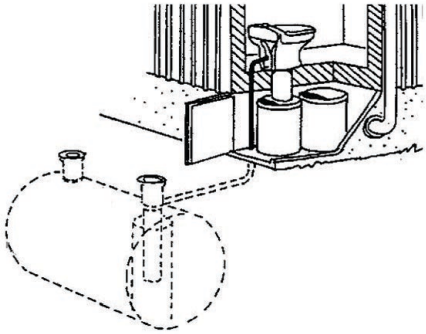
Single vault system. Figure from (Wisdom, 2010, p. 4).

Figure Key:

1 - wall substructure;
2 - extraction mouth ventilation system;
3 - faeces vault door;
4 - separating vaultwall;
5 - stairs to the toilet room;
6 - toilet room door;
7 - Ecosan removable toilet slab;
8 - closed, inoperative vault;
9 - urinal;
10 - washbasin.

ash, charcoal and/or lime) is sprinkled over the faeces to absorb moisture, to prevent smell and help speeding up the dehydration process.
Urine and anal cleansing water diversion is equally important in order to maintain the dehydration process (see p. 17).

Comparing the systems, the double vault toilet construction requires a bit more space. The single vault model requires more handling with faecal matter than the double vault.



Underground urine reservoir. Figure from (Esrey et al., 2008, p. 26).

As handling fresh faecal matter causes health risks, the double vault system is generally recommended.

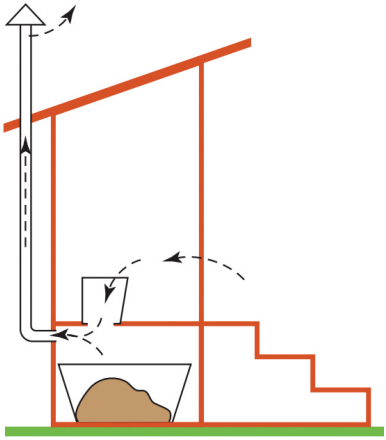
For urine collection, the type and size of the tank has to be planned. The reservoir can be placed above or below the ground level. For estimating the most suitable urine reservoir volume, the designer should take into consideration the number of toilet users and the frequency the owner is willing to empty the reservoir.

Location of the toilet
A well constructed and maintained UDDT does not produce bad odours. Hence, there is no reason to install the UDDT far from the house. In principle the UDDT can be constructed inside the house, adjacent to the house, or possibly just around the corner of the house (see figure on p. 24). The final selected location will depend in particular on the available space and potentially on the climate of the area. In regions with cold winters, an outdoor toilet is less preferable.

Requirements for optimal performance

For optimal performance concerning UDDTs, a few things must be borne in mind. This will assure that there will be no smell and the products can be adequately sanitised:

- The design of the toilet assures that the urine is directly diverted from the faeces; the urine must not get in contact with the faeces
- The vaults must be kept completely dry and covered with sufficient dry soil, sawdust, ash, charcoal and/or lime
- The urine should be collected in a reservoir and odor seals can be used.
- An adequate ventilation system has to be in place
- Urine and faeces always have to be stored and treated separately



Adequate ventilation system. Figure from (Andreev & Andreev, 2010, p. 26).

Collection and treatment of urine

The UDDT has a separator bowl and a hose, which leads urine into a reservoir or canister. If the time recommendations for the storage of urine are followed, it can be safely used as fertiliser and does not pose a health hazard.

Urine is an excellent fertiliser (see Chapter 5). It is rich in nitrogen, potassium and phosphorus; the nutrients and minerals which plants need for growing are available in a good balance. It is recommended to collect the urine in a reservoir or canister and to store it in a cool, shady place and to apply the urine when fertiliser is needed.

Urine of a healthy person does not contain pathogens. But urine can be contaminated easily (e.g. by traces of faeces) and for safety reasons it is recommended to sanitize urine before application.

In 2006, the World Health Organization (WHO) published guidelines on how to sanitise (how to treat/store) human urine and faeces from e.g. UDDTs and how these products can be safely used for gardening and in agriculture.

Fertilising crops with urine

A woman who fertilised her crops with urine

Depending on the source of the urine and consumption purposes, different recommendations are formulated:

- For urine of a household, a storage time of 1 or 6 months is required, depending on the storage temperature (above or below 20°C). If a household uses its urine in their own garden, no storage is required.
- A storage time of 1 month is recommended for food and crops that are being processed (e.g. cooked).
- It is required to keep a 6-month (if >20°C) storage time for commercial food production and when products are consumed raw.
- Urine from public and institutional toilets, like schools or restaurants, is required to be stored for at least 6 months. After this storage time the urine can be used for fertilising all crops if >20°C.

In any case, for fertilising crops or trees, it is recommended for safety reasons, that a withholding time of

at least one month between urine application and harvesting exists. Urine should be applied directly to the ground if the edible parts grow above the soil surface and never touch the plant's foliage since it can cause foliar burns.

Consider urine as a nitrogen rich fertliser, do not apply later than one month before the harvest

Filled box of a single vault urine diverting dry toilet

Collection and treatment of faeces

When a double vault (two compartments) toilet is used, the faeces are collected in the one of the two vaults that is currently in use. The volume of one vault is designed in such a way that it can be used for approximately one year. If the first vault is about to be full, the toilet seat or slab is moved to the hole above the second, empty vault. The full vault is covered with a layer of soil and left to decompose for a period of one year while the second vault is in use. The continued storage and dehydration in the closed vault leads to a significant pathogen reduction already before emptying.

Depending on the situation, a one-vault system using containers

Composting faecal matter

Compost can be used for gardening

to collect the faeces can be used. In this case, a post treatment measure like composting is needed. In order not to deal with fresh faeces, at least two containers should be used to create an alternating system. When the container is full, it should be covered with a lid or foil and stored. The stored container is emptied into the compost heap when the container in use has to be replaced (1-2 weeks depending on family and container size).

However, the faeces in the container is still pathogenic after a period of 1-2 weeks, containing many potentially dangerous microorganisms. Adequate safety measures should be practised such as wearing gloves during handling and careful hand washing is required. WHO recommends a faecal storage duration of 1-2 years for full pathogen inactivation. The compost process is recommenced to be at least one year for safety reasons

Compost a safe and nutrient-rich soil conditioner

The single vault is not the preferred option as it involves a more frequent handling of the faecal material, which poses a higher hygienic risk.

Alternated use of both vaults assures enough time for properly sanitising the faeces. Ash or lime used for covering the faeces and the lack of humidity inside of the vaults aid in the destruction process of pathogens. If the vault has to be emptied and the storage time was not long enough, the treatment of the faecal material must be continued in a compost heap.

In regions with cold and long winters, a storage time of 2 years is preferable. Fresh faeces contain high amounts of pathogens. Therefore, faeces must always be treated before they can be applied on a field or a garden.

Preparing the bottom of the vaults

Before using a vault or other container, a 3-5 cm fine layer of prepared soil or compost must be placed on the floor.

How to make prepared soil:
Two parts of fine dry soil mixed with approximately one part of ash or lime. Some sawdust can also be added. If not enough dry soil is available, sawdust or other dry organic materials can be used instead. Ash is to be preferred over lime. Ashes, charcoal and lime take away the smell and decrease pathogens.

Ashes have a fine structure and are an excellent humidity and odour absorber

Sawdust is another excellent humidity absorber

Covering the faecal matter after defecation

After each defecation, at least one cup of a mixture of prepared soil, sawdust, ashes, charcoal or lime must be added, to cover the fresh faeces. Don't be sparing with the covering. Used toilet paper can be disposed into the vault; it does not affect the pathogen destruction and supports moisture absorption and aeration.

It is important, that the cover material has a fine structure and absorbs humidity.

Covering faecal matter with ashes

Leveling

It is important to level the mound formed by falling excreta regularly. Depending on the toilet's frequency of use, the faeces must be leveled weekly with a stick or other tool, additional prepared soil or sawdust should be added during the process. This can be done through the faecal vault door opening or through the toilet hole.

Changing the vault and emptying

In case a double vault UDDT is used, only one vault is in-use at a time while the other vault is at rest, creating an alternating system. When the in-use vault is about to be full, the faeces must be covered completely with a dry soil layer and covered with a lid for a period of around one year while the empty vault is used.

When both vaults are full, the vault that has been out-of-use should be emptied. After the storage time of at least one year, (the time it takes to fill one vault), the product is smell-free and can be further composted and used in agriculture (see Chapter 5). it is recommended to place a fine layer of prepared soil or compost on the floor before using it again; this aids with moisture absorption and creates a stable environment for fresh faeces.

If the toilet has only one vault, replace the container with an empty one. While taking out and further handling the container, avoid faecal contamination of clothes and hands by at least wearing gloves.

The filled container is covered with dry material and sealed with foil or a lid and is stored in a dry place while the other container is in use. Don´t allow any rain, animals etc. to enter the sealed containers. After the next container is filled, the content of the stored container is emptied carefully onto a compost heap and covered with other non-pathogenic materials, such as straw, garden waste, organic kitchen waste or soil to be further treated.

Urinating

On the sitting and squatting toilets, men must urinate whilst sitting down. They should take care not to wet the faeces vaults. For public toilets or cultures where men don't like to sit, a urinal is therefore preferable.

The urine can be collected in the same reservoir to which the toilet seat or slab is connected, or to a separate canister.

Example of urinal in toilet room

Cleaning

The toilet floor can be cleaned as usual with water and some detergent. Nevertheless, it is very important that no, or very little water enters into the faeces vaults. For cleaning the toilet seat and bowl or slab, a wet rag or sponge can be used, avoiding to moisten the vaults' interior.

Cleaning toilet seat with a spray can for minimal water use

Likewise, a bit of warm water or vinegar can be added periodically to the urine separator and to the urinal for avoiding smell and sediment build-up.

Wrong toilet cleaning, do not add water into the toilet bowl! (Figure: GIZ Philippines)

Bad smells

If the UDDTs and water-less urinals are properly installed, used and maintained, there is no smell at all. Odours could only occur from the faeces vault or from the urine pipes and tank if proper conditions are lacking. This can be avoided by ensuring the following:

Faeces vault:

- Covering with dry soil/sawdust/ashes/charcoal/lime after each defecation
- Proper installation of the ventilation (passive or active)
- Closing doors of the faeces vault
- Proper sealing of the whole faeces vault to prevent any uncontrollable air flow
- Flattening the heap of faeces from time to time (usually done by the caretaker)

Covering faeces with a sawdust mix

Urine pipes and storage:

- Proper installation of the piping
- Sealing of the piping system to prevent any uncontrolled urine discharge and uncontrollable air flow
- Installation and maintenance of a smell trap (see Chapter 11)
- Regular use of citric acid or vinegar for cleaning urinals and/or urinal bowl

Humidity: bad smells or flies

If unpleasant odours or flies are perceived, a check must be done to assure that there are no uncovered excreta or leaks in the urine hose. The toilet caretaker should check regularly that it is not too wet inside the vault.

Humidity can also enter through a poorly sealed opening or through the faecal vault doors if they are not sealed tight. Too much water entering during the cleansing of the toilets can be another cause for increased humidity. If humidity is too high, it is recommended to add abundant prepared dry soil or other organic absorbing material.

5 | How to use sanitised urine or faeces in agriculture or garden?

To be safe, the ecosan products should not be applied on vegetables that are supposed to be eaten raw, and no later than a month before harvesting.

See the manual *"Ecological sanitation and hygienic risks"* and the flyer "Urine - the yellow gold" (see p. 39).

Safe use of urine

Urine contains several macro nutrients like nitrogen, potassium and phosphorus, but in contrast to chemical fertilizer, also a number of micronutrients which are essential for plant growth. Depending on diet, human urine collected during one year (up to 500 liter) contains 4-5 kg nitrogen, while faeces (ca. 50 kg) only contains approximately 0.5 kg nitrogen. The urine from 30 persons collected during one year can fertilise one hectare of farmland, which is equal to an application of 120 –150 kg nitrogen per hectare. In other words, daily urine from one person contains enough nutrients for fertilising approximately a 1 m^2 field.

Urine storage container with ready-to-be-used urine

A 1,000 L urine collection bin, ideal for large urine volumes. Figure from (Andreev & Andreev, 2010, p. 32)

Be aware, the nitrogen characteristics of urine are comparable with that of artificial fertilisers, therefore there is a danger to fertilise too much or to use overly concentrated urine while applying to plants. Every cultivar of crop or plant has its own specific needs of nutrients for growing. For example, the nitrogen demand for potatoes or maize is much higher than for fruit trees.

More ways to use urine as a fertiliser:

Applying urine without dilution

Before sowing or planting, urine can be applied undiluted onto the soil. In addition, urine can be given to trees in small quantities and undiluted, according to the nutrient need of the tree. Urine can also be used undiluted to moisten dry compost heaps.

Irrigating with urine

Applying with dilution

Once crops have started to grow, the urine should be diluted with water in a ratio of 1 to 4 till 10 for fertilising the plants. A safe dilution ratio is 1 to 8 (one part urine plus 7 parts water) for all plants. After urine application it is recommended to cover area with soil or leaves, to avoid evaporation. To avoid over-fertilisation, it is recommended to apply urine only during the vegetation growth periods, during spring and summer time or, for winter crops, in early autumn.

Do not fertilise during wintertime!

What are the benefits of using sanitised faeces?

Fresh faeces contain high amounts of pathogens; therefore faeces must always be treated before they can be applied on a field or a garden. Well treated (composted) faeces and other composted organic materials are safe to use and they

- Improve soil structure
- Improve soil health
- Are good fertiliser (phosphorus, potassium, magnesium)

How much compost or sanitised faeces should be used?

Human excreta collected during one year contain on average only 0,5 kg nitrogen, 0,2 kg phosphorus and 0,17 kg potassium. Therefore, due to the rather low nutrient content and high humus concentration, sanitised faeces or compost is best used as a soil conditioner and can be applied in rather high amounts:

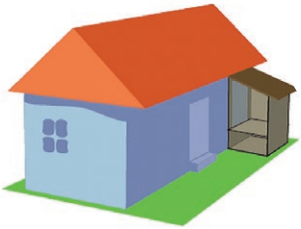
- 1 to 2 litres compost per square meter of soil (/m^2)
- 2 to 3 litres /m^2 for plants with rather high nutrient consumption like potatoes or onions
- 3 to 4 litres /m^2 for plants with high nutrient consumption like maize, tomatoes or pumpkins
- 1 part compost mixed with 1 part soil for balcony or bucket plants

Wheelbarrow filled with compost

Compost ready to be used for gardening

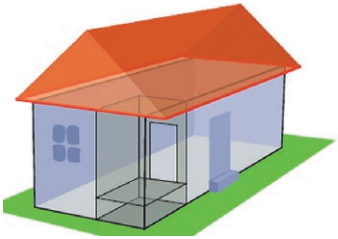
Growing vegetables with compost

UDDT location outside of the house



UDDT location adjacent to the house with indoor entrance

UDDT location adjacent to the house with outdoor entrance



UDDT location inside of the house. Figures from (Andreev & Andreev, 2010, p. 27).

In this manual, the construction of a double vault urine diverting dry toilet (UDDT) is explained. Before construction can start, the following considerations must be taken:

Selection of the place for the toilet

In general, there are three possibilities to locate toilets: inside the house, outside the house or adjacent to the house. When the toilet is constructed adjacent to the house, the entrance to the toilet can either be from outside or from inside of the house.

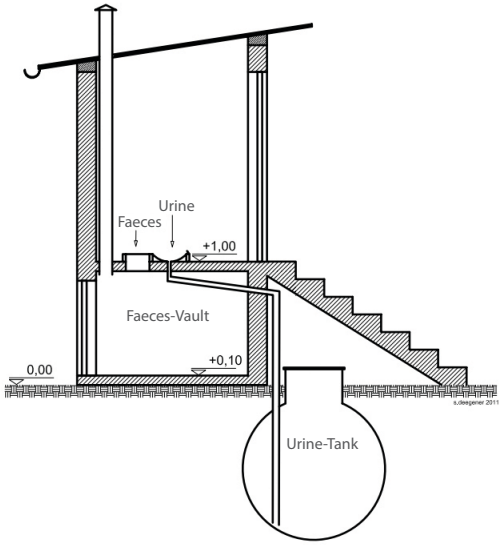
The faeces vaults doors have to be accessible. Additional space on the backside of the toilet is required for emptying the faeces vaults (approx. 2 sqm). A place for the greywater treatment also has to be considered.

Design challenges

The following factors have to be considered when designing a UDDT:

- Will there be a shower and/or a place for hand washing inside the toilet room?
- What kind of anal cleansing do the users prefer? Are they washers or wipers?

- What kind of toilet do the users prefer? Are they squatters or sitters?
- What kind of water supply is available? Is there a connection to a central water pipe? Is it possible to install a water tank (e.g. rainwater tank) or is it necessary to bring water into the toilet by hand?
- Water storage inside the toilet or outside, e.g. on the roof?
- Depending on the volumes of greywater produced, different options for greywater treatment have to be considered
- How many users will be there?
- Will the faeces be treated inside the toilet vaults? Will the faeces be composted outside? Is there a place for a compost heap in the garden? Is external composting possible?
- Slope of area and surrounding geography
- Preferences of owners
- Use of urine and faeces: Will the owner/beneficiary use the excreta themselves? Do they have enough garden/land and are they willing to use the treated excreta? If not, other users should be found



Scheme of a UDDT side view

After these decisions have been taken, construction can start:

The toilet consists of 2 parts: the toilet room itself and 2 faeces vaults, which are located underneath the toilet room.

The toilet has a square ground plot of 1,5 m x 1,5 m = 2,25 sqm. An additional 2 sqm in front of the toilet is required for the stairs and 0,5 - 2 sqm on one side of the toilet for the urine reservoir.

The *construction time* is approx. *1 week* (incl. time to let concrete dry, 5 working days net).

7 | Construction of foundation

Excavation for the foundation

Finished excavated foundation

Filling foundation with stones

The list of needed materials for whole construction is shown in appendix 1.

In general, UD-toilets should be built in such a way that the floor of the faeces vaults is above the surrounding ground level to avoid water leakage into the faeces vaults during heavy rainfall. Also, the emptying of the vaults is easier when the floor of the faeces vaults is slightly above the ground level.

In general, the foundation has to be strong enough to carry the toilet. The form of the foundation depends on the kind of ground. If the ground is solid rock, no extra foundation under the floor of the faeces vaults is necessary. For most grounds, a ***round foundation*** of *30 cm depth* and *25 cm width* is adequate, see top left figure. In case of doubt ask an experienced construction worker what kind of foundation suits your situation best.
First, the soil has to be excavated. The size of the foundation has to be at minimum the size of the toilet, so a *square of 1,5 m x 1,5 m*. After this, the excavated space should be filled with concrete. To save cement and

thus costs, the excavation can first be filled with stones and the gaps are then filled up with concrete. Attention has to be paid that all gaps between the stones are filled with concrete. The mix for foundation concrete is 1 part cement : 4 parts sand or 250 kg/m^3.

Laying floor slab with high quality concrete

Floor of faeces vaults

The floor of the faeces vaults should be built from high-quality concrete (mix: 1:3). The *thickness* of the floor should be a *minimum of 7-10 cm*. The floor should be levelled. A slope of 1-2 % towards the faeces vault doors can be applied. This slope can drain possible water or urine that has entered the faeces vault (remember: this should not happen!).

Formwork from wooden slats filled to top with concrete

A formwork from wooden slats has to be built. The top of the slats has to be levelled (the top of the formwork defines the final level of the floor. Then the formwork is filled up with concrete until the top of the formwork is reached, see middle figure on the right, it is recommended to build the foundation and the floor of the faeces-vaults in one step. The concrete has to dry (min. 1-2 days).

Faeces vaults built on top of floor slab

Faeces vault outside walls

The faeces vaults outside walls have to be built from solid material because they have to carry the whole weight of the superstructure (including toilet users).

Possible materials include concrete or bricks from different materials (clay bricks, concrete bricks). *The height of the faeces vaults* outside walls should be a minimum of 60 cm, better *80 cm*. Don't forget the outflow for the urine and greywater pipe. The hole in the side wall for the piping should be 50 mm in diameter each.

During brickwork it is essential to moisten the bricks. Due to high temperatures and the brick water absorbtion the mortar itself dries quickly and gets would otherwise dry quickly and get brittle, which affects stability.

50 mm diameter holes for urine and greywater pipes

Building dividing wall with bricks

Faeces vaults dividing wall

The faeces vault dividing wall is located between the 2 faeces vaults. The easiest way to build this wall is from bricks, but concrete is also possible. The faeces vaults dividing wall can be built in one step with the faeces vault outside walls. The *height of the dividing wall* should be *10 cm lower than the outside walls*. If the dividing wall is constructed from bricks, just leave away the last layer of bricks.

Faeces vault doors

The doors of the faeces vaults can be built from different materials including wood or metal (iron, aluminium). Metal doors are prefera-

ble, because wooden doors can be attacked by rodents (e.g. mice or rats) who are attracted by the faeces (or the undigested food contained in the faeces). The size should be minimum 50 cm in height and width to ensure easy emptying of the faeces vaults. The doors have to be big enough so that an adult person (caretaker of the toilets) can enter the faeces vaults if necessary (e.g. if the urine pipes have to be changed). Therefore, a door size of 60 cm x 60 cm or bigger is recommended. The doors should be as air-tight as possible, e.g. with a rubber sealing. In areas with cold winters insulation of the doors is recommended.

Sealing a vault door with rubber to promote air-tight conditions. Photo from Lukas Ulrich.

DOs

- ✓ Use proper baked bricks for the faeces vault(s)
- ✓ Be sure that the treated faeces can be removed after drying (install sufficiently large doors)
- ✓ Put a 3-5 cm fine layer of ashes or sawdust on the floor before using a vault. This stimulates the drying process
- ✓ Insulate the faeces vault doors to prevent heat-losses in the building

DON'Ts

- ✓ Don't design the faeces vault(s) too small
- ✓ Don't forget to leave a hole for the urine pipe
- ✓ Don't make the doors too small so that the faeces can easily be removed

Frame for toilet room floor located on top of the faeces vaults

Cutting hole for UD-toilet seat riser into the floor

Floor

The floor of the toilet room (ceiling of the faeces vaults) can be constructed from wood or concrete. In any case, the floor has to be covered by easy to clean materials, e.g. tiles or linoleum, but not PVC. If the floor is made from wood, a covering is also necessary in order to avoid wetting the wood during cleaning the toilet room.

The first step is to build a frame which has got the outside dimensions of the faeces vault walls, here 1,5 m x 1,5 m. The stairs can be built in the same step. Afterwards the frame is covered with *4 cm thick wooden slats.*

After finishing the floor, the 2 holes for the UD toilet seat riser (or UD squatting pan) have to be sawed into the floor. To do so, the seat riser is placed onto the floor and marked. The 2 holes should be centred above the middle of the corresponding faeces vaults. Also a 50 mm hole for the piping of the urinals to be cut (before covering with linoleum!). After the holes have been sawed, the linoleum can be applied.

Walls

The walls can be built from solid material (bricks), wood etc. Here the construction of the walls from wood is explained. In the first step a frame is built. The frame can be constructed directly inside the faeces vaults or in a separate place and carried onto the faeces vaults when the frame is finished.

Constructing a frame

In every corner a pile is placed. The slope of the roof is defined by the height of the four corner piles. In climates with snowfall a sufficient slope of the roof has to be built to not overload the roof in case of heavy snowfall. The height of the 2 *piles in the back* is *1,8 m*, the height of the *front piles* is *2,2 m*. The upper ends of the piles are then connected via bars. 4 reinforcing bars with an angle of 45° towards the floor are built in every side of the toilet (see photo on p. 30).

After placing the frame onto the faeces vaults, the cover of the walls can be applied (here 2 cm thick wooden slats). Remember to leave the space for the door. A window is optional but recommended for lighting during daytime.

Framing the toilet room with 2 cm thick wooden slats

Constructing roof with wooden slats

Door

The door can be built easiest from wood. Of course pre-fabricated doors can also be used. Another low-cost option is to build a frame from wood and cover with e.g. bamboo or reed. If no window is constructed (and no electrical light is installed), holes have to be sawed inside the door to allow light to enter.

Roof-covering with zinc-covered metal-sheet

Roof

The roof can be built from water-proof materials of all kind. The size of the roof should be larger than the footprint of the toilet in order to avoid water running down the walls (protection of the walls). First, four wooden slats are fixed on top of the frame. The *length of* the *slats is 1,8 m*, so an overlap of 15 cm on each side of the toilet is guaranteed. On these slats the *roof cover* from metal (2 m x 2 m = *4 sqm*) is fixed with sealed screws. This results in an *overlap* of the roof cover of *25 cm on each side*. The sealed screws are necessary to avoid water from entering the roof.

Stairs
The stairs can be constructed from wood, bricks, stones or concrete. A handrail should be built for safety reasons. It is recommended that all steps have the same height (to avoid stumbling). Sometimes the slope of the terrain can be used to avoid stairs.

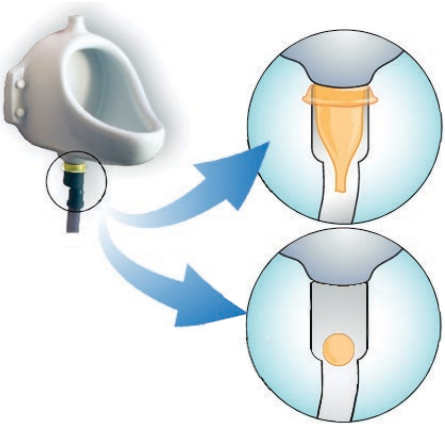
UD-seat riser or UD-squatting slab
The toilet users decide if they prefer a sitting or a squatting model for urine diversion. The flexible hose for urine must be fixed to the urine pipe of the seat riser.

Waterless urinal
Urinals are optional. If men do not want to sit down to urinate, the use of a urinal is necessary to keep urine from entering the faeces vaults and avoid bad smell caused by sprinkles of urine on the floor.

Special waterless urinals are available. Water flush urinals from ceramics can also be modified and used as waterless urinals. Reducing the number of outflow holes in the

Example of a waterless urinal

A smell trap will help reduce odours from a urinal as well as from the UD toilet



Alternative smell-blockers. Figure modified from (Andreev & Andreev, 2010).

Solution 1: condom with a cut tip

Solution 2: table tennis ball installed below the urinal. Photo from Dima Mamaliga, Apasan, Moldova

urinal by closing all but one or two holes does the modification of the urinals. This is done in order to reduce the exposure of the urine pipe to the toilet room and thus to reduce bad smell coming from the pipes.

Other possible smell traps are shown on the left. The principle of a smell trap is that the urine can flow off while the odour from the tank and pipes is prevented from entering the toilet room.

First solution is a simple condom where the top is cut and put into the urine pipe as shown in the photo as shown on the left.

Another effective smell trap is the installation of a table tennis ball below the urinal. A rubber-reduction in diameter of the pipe holds the ball in place.

The wall behind the urinal should be covered with a material which can be cleaned easily, e.g. linoleum or tiles. Then the urinal is attached to the wall. Don't hang the urinal too high if children should also use it.

Urine piping

For the urine, piping hoses and pipes from different materials can be used. For the UD slabs or UD seat risers flexible hoses are recommended for easy installation and changing. For the urinal 50 mm pipes from Poly-Propylene (PP) are a good choice. PVC-pipes should not be used for environmental reasons.

It is important that all pipes and hoses have a slope of minimum 1% to avoid a negative gradient and thus urine staying in the pipes (and causing bad smell). In colder climates the pipes and hoses should be covered with insulation.

Urine collection and urine storage

What volume for the urine collection is chosen is mainly a question of costs and comfort. The smaller the container, the more often it has to be emptied (comfort aspect). The bigger the container, the more expensive it is, and a pump may be needed for emptying the container. If applicable, the container should be buried in such a way that it will not freeze in winter but can still be emptied easily.

Bad example of urine hose installation, urine stagnating in hose can cause bad smells

Good example of pipe installation with insulation for colder climates

Different sizes of containers suitable for urine collection. Figure adapted from (Andreev & Andreev, 2010 p. 32)

DOs

- ✓ Make sure that the urine tank can be emptied easily
- ✓ Use a urine tank with strong walls , especially for under-ground installation
- ✓ Be careful in the choice of material for the tank. Plastic and concrete is okay
- ✓ Make a proper connection between the reservoir and other urine pipes
- ✓ If the pipe is curved make sure it will not block
- ✓ Make a little ventilation hole in the urine collection tank so that urine can go in and air can go out
- ✓ Use PP or PE, it is better than PVC

DON'Ts

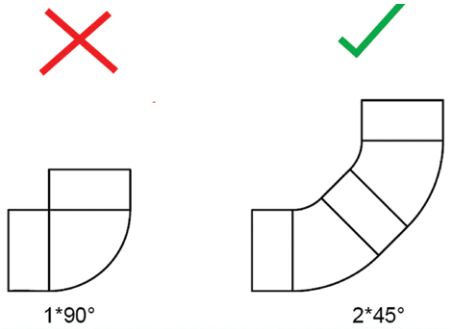
- ✓ Avoid an upward or horizontal gradient of urine pipes (always slope downwards)
- ✓ Avoid sharp bend in the piping
- ✓ Don't install the urine pipe below the faeces hole
- ✓ Don't use iron pipes or barrels because it will corrode

Faeces vault ventilation

The faeces vaults ventilation pipes conduct the air from the faeces vaults to above the roof. The pipe should be long enough so that it ends at least 30 cm above the roof. If the pipe goes through the roof, it has to be sealed in the roof with silicone or another sealing material to keep water from entering. A rain-cap or a T-pipe has to be applied to the top of the pipe for the same reason. If the toilet is built inside or adjacent to the house, an active ventilation is recommended. A diameter of minimum 110 mm is recommended for the ventilation pipe. The pipe should be as straight as possible.

Example of an active ventilation system with wind-driven rotor

If corners are unavoidable, two 45°-bends should be used instead of one 90° elbow.



Incorrect and correct ways to install pipe bends

DOs

- ✓ The pipe should be as straight as possible
- ✓ Connect the two faeces vaults in such a way that only one ventilation pipe is needed
- ✓ Use black materials for the vent-pipe, which absorbs heat more easily

DON'Ts

- ✓ Don't make sharp turns in the ventilation pipe, it blocks the airflow

References and further reading

Andreev, S., Andreev, N. (2010). *"Sanitaţia ecologică: Concepţia EcoSan. Toaletele uscate cu colectarea separată a excreţiilor. Utilizarea Deşeurilor umane în agricultură"*. Wisdom. ISBN 978-9975-9813-1-6. (in Moldovan). http://www.wisdom.md/Brosura_Sanitatia_ecologica_WiSDOM.pdf

Deegener, S. (2014). *Workshops on Construction of UDDTs in Dayet Ifrah*. Report for Programme AGIRE of GIZ, Morocco. http://www.susana.org/en/resources/library/details/1996

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Rieck, C., von Münch, E., Hoffmann, H. (2012). *Technology review of urine diverting dry toilets (UDDTs): Overview on design, management, maintenance and costs.* GIZ, Germany. http://www.susana.org/en/resources/library/details/874

WECF (2008). *Safe and profitable toilets - a solution for health and wealth* (in English and Russian). http://www.wecf.eu/english/publications/2008/ecosanguide.php

WECF (2009). *Sustainable and safe school sanitation. How to provide hygienic and affordable sanitation in areas without a functioning wastewater system* (in English and Russian). http://www.wecf.eu/english/publications/2009/school-sanitation.php

Wisdom (2010) *Construcţia toaletei uscate cu colectarea separată a excreţiilor (TUCSE)*. WISE Attitude Brief 1. Wisdom. (in Moldovan) http://www.wisdom.md/Compendiu_nr1_Constructia_TUCSE_WiSDOM.pdf

11 | References and further reading

Further resources

General information:

Sustainable Sanitation Alliance (SuSanA)
http://www.susana.org

Swedish Environmental Institute (SEI)
http://www.ecosanres.org/

Sustainable Sanitation and Water Management Toolbox
http://www.sswm.info/category/implementation-tools/water-use/hardware/toilet-systems/uddt

WHO Guidelines for the safe use of wastewater, excreta and grey-water
Volume 4: Excreta and greywater use in agriculture
http://www.who.int/water_sanitation_health/wastewater/gsuww/en/

WECF publications:

Compost – the black gold
http://www.wecf.eu/english/publications/2010/compost-flyer.php

Urine – the yellow gold
http://www.wecf.eu/english/publications/2010/urine-flyer.php

Making Sustainable Sanitation work for women and men
http://www.wecf.eu/english/publications/2009/genderandsanitation.php

Safe and profitable toilets
http://www.wecf.eu/english/publications/2008/ecosanguide.php

Ecological Sanitation and Associated Hygenic Risks
http://www.wecf.eu/english/publications/2007/ecosan_hygiene.php

Sustainable and Safe School Sanitation
http://www.wecf.eu/english/publications/2009/school-sanitation.php

12 | Appendix

Appendix 1: Bill of quantities for outdoor double vault UD toilet with urinal (design as shown in Chapters 7-10 of this manual)

Category	Name	Unit	Quantity
Foundation	*gravel and stones*	*m^3*	*1*
	cement	*kg*	*100*
	*wooden slats 3*20*160 cm for formwork*	*piece*	*4*
Faeces-vaults	*bricks e.g. 6,5*11,5*24 cm*	*piece*	*300*
	cement	*kg*	*50*
	sand	*kg*	*150*
	*doors metal or wood (60*60 cm)*	*piece*	*2*
	framejoints inkl. Screws (for doors)	*piece*	*4*
	doorknob (for doors)	*piece*	*2*
Super structure	*wood beam 10*12*600 cm (for piles and basis and stairs and plateau)*	*piece*	*4*
	wooden slats 4 cm for floor	*m^2*	*2,6*
	wood plate 2 cm for walls including door	*m^2*	*13*
	framejoints inkl. 10 mm Screws (for doors)	*piece*	*2*
	doorknob (for door)	*piece*	*1*
	cover for unused faeces-vault-hole	*piece*	*1*
	nails 100 mm	*kg*	*1*
	nails 50 mm	*kg*	*1*
	roof cover (metal)	*m^2*	*4*
	Sealed screws 20 mm (to fix roof cover)	*piece*	*20*
	wood for stairs and plateau 4 cm	*m^2*	*1,28*
	screws (to fix urinal)	*piece*	*4*
	wood protection	*l*	*5*

Sanitary Installations	*tank e.g. 1000 l (for urine); alternative: 20 l Canister*	*piece*	*1*
	PVC-Hose (inner diameter=25mm)	*m*	*2*
	50 mm PP-pipe 1 m	*piece*	*1*
	50 mm PP -pipe 0,5 m	*piece*	*2*
	50 mm PP -pipe angle 90°	*piece*	*2*
	50 mm pipe joint	*piece*	*1*
	50-40 reduction	*piece*	*2*
	creme (to connect pipes)	*piece*	*1*
	UD-toilet seat	*piece*	*1*
	toilet seat cover	*piece*	*1*
	metal-tube-rings 20-40 mm (to fix hose)	*piece*	*1*
	pipe holder 50mm	*piece*	*2*
	PP-tube (inner diameter=50 mm)	*m*	*2*
	PP-ventilation pipe 125 mm	*m*	*2,5*
	ventilation pipe cover 125 mm	*piece*	*1*
	silicone (to seal ventilation pipe in roof)	*piece*	*1*
	urinal	*piece*	*1*
Other	*bucket 10 liter (for earth/charcoal/ashes/ sawdust)*	*piece*	*1*
	small shovel (for earth/charcoal/ashes)	*piece*	*1*
	Linoleum	*m^2*	*4,8*
	toilet brush	*piece*	*1*
	window cleaner (to clean urinal and urine bowl)	*piece*	*1*
	pump for urine	*piece*	*1*
Tools	*electr. jig-saw*	*piece*	*1*
	shovel	*piece*	*1*

	hammer	*piece*	*1*
	wood-saw	*piece*	*1*
	abrasive paper, better for drilling-machine	*m^2*	*1*
	wood-file	*piece*	*1*
	electr. Screwdriver	*piece*	*1*
	screwdriver	*piece*	*1*
	drilling-machine with wood- and stone- drills	*piece*	*1*
	cutter	*piece*	*1*
	wood-pencil (marker)	*piece*	*1*
	water-level	*piece*	*1*

Toilet seat riser	*mold for construction of urine diverting toilet seat riser*	*piece*	*1*
	modeling clay	*piece*	*1*
	spatula	*piece*	*1*
	abrasive paper 80-1000	*piece*	*3*
	20 mm pipe (PVC)	*m*	*0,3*
	paint (on oil-basis)	*l*	*0,5*
	paint-brush	*piece*	*1*
	hammer	*piece*	*1*
	bucket	*piece*	*1*
	cement	*l*	*8*
	sand	*l*	*10*
	*wire mesh 12*20 cm*	*piece*	*1*
	soap	*piece*	*1*
	rag	*piece*	*1*
	gloves	*pair*	*1*

Urine diverting dry toilets (UDDT) are an ecological sanitation solution, that is why they are often called Ecosan toilets. The main advantage of UDDTs, in contrast to conventional pit latrines, is the conversion of faeces into a safe, dry and odourless material. This leads to an odour and insect free toilet, which is appreciated by users.

Women and girls especially appreciate the use of the toilet and benefit from its implementation. Ecological sanitation is a step towards gender equality and sustainable development.

The design of the toilet makes it easily adaptable to different types of communities, can be constructed with cheap and locally produced materials and can even be constructed inside the house or adjacent to the house. According to the wishes or habits of the users, UDDTs can be designed as a sitting or a squatting toilet. The design can be adapted to the needs of handicapped people as well.

The risk of ground and surface water pollution is minimised through the safe containment of faeces and urine, which also allows the toilets to be constructed in locations where pit-based systems are not appropriate. Human faecal matter and urine are considered a valuable resource which can be used for food production or gardening.

This manual provides the background of ecological sanitation and gives guidance how to construct and operate a UDDT. This manual has been revised based on the experiences of more than 10 years in 12 countries by WECF with local partners. The manual is complementary to the WECF manual "Greywater Treatment in Sand and Gravel Filters".

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