

Women in Europe for a Common Future



Urine Diverting Toilets

Principles, Operation and Construction

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Dry Urine Diverting Toilets

Principles, Operation and Construction

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by Margriet Samwel
WECF

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by Stefan Deegener
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Part 1

Dry urine diverting or no-mix toilets

Principles and Operation

1 | Why safe and environmentally friendly toilets?

Pit latrines

In communities where no access to central water or sewage systems exists, people use often pit latrines. Latrines are in general a source of nuisances: they smell badly and attract flies, unattractive to see and to use.

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 others which cause illness). In addition nitrates and faecal bacteria leaching from latrines into soil and ground water can pollute groundwater, which often is used as drinking water.

Flush toilets

One person produces during the period of one year about 500 litres of urine and 50 kilograms of faeces. For flushing away these excrements a flush toilet uses in average 12,000 litres water per year. That means, large amounts of water are severely contaminated with faecal pathogens by rather small amounts of human waste, but also nutrients are wasted. To collect and clean the polluted wastewater, expensive sewage and treatment systems are needed.

Dry urine diverting toilets: ecological sanitation or ecosan

Dry urine-diverting (U.D.) toilets do not pollute nor waste water; potential dangerous human waste is diverted, sanitised and recycled in a safe way. Human waste is considered as a resource. This approach is also called ecological sanitation or ecosan. For an adequate functioning of these kinds of toilets no central water supply or sewage system is needed.

The design of the toilet makes it easily adaptable to different types of communities, and can be constructed with cheap and locally produced materials.

2 | How does a dry urine diverting toilet function?

Diverting, sanitising and recycling of nutrients

Human bodies are made in such a way, that the different out flows are stored separately in intestinal and bladder, and leave the human body also separately.

Special toilets make use of this natural condition: they don't mix the urine and faeces, see fig. 1. Dry urine diverting toilets separate, collect, store and treat these two flows. Well-constructed and well-maintained U.D toilets don't develop bad odours, nor attract flies. After sanitising the urine and faeces, these nutrients rich products are reused in agriculture or garden, see fig. 2.

Requirements for good performance of dry urine diverting toilets

For a good performance of the dry urine diverting toilet, just 4 things must be borne in mind. This will assure that there will be no smell and the products can be adequate sanitised:

- The design of the toilet-slab assures that the urine is directly diverted from the faeces; the urine does not touch the faeces.
- The faeces are led into a faeces chamber or container and are covered with prepared soil, ashes, lime and/or wood-flints.
- The chambers must be kept completely dry and covered with sufficient soil, ashes, lime and/or wood-flints.
- Urine and faeces are always stored and treated separately.

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fig. 1: A Urine Diverting Squatting Toilet*



fig. 2: Reuse of ecosan products in agriculture or garden*

3 | How to divert, to treat and to sanitise?

The dry urine diverting toilet has a separator bowl and a hose, which conducts urine to a reservoir or canister. If the time recommendations about the storage of urine are followed, it can be safely used as fertilizer and does not pose a health hazard.

When a double vault (two chamber) toilet is used, the faeces are deposited in one of the two chambers: in the "in-use" one. The volume of one chamber is designed in such a way, that it can be used for approx. one year. If the "in-use" chamber is about to be full, the toilet seat or slab is slid to the hole above the empty chamber, and the filled chamber is covered with a layer of soil. In the meanwhile the second chamber is in use. In the first filled "faeces" chamber the process of pathogen reduction is going on, which converts excrements into a good soil conditioner. When the "in-use" chamber is about to be full, the other one must be emptied, so that it is ready to be

used again. By that time the faeces have become a safe odourless, dry humus soil conditioner, which smell like soil.

Depending on the situation, also just one chamber or a bucket to collect the faeces can be used. In this case a post treatment like composting is needed. This is not the preferred option as there is a more frequent handling of the faecal material.

Alternated use of both chambers assures enough time for a sanitising of the faeces. Ash or lime used for covering of the faeces and the lack of humidity inside the chambers aid the destruction process of pathogens. The storage time of the faecal must be at least one year to obtain a hygienically safe material. If the chamber 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 (illness making bacteria or viruses).

Therefore, faeces must always be treated before they can be applied on a field or a garden.

Different designs of urine diverting toilets

Depending on the money available, wishes or habits of the user, there are different designs of U.D. toilets possible:

- Slabs of e.g. fibreglass for squatting
- Slabs of concrete for squatting, which can be hand made
- Seat toilets where a separate part is fitted, the casing can be constructed by oneself
- Seat toilets of concrete, which can be produced locally with help of a mould
- Seat toilets of fibreglass
- Seat toilets of porcelain

4 | How to maintain the double vault dry urine-diverting toilet?

Dry bottom

Before using a chamber, a 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 circa one part of ash or lime. Some sawdust can be added. If not enough dry soil is available sawdust or other dry organic materials can be used instead. Ash is to be preferred above lime. Ashes and lime take away the smell and decrease pathogens.

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

Covering

After each use, at least one cup of a mixture of prepared soil or sawdust must be added, to cover fresh faeces. Don't be sparing with the covering. Used toilet paper can be disposed in the chamber; it does not effect the pathogen destruction

Levelling

It is important to level the mound formed by falling excreta regularly. Depending on the toilet's frequency of use, the faeces must be levelled weekly with a stick or other tool, and some more prepared soil or sawdust should be added.

Changing the chamber

Only one faeces chamber is in use at one time. The other one (which is not in-use) must be closed. When the in-use chamber is about to be full, the toilet must be moved and the faeces must be covered completely with a dry soil layer. The toilet is moved to the empty chamber and the full chamber is well covered with a lid.

If the toilet has only one vault the compost process must be continued on a compost heap.

Emptying

When both chambers are full, the one, which has been out-of-use, should be emptied. After storage time of at least one year the product is a fertilizer or soil improver, which looks like dry soil and does not smell.

It is better to let a bit of the material on the bottom of the chamber before using it again.

Urinating

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

The urine is collected in a reservoir and should preferably be used as a fertiliser in agriculture or garden.

How long to store the urine?

Urine is an excellent fertilizer. Urine 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 fertilizer 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 recommendable to store urine before application.

There are different origins of urine to include the storage time:

- For urine of a household, a storage time of 1 month is suggested. However, if the urine is used for one's own garden this is not necessary
- Urine of a household used for fertilizing public places and gardens for common food production: keep a safety limit of 6 month storage time
- Urine from public places, like schools or restaurants: a storage time of 6 month is required

Cleaning

The toilet floor can be cleaned as usual with water and some detergent. Nevertheless it is very

important that no, or only very little water enters into the faeces chambers. For cleaning the seat and the bowl, a wet rag or sponge can be used, trying not moistening the chambers interior as little as possible. 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.

Humidity: bad smells or flies

If bad smells or flies are perceived, a check must be done to assure that there is no uncovered excreta, nor leaks in the urine hose. The toilet caretaker should check regularly if the chamber inside is not too wet. Humidity can also enter through a bad sealed slice or through the walls, if these are not tight, or too much water enters during cleaning the toilets. If humidity is too high, it is recommended to add abundant prepared soil or other organic absorbance material.

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

In general:

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

Usage of urine

Urine contains several nutrients like nitrogen, potassium and phosphorus, which are essential for to grow plants. Depending on the diet, human urine collected during one year (ca. 500 litter) contains 4 -5 kg nitrogen, but faeces (ca. 50 kg) only approx. 0,5 kg nitrogen,

The urine from 30 persons collected during one year can fertilise one-hectare farmland, which is equal with an application of 120 –150 kg Nitrogen per hectare. Or in other words, the daily urine from one person contains enough nutrients for fertilising approximately 1 m² field.

In case of high nitrogen demand more urine can be given in several applications.

Be aware, the nitrogen characteristics of urine are comparable with that of artificial fertiliser and therefore there is a danger to apply too much or too concentrated urine to plants.

There are more ways to use urine as a fertilizer:

- Applying urine without dilution

Before sowing or planting, urine can be applied undiluted onto the soil.

In addition urine can be given undiluted to trees. Urine can also be used to moisten too dry compost heaps.

- 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-7 parts water) for all plants.

After application it is recommendable to cover the place with soil or leaves, to avoid evaporation. To avoid wasting this fertilizer, it is recommended to apply urine only during the vegetation period, so during spring and summer time or, for winter crops, in early autumn. Don't fertilize during wintertime!

Why is it convenient to use sanitised faeces?

Fresh faeces contain high amounts of pathogens (illness making bacteria or viruses). 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

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

How much compost or sanitised faeces should be used?

Human excrete contain in average only 0,5 kg nitrogen, 0,2 kg phosphor and 0,17 kg potassium a year. Therefore, due to the rather low nutrient and the high humus concentration, sanitised faeces or compost is best used as a soil conditioner then as a fertilizer and can be applied in rather high amounts:

1 to 2 litre compost per square meter soil (/m²)

2 to 3 litre /m² for plants with rather high nutrient consumption like potatoes or onions

3 to 4 litre /m² for plants with high nutrient consumption like maize, tomatoes or pumpkins

1 part compost mixed with 1 part soil for balcony or bucket plants

6 | Websites for more information on ecological sanitation:

www.ecosanres.org

EcoSanRes Publications:

2004-1 Guidelines for the Safe Use of Urine and Faeces in Ecological Sanitation Systems

2004-2 Guidelines on the Use of Urine and Faeces in Crop Production

2004-3 Open Planning of Sanitation Systems

2004-4 Introduction to Greywater Management

2004-5 Norms and Attitudes Towards Ecosan and Other Sanitation Systems

2005-1 Review of Sanitation Regulatory Frameworks

GTZ ecosan database: <http://www.gtz.de/en/themen/umwelt-infrastruktur/wasser/9835.htm>

<http://www.ecosan.org/>

<http://www.tu-harburg.de/aww/>

http://www.novaquatis.ch/english/general_e.html

<http://www.otterwasser.de/>

Part 2

Construction of an Outdoor Dry Urine Diverting Toilet with Urinal

1 | General

In this instruction the construction of a double chamber urine diverting dry (UD) toilet is explained.

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

The toilet has a square ground plot of $1,5\text{m} * 1,5\text{m} = 2,25\text{ sqm}$. 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).

Selection of the place for the toilet

The faeces chambers doors have to be accessible. Additional space on the backside of the toilet is required for emptying of the faeces chambers (approx. 2 sqm).



fig. 1: Dry Double chamber UD-Toilet: outside view (left) and inside view (right)

2 | Material list

The list of needed materials is shown in appendix 1.

3 | Foundation

In general UD-toilets should be build in such a way that the floor of the faeces chambers is above the surrounding ground level to avoid water in leakage into the faeces chambers during heavy rainfall. Also the emptying of the chambers is easiest when the floor of the faeces chambers 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 underground. If the ground is solid rock no extra foundation under the floor of the faeces chambers is necessary. For most undergrounds a **round foundation** of **30 cm depths** and **25 cm widths** is adequate, see fig. 2. 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 1,5m * 1,5m**. After this the excavated space should be filled up 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 concrete has to dry (min. 1-2 days).

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fig. 2: Excavation for round foundation (left) and filling with stones (right)

In order to save time, the foundation can be build in one step together with the floor of the faeces chambers, see next chapter.

4 | Faeces Chambers

Floor of Faeces Chambers

The floor of the faeces chamber should be build from high-quality-concrete (high fraction of cement). 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 chamber doors can be applied. This slope can

drain possible water or urine that has entered the faeces chamber (remember: this should Not happen!).

A formwork from wooden slats has to be build. The top of the slats have 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 fig. 3. The concrete has to dry (min. 1-2 days).



fig. 3: Floor of faeces chambers from concrete: formwork (left), finished (right)

Faeces Chambers Outside Walls

The faeces chambers outside walls have to be build 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 chambers** outside walls should be a minimum of 60 cm, better **80cm**. Don't forget the outflow for the urine, see fig. 4. The hole in the side wall for the urine piping should be 50mm in diameter and located app. 20-40 cm above the floor.



fig. 4: Construction of the faeces chamber outside walls from bricks (left), hole for urine piping (right)

Faeces Chambers Dividing Wall

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

Faeces Chamber Doors

The doors of the faeces chambers can be built from different materials including wood or metal (iron, aluminium). The size should be minimum 50 cm in height and width to ensure easy emptying of the faeces chambers. The size of the doors has to be big enough so that an adult person (caretaker of the toilets) can enter the faeces chambers if necessary (e.g. if the urine-pipes have to be changed). Therefore a door size of 60 cm * 60 cm or bigger is recommended.

5 | Toilet room

Floor of Toilet room

The floor of the toilet room (= ceiling of the faeces chambers) 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 chamber walls, here 1,5 m * 1,5 m. The upper part of the stairs can be built in the same step. Afterwards the frame is covered with **4 cm thick wooden slats**, see fig. 5.

After finishing the floor and after the walls, roof and stairs have been constructed 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



fig. 5: Frame for floor of toilet room (left) and cutting hole for seat riser (right)

of the corresponding faeces chambers. Also a 50 mm hole for the piping of the urinal and a 110 mm hole for the ventilation pipe of the faeces chambers have to be sawed into the floor (before covering with linoleum!), see fig. 5. After the holes have been sawed the linoleum can be applied.

Toilet room Walls

The walls can be build from solid material (bricks), wood etc. In fig. 6 the construction of the walls from wood is shown. In the first step a frame is build. The frame can be build directly inside the faeces chambers or in a separate place and carried onto the faeces chambers when the frame is finished (offsite as shown in fig. 6). 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 build 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 build in every side of the toilet.

After placing the frame onto the faeces chambers 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.



fig. 6: Offsite-Construction of the frame for the toilet room walls from wood (left), covering walls with 2 cm wooden slats (right)

Toilet room Door

The door can be build 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. The door can be seen in fig. 1.

Toilet room Roof

The roof can be build from waterproof 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 4 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 exists. On these slats the **roof cover** from metal ($2\text{m} * 2\text{m} = 4\text{ sqm}$) 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.



fig. 7: Construction of roof-bars from wood (left) and the roof-covering with zinc-covered metal-sheet (right)

Stairs

The stairs can be constructed from wood, bricks, stones or concrete. The finished stairs made from wood can be seen in fig. 1. A fence should be build for safety reasons. It is recommended that all stairs have got the same height (to avoid stumbling). Sometimes the slope of the terrain can be used to avoid stairs.

6 | Sanitary Installations

UD-Seat riser or UD-Squatting Slab

The toilet users decide if they prefer a seating 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 on the seat-riser, the use of an urinal is necessary to keep urine from entering the faeces chambers and avoid bad smell causing sprinkles of urine on the floor. Special waterless urinals are available; see fig. 9. Also water flush urinals from ceramics can be modified and used as waterless urinals. The modification of the urinals is done by reducing the number of outflow-holes in the urinal by closing all holes except 1 or 2. This is done in order to reduce the contact area between the urine pipes and the toilet room and thus reduce bad smell coming from the pipes, see fig. 9.

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.



fig. 8: UD-seat riser (left)* and UD-squatting pan (right)

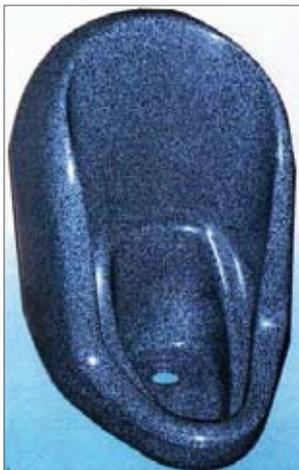


fig. 9: waterless urinal from addicom¹ (left) and modified water flush urinal from ceramics (right)

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. Directly under the seat-riser the diameter of the hose should be reduced to about 10mm by a metal-tubing to avoid bad smell from the pipes entering the toilet room. For the urinal 50mm pipes from Poly-Propylene (PP) are a good choice. PVC-pipes should not be used. 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.

¹ <http://www.addicom.co.za/>



fig. 10: Urine hose 25mm with insulation and PP-pipes 50mm inside the faeces chambers (left); Small 20 litre urine container outside the toilet (right)

Urine Collection and Urine Storage

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

Faeces Chambers Ventilation

The faeces chambers ventilation pipes guide the air from the faeces chambers through the toilet room to above the roof. The pipe should be so long that it ends at least 30 cm above the roof. The pipe 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. You can see the ventilation rain-cap in fig. 7.

7 | Appendix

Appendix 1: Materials for Outdoor Double Chamber UD toilet with urinal

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

Sanitary Installations	tank 1000l (for urine); alternative: 20l Canister	piece	1
	PVC-Hose (inner diameter =25mm)	m	2
	50 mm PP -pipe 1m	piece	1
	50 mm PP -pipe 0,5m	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 20-40mm (to fix hose)	piece	1
	pipe holder 50mm	piece	2
	PP-tube (inner diameter=50mm)	m	2
	PP-ventilation pipe 110 mm	m	2,5
	ventilation pipe cover 110 mm	piece	1
	silicone (to seal ventilation pipe in roof)	piece	1
	urinal	piece	1
Other	bucket 10 liter (for earth/ashes/sawdust)	piece	1
	small shovel (for earth/ashes)	piece	1
	Linoleum	m_	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_	1
	wood-file	piece	1
	electr. Srewdriver	piece	1
	srewdriver	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 riser²	mold for construction of urine diverting toilet seat riser	1	1
	modeling clay	piece	1
	spatula	piece	1
	abrasive paper 80-1000	piece	3
	20mm 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*20cm	piece	1
	soap	piece	1
	rag	piece	1
	gloves	1	1

² Materials needed for the fabrication of a urine diverting seat riser using the mold of Cesar Anorva Millan, Centro de Innovacion en tecnologia Alterniative A.C., aqua@terra.com.mx.