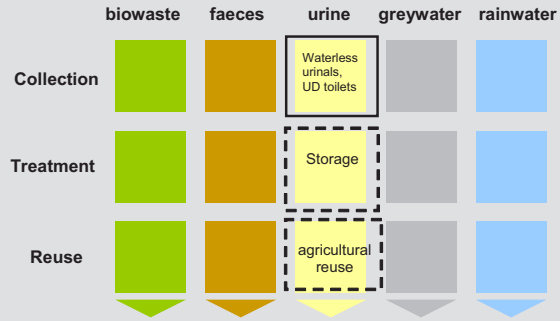
Basic overview of urine diversion components (waterless urinals, UD toilet bowls and pans, piping and storage)

DRAFT April 2009



Preface and Acknolwedgements

Dear Readers,

This document is a revised version of the earlier version of four separate documents (technical datasheets) on “urine diversion” which was published on the GTZ ecosan website in 2005. Authors of those four documents were Nathasith Chiarawatchai, Florian Klingel, Christine Werner and Patrick Bracken (in 2005 they were all working for the GTZ ecosan team and today they work for GTZ Marocco (Christine Werner) or elsewhere). The revision after now four years became necessary to include new findings obtained from research projects and through practical experiences, and to update the information about suppliers of waterless urinals and urine diversion toilets.

The new document was edited by Dr. Elisabeth von Münch (leader of GTZ ecosan team), with assistance from Christian Olt (GTZ ecosan team).

During the review process, the following colleagues provided substantial input to the text: Dr. Hakan Jönsson (especially to Section 2.9, 3 and 4) and Dr. Elisabeth Kvarnström (for Section 2.8) (both from Stockholm Environment Institute (SEI), Sweden), and Dr. Martina Winker (Technical University Hamburg-Harburg, Germany) who helped with Section 2.9.5, together with Dr. Arno Rosemarin (SEI, Sweden). The GTZ ecosan team is deeply grateful for their advice and contributions. We also thank all the suppliers who have provided data on their products (this data is included in the tables in the Appendix).

If you spot any omissions, errors or confusing text, please do not hesitate to get in contact with us by e-mailing us at ecosan@gtz.de so that we can work on improving the document.

We from the GTZ ecosan team hope that you find this publication useful.

Kind regards,

Dr. Elisabeth von Münch

Note: Text in light blue is currently still being worked on.

Please send feedback and comments to the e-mail address given below. We look forward to hearing from you.

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
ecosan program
Dag-Hammarskjöld-Weg 1-5
65760 Eschborn, Germany
T +49 6196 79-4220
F +49 6196 79-7458
E **ecosan@gtz.de**
I www.gtz.de/ecosan

partner of sustainable sanitation alliance
www.susana.org

Contents

List of Tables:

List of Figures:

1 Summary and target audience

The target audience for this publication consists of people who are new to the topic of urine diversion (or new to the topic of ecosan), with little technical background and who:

- need to obtain a concise, easy-to-read overview of the main issues for urine diversion and the main technical components;
- want to know which are the main important documents in this field for further reading;
- may have a particular interest in the developing countries, pro-poor perspective;
- need information on available suppliers worldwide and on costs for waterless urinals and urine-diversion toilet pedestals and squatting pans.

This publication explains the purposes of urine diversion, its advantages and disadvantages, urine precipitation, urine treatment and reuse in agriculture. It provides an overview on design and operational aspects for equipment needed, such as waterless urinals and urine-diversion toilets including supplier information and indicative costs. The publication also provides basic design information for urine piping and storage tanks (including tank sizing and ventilation issues).

Urine diversion is the term used to describe keeping urine and faeces separate at the point of discharge from the user. The four main purposes of implementing systems with urine diversion (UD) are: to reduce odour, to prevent production of wet faecal sludge, to reduce water consumption and to collect urine pure for use as fertiliser in agriculture.

Further potential advantages include for example minimised toilet-related groundwater pollution, the fact that the toilet can be indoors (as opposed to a pit latrine) and better control over micropollutants discharged to the environment. The associated disadvantages are mainly to do with having to “re-train” the users and urine precipitation.

The most common and cheapest method to treat urine (for pathogen removal) is by extended storage. Equipment needed for urine diversion includes waterless urinals (optional), urine diversion toilets (either dry (UDDTs) or water-flushed), urine piping and urine storage tanks (optional).

Urine can safely be used in gardening and agriculture as a nutrient-rich fertiliser, provided relevant guidelines (WHO, 2006) are followed. Should there be no use for the urine, it can be discharged to a sewer or infiltrated in the ground (if local soil and groundwater conditions permit this without adverse impacts on groundwater quality).

Waterless urinals allow the collection of undiluted urine. Despite the fact that hundreds of thousands of waterless (and odourless) urinals are now already in use worldwide, many municipalities are not yet aware of their existence or are reluctant to accept them as a viable option.

Odour control in waterless urinals is crucial for user acceptance, and is achieved by (i) various designs available for an odour blocking mechanism (most notably with a flat rubber tube, silicon curtain valve or sealant liquid), and (ii) by ensuring correct maintenance procedures.

UDD toilets collect faeces dry in vaults located under the UD pedestal or squatting pan. For pro-poor approaches in developing countries, UDD toilets are more suitable than UD flush toilets, as the latter still require a sewer system and treatment for brownwater.

Waterless urinals and UDD toilets are a proven and promising step forward towards implementing water saving, more sustainable sanitation and reduced dependency on costly artificial fertiliser, thus contributing to poverty reduction.

2 Introduction to urine diversion (UD)

2.1 Definition of UD

The major difference between urine diversion (UD) and other sanitation systems is that a urine-diverting toilet has two outlets and two collection systems: one for urine and one for faeces, in order to keep these excreta fractions separate. UD toilets may, or may not, mix water and faeces, or water and urine, but they never mix urine and faeces. Urinals – widely used by men at public toilets, restaurants, schools, etc. – act *per se* as a urine-diversion device because urine is collected separately from faeces. When urinals are of the waterless version, they can collect the urine pure, i.e. without dilution with water.

Urine diversion may be used in ecological sanitation (ecosan) concepts, but not all ecosan projects use urine diversion. Ecosan is an approach to sanitation which focusses on options for reuse of nutrients and organic matter contained in excreta and wastewater, and emphasises sustainability in all aspects[1].

2.2 Purposes of UD

The purpose of UD installations (as opposed to conventional, non-UD systems) is usually one, or several of the following:

1. to reduce **odour** (in dry toilets): when urine and faeces are not mixed, the odour from a dry (or waterless) UD toilet is much, much less than when urine and faeces are mixed together (as in a pit latrine). Therefore, a dry toilet with UD can even be placed indoors without causing odour problems.
2. to **avoid production of wet, odorous faecal sludge**, which has to be removed by someone when the pit latrine is full. Faeces collected dry, separately from urine and water, are hardly offensive, especially after an extended drying period in a faeces vault); this is particularly relevant for hilly or crowded areas with difficult access for vacuum trucks to pit latrines.
3. to **reduce water consumption** – in the case where UD devices are of the waterless type (i.e. waterless urinals; UD toilets without flush water) or of the water-saving type (UD toilets where the urine is flushed with a smaller amount than the faeces).
4. to be able to **collect urine pure** so that it can – after sanitisation by storage – be safely used as fertiliser in agriculture. This is particularly important for small-scale African farmers who cannot afford costly artificial fertilisers.

2.3 Advantages of UD

The advantages of UD are closely linked to the purposes of UD, which were outlined in the previous section. The advantages are always case-specific and may include:

- Significantly **less odour** when compared to pit latrines (but odour is the same when comparing UD flush toilets with conventional flush toilets)
- Toilet can be **indoors** (when comparing UDD toilet to pit latrine), which leads to higher security, privacy and user comfort. In UDD toilets, the faeces dry out unlike in a pit latrine. Consequently, less odour is produced compared to pit latrines. Hence, the toilet can be indoors. This aspect is very important for women and girls, who may fear to go to the toilet outside in darkness if security levels in the community are low.
- **No production of wet faecal sludge** when comparing UDD toilets with pit latrines (but no difference in brown-water (faeces plus water) production for UD flush toilet and conventional flush toilets).
- **Water savings**: Even the urine diversion flush toilets can reduce water consumption for flushing compared to conventional water-flushed toilets: this is because after urination, the amount of flush water can be set to a low volume to flush away some remaining urine and the toilet paper. If urine-soiled toilet paper is collected in a bin, rather than flushed away, water savings can be even higher. Obviously, the potential savings from UDD toilets (without flush water) are even greater. Waterless urinals use no water for flushing, whereas conventional urinals use around 4 L per flush.
- **Recycling of phosphorus from urine** is easier if urine is collected pure, rather than mixing it with other wastewater. The element phosphorus is a finite resource, which will eventually run out - and up to that point, it will become increasingly expensive to produce phosphorus from phosphate rock. Phosphorus is an essential element in fertilisers. But at current rates of exploitation (increasing about 3% per year), the economic reserves of P will last no more than 50 years, and the US economically viable reserves will be depleted within 25 to 30 years (Rosemarin et al., 2008). Hence, in the future increased efforts to recycle the P content in human excreta are in fact unavoidable (EcoSanRes, 2008).
- Ability to use collected urine as **fertiliser**, which can lead to higher food security for poor farmers. As explained further in Section 2.9, urine is a liquid fertiliser rich in nitrogen and phosphorus and can thus be an important resource for people growing food or non-food crops.
- Environmental benefit (1): **No toilet wastewater production** (in the case of UDD toilets compared to flush toilets) since UDD toilets are not connected to a sewer. In the case of UD flush toilets, this advantage does not apply as the faeces and water mixture is still discharged to the sewer. In cases where untreated wastewater is discharged to surface water, then another advantage of a UDD toilet is the reduced pollution of surface water with nutrients (nitrogen and phosphorus) and pathogens; note however, that greywater is being produced in the same manner as before.
- Environmental benefit (2): **Minimised toilet-related groundwater pollution with nitrate and pathogens** (in the case of UDD toilets compared to pit latrines and septic tanks). Pit latrines and septic tanks are designed to infiltrate liquid into the soil, which can lead to groundwater pollution if the population density is high and the groundwater level is high as well. UDD toilets on the other hand collect the urine and faeces above-ground and therefore achieve groundwater protection[2]. Note that onsite greywater disposal can also lead to groundwater pollution and this issue is not addressed by urine diversion systems.

[1] For definition of sustainable sanitation, please refer to the Vision Document of the Sustainable Sanitation Alliance (http://www.susana.org/index.php/lang-en/vision/42-vision/53-what-is-sustainable-sanitation)

[2] See Section 2.9.4 regarding possible risks of groundwater pollution when urine is reused in agriculture.

- If there is concern about **hormones and pharmaceutical residues** entering drinking water sources via sewage, then the separate collection of urine has the advantage that these substances can be eliminated from a concentrated source (urine), rather than from a dilute source (sewage). Treatment options are further discussed in Section 2.8. For industrialised countries, this can be a major driving force in favour of UD systems (e.g. in the Netherlands, where the concept is now better known under the title "new sanitation systems").
- Urine diversion may also create **business opportunities** for the private sector via the sale of the new UD technology, implementation, management, and marketing of the product (urine) to farmers.

Cost savings: whether or not there will be cost savings when implementing UD systems, cannot be answered universally, but is context specific (see Section 0).

2.4 Disadvantages and challenges of UD

2.4.1 Overview

Urine diversion may also have disadvantages and challenges, which are case dependent. They depends what the situation was like before (e.g. did the users have pit latrines before? Or did the users have conventional flush toilets before?), and what is compared with what. Possible disadvantages include:

- Users have to think a bit when they use the toilets especially if they use them for the first time (this point does not apply to waterless urinals, which are used in the same way as water-flushed urinals). Thus urine diversion needs a certain level of **awareness raising** to achieve social acceptance.
- If users do not cooperate, the resulting abuse can result in odour (if users urinate in the faeces compartment of a UDD toilet) or a "messy" toilet (if users defecate into the urine compartment of a UD flush toilet).
- Anal washwater has to be collected separately (in the case of UDD toilets), which requires again a basic level of understanding/cooperation from the user.
- In the case of UD flush toilets, maintenance requirements of urine diversion systems may be higher in comparison with conventional sewer-based systems. Users' commitment to the proper use of these facilities is very important:
    - Cleaning of UD flush toilets is more time consuming than cleaning of conventional flush toilets, due to the separate urine compartment.
    - Blockages of urine pipework due to precipitates can occur (see Section 2.4.3).
- If urine diversion is applied in cities, urine needs to be transported to the reuse areas by truck, leading to increased truck movements (and related CO_2 emissions).
- When urine is used in gardening and agriculture, there are some aspects which the farmers needs to consider – as with other fertilisers (see Section 2.9).
- If urine is not reused, but infiltrated, this could lead to groundwater pollution with nitrate (depending on the amount of urine infiltrated, soil properties, groundwater table).

2.4.2 Social acceptance

Regarding social acceptance, successful adoption of urine diversion is closely linked to:

- political will, messages from the media and local "champions"
- users' motivation and willingness to change existing habits and behaviours
- supportive attitude of all stakeholders involved (e.g. users, maintenance staff, planners, farmers, politicians)
- demand for urine as a fertiliser (or some other reuse/disposal option for collected urine if agricultural reuse is not possible).

Hence, careful planning with stakeholder participation is crucial.

For the users, odour is obviously a potential obstacle to social acceptance, but with the correct design and operation, odours from waterless urinals and UD toilets should be the same or less than conventional urinals and toilets. Also, UDD toilets can be expected to have significantly less odour than pit toilets, and can therefore be placed indoors which can be a significant driver for social acceptance.

Social acceptance also depends to a high degree on:

- What people are currently using (are they used to "flying toilets" (plastic bags) or to water-flush toilets?) and what they are expecting to get.
    - UDD toilets may be perceived as a sub-standard, unhygienic solution, compared to flush toilets which the wealthy people have. It is important that UDD toilets are not seen as a solution for the poor only.
- Does their culture have a tradition of reusing human excreta (e.g. in China) or not? Are their taboos surrounding faeces? If yes, these taboos need to be addressed.

2.4.3 Urine precipitation

The information given in this section has mainly been taken from Larsen and Lienert (2007), where further more detailed information is available.

Precipitation in urine pipes and storage tanks occurs in both water flushed and waterless systems. The solid precipitates consist of mineral compounds originating from urine ingredients such as calcium, magnesium, ammonium and phosphate.

In fresh urine, the main nitrogen compound is **urea**. During storage, urea is hydrolysed to ammonia/**ammonium** and hydrocarbonate by urease enzymes present in the urine storage container, soil and in aquatic systems. This process is accompanied by an increase in pH. The increased pH value results in precipitation of struvite and calcium phosphate crystals.

This may occur as hard precipitates (incrustations) or soft, viscous, paste-like precipitates (deposits). While incrustations tend to occur on the inner walls of pipes and pipe bends (e.g. in water-flushed urinals), soft deposits occur in storage tanks (where they form a sludge at the bottom of the tank) and in near-horizontal urine pipes (e.g. outlet pipes from waterless urinals).

The incrustations, widely called "urine stone", consist of various crystals – mainly struvite and calcium phosphates.

The following factors reduce the extent of precipitation:

- **Short retention time**: precipitation often occurs at locations where the urine flow velocity is low or even stagnant

(e.g. siphons, pipes with a small slope) and at the U-bend of the toilet.

- **Smooth surfaces and hydrophobic materials** should be used. Scratching of surfaces by mechanical cleaning should be avoided. Plastic PVC pipes are commonly used for urine pipes.
- **Avoid small diameter pipes** (less than 1 inch or 2.5 cm), as they may block too quickly.
- If flushing with water: **Flushing with soft water** is preferred compared to flushing with hard water (soft water has a lower content of calcium and magnesium which could react with the ammonium and phosphate in the urine to form precipitates). Flushing with rainwater may therefore reduce precipitation compared to flushing with hard water.

Using no flush water at all (e.g. in waterless urinals) does not eliminate the problem, since urine also contains calcium and magnesium to cause precipitation with ammonium and phosphate.

More information about maintenance tasks to prevent or remove blockages in urine pipes is provided in Section 5.2).

2.5 Quantity of urine

The quantity of urine produced by an adult is commonly quoted as 0.8-1.5 L per adult per day (WHO, 2006, Volume 4, section 1.5.3) – it mainly depends on the amount of liquid a person drinks. Children produce approx. half as much urine compared to adults. A widely used design figure, based on Swedish data, is **1.5 L/cap/d (or 550 L/cap/year)**[3].

2.6 Quality of urine

2.6.1 Pathogens

With regards to pathogens in urine, it is important to know that urine in the bladder of a healthy individual is sterile (meaning it contains no pathogens)[4]. Only very few diseases are transmitted via pathogens in urine. The only disease which needs to be considered from a risk perspective when urine is used is *Schistosoma haematobium* - in areas where this disease is endemic (WHO, 2006, Section 3.2.2).

In contrast, the amount of pathogens in faeces (including eggs of intestinal worms) can be very high, depending on the prevalence of diseases in a given population.

2.6.2 Nutrients

With regards to nutrients contained in urine, the following design figures are generally used:

- Mass of nutrients excreted with urine: 4 kgN/person/yr and 0.36 kgP/person/yr
- Concentrations of nutrients in urine (design figure): 7300 mg/L N; 654 mg/L P
- Concentration figures vary depending on a person's diet, (see Jönsson et al. (2004) for calculations on this) and should preferably be verified onsite.

Other parameters of fresh and old urine are listed in

- Table 1. The lower phosphate, magnesium and calcium concentration in old urine compared to fresh urine is due to precipitation processes.
- 80% of the nitrogen excreted is excreted by a person with the urine, and the rest with the faeces. Hence, in terms of nitrogen as fertiliser, urine is more important than faeces. For phosphorus, the figure is: 55% excreted with the urine, the rest in faeces.

It is useful to know that adults excrete the *same mass of nutrients* as taken up in their diet, i.e. there is no retention of nitrogen and phosphorus in the human body, except for children where a small amount is retained, e.g. for bone growth.

Table 1. Chemical composition of fresh and old (stored) urine[5]

Parameter	Fresh undiluted urine (literature)	Stored, old undiluted urine (from Eawag office building)
pH	6.2	9.1
Total nitrogen (mg/L)	8830	9200
Ammonium/ammonia $NH4^+ + NH_3$ (mg/L)	463	8100
Nitrate/nitrite $NO_3 + NO_2$ (mg/L)	0.06	0
Chemical oxygen demand (COD), a measure of the organic components (mg/L)	-	10,000
Potassium K (mg/L)	2737	2200
Total P (mg/L)	800 –2000	540
Sodium Na (mg/L)	3450	2600
Magnesium Mg (mg/L)	119	0
Chloride Cl (mg/L)	4970	3800
Calcium Ca (mg/L)	233	0

2.6.3 Micro-pollutants

Micro-pollutants in urine could include the following types of substances:

1. Heavy metals
2. Organic compounds
3. Natural hormones
4. Pharmaceutical residues, including e.g. hormones from contraceptive pill

The first two types are generally non-existant in urine, but the natural hormones and pharmaceutical residues do occur in urine. They represent however a low risk in urine reuse practices (see Section 2.8 and 2.9.5).

2.7 Technical components used for achieving UD

To achieve urine diversion, the following technical components are used: waterless urinals, urine diversion (UD) toilets, urine piping to a urine storage tank (or to a sewer) and a reuse system for the urine. UD toilets do not mix urine and faeces at the point of collection in the toilet. There are two main variants of UD toilets (described in Section 0): UDD toilets (urine-diversion dehydration toilets - no flush water is

[3] Cap = capita = person

[4] Cross-contamination of urine with faeces may occur during toilet use, see also Section 2.8.

[5] Source: Maurer, M. (2007) Urine treatment – absolute flexibility, Eawag News, March 2007, results from Novaquatis research project, Dübendorf, Switzerland http://www.eawag.ch/services/publikationen/eanews/news_63/en63e_maurer.pdf

used at all) and UD flush toilets (water is used to flush the faeces away and to rinse the urine compartment).

2.8 Urine treatment options

Urine treatment has the following objectives:

- **Pathogen kill** (this is the main objective): Collected urine could be contaminated with pathogens if careless or inexperienced users deposit faeces in the urine compartment of a UD toilet (this is termed "cross-contamination" of urine with faecal material). As mentioned above, urine itself is virtually pathogen-free.
- Other possible treatment objectives (these are not usually of relevance in the developing country context, as they are not crucial from a public health protection point of view):
  - Volume reduction
  - Conversion into solid form (struvite)
  - Extraction (further concentration) of nutrients
  - Elimination of micro-pollutans, such as pharmaceutical residues and hormones

The simplest, cheapest and most common method to treat urine is by **storage** (Section 5 provides design details).

Storage of urine in a closed tank or container (not gas tight) is an efficient treatment method for reducing pathogens in urine: The decomposition of urea into ammonia/ammonium and hydrocarbonate leads to an **increased pH value** which has a sanitizing effect (meaning it kills pathogens), so that bacteria, protozoa and viruses die out over time. An environment with a high temperature and low dilution with water enhance this effect.

Pathogen content can be reduced to a level at which safe reuse of urine in agriculture is ensured, if the following recommended storage times are respected (for full details see WHO (2006), Section 4.4.4):

- Urine originating from larger systems (community level) – where cross-contimation with faeces cannot be ruled out - should be stored for at least one month if it is used on food or fodder crops which are processed. For a higher safety margin, 6 months of storage can be used (in which case the urine can be used on all crops).
- For urine which originates from small systems (household level) or from systems where cross-contamination with faeces is definetely not occurring[6], no storage is needed when using such urine for crops grown for own consumption. This is because disease transmission within the family or within small communities via the urine-oral route is much less likely compared to the faecal-oral route.

More advanced urine treatment – other than storage – can be via biological processes (nitrification), chemical processes (struvite precipitation; ozonation) or physical processes (membrane-based). Some of these "high-tech" methods (such as ozonation and membrane-based processes) can remove micro-pollutants from urine. This is useful to know if there is concern about micro-pollutants in urine (this is a theoretical risk for urine reuse, see Section 2.9)

These "high-tech" processes are well researched and documented e.g. in Larsen and Lienert (2007) and in several research studies carried out by Tettenborn (2007) at TU Hamburg-Harburg, Germany.

[6] E.g.: urine collected from waterless urinals only (not from toilets).

2.9 Reuse of urine as fertiliser in agriculture

2.9.1 Is urine an "organic" or a mineral fertiliser?

The term "organic fertiliser" might be used for two different meanings:

- Organic in the analytical chemistry sense (a compound which contains carbon, and may contain other elements such as hydrogen, oxygen, nitrogen etc.)
- Organic in a "green", "eco" or "natural" sense ("organic farming" is a form of agriculture that relies on crop rotation, green manure, compost, biological pest control, and mechanical cultivation to maintain soil productivity and control pests, excluding or strictly limiting the use of synthetic fertilisers and synthetic pesticides, plant growth regulators, livestock feed additives, and genetically modified organisms (http://en.wikipedia.org/wiki/Organic_agriculture).

Fresh urine contains urea, and would thus classify as an organic fertiliser in the analytical chemistry sense. Old urine contains ammonia and no urea, and is therefore *not organic* in the analytical chemistry sense.

Considering the definition of organic farming, however, old urine could be termed an organic fertiliser as it is entirely "natural".

In other words: Urine is both a natural mineralized or mineral fertilzer and an organic or ecological or natural fertiliser[7]. More explanations on this double-role is available in the archive of the Ecosanres discussion forum (www.ecosanres.org, debate around December 2008).

Unfortunately, urine is currently not allowed in "certified organic" crop production in most Western countries. Making it allowed for ecological farmers in the EU remains an important challenge.

2.9.2 Beneficial aspects of urine as a fertiliser

The benefits of urine as a fertiliser have been well proven and documented. These benefits and the application methods for urine as a fertiliser in agriculture are detailed for example in SuSanA (2008), PuVeP (2008), Morgan (2007), WHO (2006) and Jönsson *et al*. (2004). The main points of general interest are summarised below.

Urine is a quick acting fertiliser that can be used for any crops which require N, P, K or S (nitrogen, phosphorus, potassium or sulphur[8]). The fertilising effects of the nutrients in urine are essentially the same as those of artificial mineral fertiliser if the same amount of N, P and K is applied. Hence, reuse of urine in agriculture has the potential to reduce demand for artificial mineral fertiliser.

One of the great advantages of urine is that the content of heavy metals and organic compounds is really really low, since it only comes from the stuff you've once decided are good enough to put in your mouth… Artifical mineral fertilisers can have a relatively high content of heavy metals (see E. Kvarnström).

Below are some rules of thumb for the vaule of urine as a fertiliser:

[7] Source: Håkan Jönsson (personal communication, 2008)

[8] Sulphur is an important macro-nutrient, needed in approximately the same amount as phosphorus, and often lacking.

- Urine is a nitrogen rich complete fertilizer, containing also sodium and chloride. This makes it well suited as fertiliser for crops thriving on nitrogen, e.g. maize, and especially for crops also enjoying sodium, e.g. Swiss Chard (spinach), while some care should be taken when applying for crops sensitive to chloride, e.g. Irish potatoes and tomatoes, even though yields of these crops also can be much improved by appropriate urine application.
- If all urine is collected, it will suffice to fertilize **300-400 m^2** of crop per person per year with N at a reasonable rate.
- For crop production, apply the amount of urine that one person excretes in one day on **one square metre** per cropping season. That means 1.5 L undiluted urine per square metre. If we assume that there is 7 gN/L in the urine (typical value for Swedish conditions), then 1.5 L urine/m^2 will correspond to 105 kg N/ha, which is a low to normal dose for cereals (depending on country and expected harvest from the field)[9].
- The resultant crop also depends very much on the soil, too. Urine will always work better in living soils compared to barren sandy soils. The nitrogen converting bacteria must be present. Compost helps enormously[10].

Some selected recommendations for application of urine as fertiliser are:

- Between fertilisation and harvest a withholding period of at least 1 month should always be applied (large and small scale systems).
- The person applying the urine to the fields should follow good personal hygiene practices (thorough hand washing, and when suitable also using gloves, see WHO (2006)).
- The best nitrogen fertilizing effect is obtained when urine is applied close to the ground and directly incorporated or watered into the soil so as to minimize ammonia losses to the air. In order to avoid leaching, frequent application of small amounts of urine is favourable.
- Urine should always be applied to the soil **next to the plant** (e.g. in furrows) but not onto the plant, especially when it is not diluted with water. *"We fertilise the soil, not the plant!".*

2.9.3 Should urine be applied pure or diluted with water?

Urine can be applied either undiluted or diluted with water, depending on the soil and the gardener's or farmer's preferences. If urine is applied undiluted, watering is usually carried out immediately afterwards because this decreases odour and tends to improve the fertilising effect.

An explanation for this issue by ecosan expert Peter Morgan (Aquamor, Zimbabwe – personal communication in 2008): "*Whatever methods works and suits the "gardener" - by applying urine in holes or furrow and adding water later – or diluting - very fine. The point is that urine is getting into the soil. I am not sure whether the conversion of the urine nitrogen which cannot be used by plants into plant nitrogen (nitrate) by the soil bacteria takes place more efficiently in urine which is diluted and therefore spread out further into the soil or in undiluted urine which is concentrated more in one place first, then is diluted from the central spot. My guess this is academic!"*

Some gardeners dilute urine with water in a ratio of 1:3, 1:5 or even up to 1:15 in order to:

1. Reduce risk of plant "fertiliser burn" (see next section);
2. Be able to irrigate and fertilise in one step and with one piece of equipment (e.g. watering cans). Note nozzles of drip irrigation may clog when a urine-water mixture is used for "fertigation" (irrigation and fertiliser application together).
3. To minimize the risk of applying too much fertiliser to potted plants, as the pot will overflow before too much nitrogen is applied.

2.9.4 Disadvantages of urine compared to other mineral fertilisers

Whilst urine is a proven fertiliser, it has some drawbacks compared to artificially manufactured chemical fertilisers:

- Urine is, compared to artificial fertilisers, a diluted fertiliser: The N, P, K and S concentration in pure urine is much lower than in artificially manufactured fertiliser. Urine's nutrient content as a fertiliser is: $N:P_2O_5:K_2O$ is approximately 0.7 : 0.15 : 0.22 : 0.05 - compared to di-ammonium-phosphate (DAP) or $(NH_4)_2HPO_4$ with the composition: $N:P_2O_5:K_2O$ = 21:46:0:0.
    - This means that in terms of transport, a large mass of water is transported, whenever urine-fertiliser is transported.
- Urine is a multi-component fertiliser, containing N, P and K, in a certain ratio, which may or may not be the right fertiliser for a given soil and crop (Winker et al., 2008)
- Urine has variable nutrient concentrations: The N, P, K and S concentrations in the urine-fertiliser are variable, depending on the person's diet and whether toilet users add some flush water to the toilet or urinal.
- It is a liquid fertiliser, where farmers may prefer a solid fertiliser (unless urine is converted to struvite, by addition of magnesium and raising pH, which is also a proven process).
- Urine adds salinity to the soil soil and therefore its use as fertiliser to pot plants is only recommended when the soil can easily be exchanged. Peter Morgan (Aquamor, Zimbabwe) explains: "*In pot soils (small volumes of soil) the salts will build up more quickly than in the garden, and may need replacing from time to time and perhaps put back into the compost pile, with fresh soil being added back to the pot. Use the pots and get the crop. Toss out the soil and introduce it back into the mound of soil and compost. Put new soil in the pot. But I guess you can't so easily do that in a flat without a garden".* (personal communication, 2008)

Like other fertilisers, urine can cause plant fertiliser burn if not applied correctly. Fertiliser burn is the visible symptom of insufficient water in a plant associated with an over application of fertiliser salts (i.e. those dissolved in urine)[11].

[9] Source: Elisabeth Kvarnström, SEI, Sweden (personal communication, 2008)

[10] Source: Peter Morgan, Aquamor, Zimbabwe (personal communication, 2008)

[11] Root cells actively absorb fertiliser salts from soil solution, and under normal conditions, maintain a higher osmotic pressure. If excess fertiliser salts are applied (i.e. concentrated urine which is not diluted), the osmotic pressure of the soil solution is raised. This means, water cannot enter the cell and may actively move out of it. The resulting injury is known as fertiliser burn or physiological drought (Robert Holmer, personal communication, 2008)

Also like other fertilisers, urine can lead to groundwater pollution (with nitrate) and nutrient run-off (resulting in eutrophication in water bodies) if excess amounts are applied.

It is paramount that if urine is reused in agriculture, experienced gardeners/farmers are consulted to advise people who normally deal only with sanitation issues on planting and cropping schemes.

2.9.5 Are hormones and pharmaceutical residues in urine dangerous for reuse?

Humans excrete hormones and pharmaceutical residues with their urine and faeces (as a rule of thumb: two thirds of pharmaceutical residues are excreted with the urine, one third with faeces, although the figures can vary widely for individual compounds). There is a possibility that if urine is reused in agriculture, these types of micro-pollutants could be absorbed into plant tissues and then enter the human food chain. This is a risk, but it is a small, theoretical one, and there has not yet been a case where this transmission route has been confirmed or a person got sick this way.

With present sewer-based sanitation systems, these micro-pollutants are generally not removed in conventional sewage treatment plants either and are thus discharged into surface water bodies and groundwater (pharmaceutical residue traces have for example been detected in groundwater of Berlin and are regularly measured in the drinking water of e.g. Stockholm).

It is safer to discharge these micro-pollutants to soil, rather than water, as these substances are degraded better in the aerobic, **biologically active soil layers** (high concentration of micro-organisms per cm^3) with long residence times than in water bodies with a relatively low concentration of micro-organisms and low residence time.

Also the microbes present in the soil are already adapted to break down such compounds as these are also discharged to the soil via animal manure (in Europe, farm animals are also often treated with hormones and antibiotics, hence animal manure also contains micro-pollutants but is nevertheless widely applied to the soil as fertiliser).

Further information on these aspect is available in Larsen and Lienert (2007) as well as in publications from TU Hamburg-Harbug, especially the PhD thesis of Winker (2009).

2.10 Costs considerations

Possible cost savings of urine-diversion systems may be related to the following considerations (in each case, one needs to consider what is being compared with what):

- If a centralised sewer system and wastewater treatment plant could be avoided by using UD toilets, then cost savings may be considerable. However, the collection and treatment of greywater, industrial wastewater and rainwater, still requires a sewer system of some sort (separate, decentralised systems may often be preferable). Note that the remaining greywater contains a far lower concentration of pathogens and nutrients compared to conventional domestic wastewater.
- Farmers can use urine as a fertiliser instead of buying artificial fertiliser.
- Reduced water and energy demand may be possible, but this depends on the baseline scenario.

Regarding potential **energy** savings, this needs to be analysed on a case by case basis. Energy savings may be possible with UD systems in three areas:

1. If the system is set up to use less water, energy savings are possible with respect to pumping, processing and distribution of the tap water.
2. Energy savings may be possible at the wastewater treatment plant, which would receive a lower load of nitrogen in the sewage if urine was collected separately (hence less oxygen required for nitrification process).
3. If urine replaces artificial mineral fertiliser, then energy savings are possible for fertiliser production.

On the basis of a life cycle analysis, a study comparing the energy demands for nutrient removal and mineral fertiliser production versus nutrient recovery identified a considerable energy saving potential with urine diversion nutrient recovery (Maurer et al., 2003).

On the other side, the following aspects could lead to UD systems having higher costs than conventional systems:

- In comparison with conventional sewer-based sanitation systems, urine diversion systems which use UD flush toilets tend to have a higher initial investment cost as they require additional components for the separate collection, transport and treatment of the urine and faeces.
- A UDD toilet may be more expensive than a simple pit latrine, or – of course - the do-nothing option of open defecation.

Adequate financing and operating schemes have to be found that ensure financial sustainability. These have to be adjusted to what the users are willing and able to pay so that their financial burden stays affordable.

Further information is available from the SuSanA working group on "costs and economics", (www.susana.org/index.php/lang-en/working-groups/wg02).

3 Waterless urinals[12]

3.1 Definition and purpose

A urinal is a specialized toilet for urinating only, which is used while standing up, and is designed for male users. Urinals are widely used around the world, primarily in public facilities being frequented by a large number of people, because they save space and costs compared to toilets (simpler design; no separate cubicles needed, although in many cases separation panels are installed). Urinals are not commonly used in private households due to their additional space requirements.

A limited number of urinals for females (to be used while standing up, rather than squatting) are on the market but they are not generally accepted for various reasons, e.g. females have greater need for privacy as they have to partially undress. Squatting-type urinals (i.e. squatting pans without an outlet for faeces) are sometimes used for girls in e.g. African or Asian primary schools to save on space and costs compared to toilets.

Conventional urinals are flushed with approx. 4 L of water either after each use or based on a timer, whereas waterless urinals use no water for flushing. The main motivation for using waterless urinals (example shown in Figure 1) is to:

1. Save water (and energy) and hence costs – these urinals are simply connected to the sewer system.
2. Allow collection of pure, undiluted urine for use in agriculture as a nitrogen and phosphorus-rich fertiliser – these urinals are connected to a urine storage tank.

As has been pointed out previously, urine diversion can be a first step towards ecological sanitation (Kvarnström et al., 2006). And waterless urinals are the first and easiest step towards urine diversion.

Figure 1. Waterless urinals for men (left: Centaurus model of Keramag company; right: Plastic urinal from Addicom, South Africa, with Eco-Smell-Stop device (see Table 2).

3.2 Historical development of waterless urinals

In 1894, Mr. Beetz from Austria patented a drainage device (trap) which allowed urinals to be made "flushless". The trap used a sealant liquid (the mechanism is explained later in this paper). This patent was then commercially exploited by the company F. Ernst Engineer in Zürich, Switzerland who was the sole supplier of waterless urinals worldwide for approximately 100 years.

In the early 1990s, water saving came into fashion and several companies appeared on the market using derivatives of the Beetz patent. At more or less the same time Hepworth, a UK plumbing manufacturer, patented a drainage device (one way valve) which was in fact a flat tube. A similar device is used in small boats to drain spray water from the bilge. Derivative patents of the flat tube elements are today used in waterless urinals and marketed by various sanitary ware companies, for example Keramag (model Centaurus).

In 2002, a Swiss engineer (Peter Dahm) patented a one way valve similar to the flat tube design but using a “curtain” mechanism in order to reduce maintenance requirements. This unit, which is now used in waterless urinals of several suppliers, is sold under the name of EcoSmellstop (ESS). Even the 100-year old company F. Ernst Ingenieur AG is since October 2006 using the ESS unit instead of its sealant liquid system.

At present (2008), Germany may well be the country with the highest number of waterless urinals per capita, as the price of municipal tap water in Germany is arguably the highest in the world, and Germans are consequently very interested in all water-saving opportunities. Waterless urinals are commonly used for public toilets which are not connected to the sewer (e.g. rest stops along highways). – Now it is time for this technology – in a low-cost derivate – to also take off in rapidly developing African cities.

3.3 Odour control methods (general)

To guarantee a success, waterless urinals must meet the accepted standards applicable for conventional waterborne installations. Their odour emission must be less or at worst equal to the old system. To achieve this odour-free performance four aspects are absolutely crucial for waterless urinals:

1. Suitable mechanism to block the odour coming back from the sewer or urine storage tank, for example (discussed in detail in the sections below):
   - rubber tube seal
   - curtain valve seal
   - sealant liquid (blocking fluid)
   - old light bulb or plastic table tennis ball placed in a funnel which is inserted in the opening of a jerrican; or
   - place urinal in a well ventilated area (located outside of houses), and put up with some odour (may be possible for rural areas).
2. Appropriate surface of the urinal bowl (smooth, non-stick, e.g. with wax coating)
3. Correctly designed interrelation between urinal bowl and the drain fitting to minimise crevices where urine can accumulate
4. On operational level: a thorough maintenance regarding the bowl and the odour blocking device. The surface of the urinal bowl is usually wiped clean once, twice or several times per day with a moist sponge. For the odour blocking device, the maintenance depends on the specifications by the urinal supplier (see below).

3.4 Odour control for connection urinal to sewer or storage tank

3.4.1 Rubber tube seal

For this method, a flat rubber tube is used (Figure 2). This rubber tube is flat at the bottom when not in use (and hence

[12] This chapter draws on the publication v. Münch and Dahm (2009).

blocks odour from the sewer or urine storage tank) but opens up when urine is flowing through. This one-way valve allows passage of grit up to 2 mm.

Urine precipitates ("urine stone"), which stick to the rubber tube need to be cleaned off with water regularly (otherwise the flat rubber tube does not close properly anymore). The cleaning frequency depends directly on the number of uses per day (e.g. cleaning once per month under average circumstances may be sufficient). The rubber tube needs to be replaced approx. once a year. The rubber material is sensitive to solvents, acids, and deodorising tablets often used in urinals. The use of acids or aggressive cleaning agents must therefore be avoided. This system is used for example by the German company Keramag in their Centaurus model.

3.4.2 Curtain valve seal

The curtain valve seal is similar to the rubber tube seal, but was designed to reduce maintenance requirements. It was designed to hydrodynamic laws quantified by Bernoulli (relation between flow speed of a medium and its pressure). This type of "one-way valve" has "self cleaning properties" as a small pressure difference forces the urine to wet the whole inner surface between the "curtains", therefore flushing them clean. The element is designed in a manner to minimise build up of urine precipitates or urine sludge and thus keeping the sealing surfaces clean. Like the flat rubber tube seal, this one-way valve also allows passage of grit up to 2 mm.

The silicon curtain element is integrated into a plastic casing (Figure 3). The placing of the EcoSmellstop (ESS) element into a plastic sleeve has a twin purpose, firstly to guarantee that no odour from the sewer or urine storage tanks escapes into the room, and secondly to allow an easy removal of the ESS unit for maintenance purposes. For replacement of the curtain, the entire plastic casing is removed with a small plastic extractor tool (Figure 4), then discarded and replaced with a new ESS. This replacement process takes only a few seconds and can be performed without having to touch the ESS element by hand.

The ESS manufacturing process is "high tech" as the injection moulds are of extreme complexity, and the mixing and injection requires very sophisticated machinery (for this reason, it is not yet possible to manufacture the ESS locally in developing countries, but it can easily be imported as it is small, light-weight and low-cost).

This patented ESS unit is used by the companies Addicom, Kellerinvent AG and F. Ernst Ingenieur AG (see Table 2) since 2006.

Figure 2. Two types of odour seals for waterless urinals: Left: flat rubber tube (Keramag Centaurus) and right: Transparent EcoSmellstop (ESS) unit showing the blue silicon curtain one-way valve inside. Photo: P. Dahm.

Figure 3. EcoSmellstop (ESS) fitting with extractor (photo: P. Dahm, Addicom). Inside the ESS is the silicon curtain valve.

3.4.3 Sealant liquid (blocking fluid)

This system works with a sealant liquid (also called blocking fluid) which is made of vegetable oils or aliphatic alcohols – they are biodegradable if released to the sewer or urine storage tank. The sealant liquid, with a specific gravity of around 0.8, floats on top of the urine contained in the trap and thus constitutes an effective odour barrier. Urine immediately penetrates the sealant liquid and flows to the drain. Urine precipitates are collected in the cartridge (e.g. for Falcon Waterfree urinals) or inner cylinder of the trap (e.g. for Uridan urinals).

The maintenance program of waterless urinals with a sealant liquid calls for the cleaning of the urinal bowl and the exchange of the cartridge (or the sealant liquid). Again, the required exchange frequency depends on the number of uses. With each use and in between uses, some urine precipitates accumulate which eventually renders the trap inoperative. Foreign objects, such as cigarette stubs, accelerate the process. At this point the cartridge has to be cleaned or replaced.

Should the trap commence to smell, while it is still freely passing urine, merely a refill with the sealant liquid can resolve the problem for some designs.

In the USA, this type of waterless urinal is currently the most common type of waterless urinal, as under current legislation only liquid filled traps are approved, but not waterless urinals that use the rubber tube or silicon curtain system.

Possible advantages of liquid sealant system:

1. does not need to exchanged when full with precipitates, but instead easily can be cleaned out.
2. Furthermore, not patented in the developing countries, which means that they can be copied locally.
3. Thirdly, after being cleaned out they can be refilled with some cooking oil. Does not last as long as the recommended liquid, but is available everywhere.

+ diagram

It is interesting to note that one of the market leaders for waterless urinals which had the sealant liquid system (F. Ernst Ingenieur AG), changed over to the EcoSmellstop curtain system in October 2006, and is now retrofitting all of its approx. 100,000 urinals which were installed prior to that date (F. Ernst AG operates its urinals under a maintenance contract should the client not decide otherwise). The reason is the lower maintenance requirement of the ESS unit.

3.4.4 Other methods for the odour seal

Other methods for odour control have been invented and used. One example is the system introduced to the market by Urimat[13] where the sealant liquid was replaced by a float (hydrostatic float barrier) which is magnetically activated thus opening the channel to the overflow chamber. For low-cost applications in African countries, this system has the disadvantage of a higher complexity compared to the systems described above.

For small simple systems, with just a pipe or hose without any odour trap connecting the urinal with the tank, the odour can be controlled by having the urine pipe (filling hose) going down to almost the bottom of the collection vessel, thus creating a liquid seal in the collection vessel. Another option is to pour some cooking oil into the collection vessel, thus getting a thin sealant film in the collection vessel itself.

In the “eco lily” (see photo in Table 2) an old light bulb is sometimes used. However it is recommended to use a table tennis ball or other similar small ball, as the solder and metal cap on the light buld contains heavy metals which will contaminate the urine.

3.5 Design information

The space requirement of a urinal is less than that of a toilet, which makes them popular for any venue where many people need to urinate (soccer stadiums, restaurants, schools, etc.). Waterless urinals are usually wall hung and do not require piping for fresh water nor flushing devices, thus allowing a considerable cost saving.

The flushing devices as well as the traditional water traps in the outlet piping (U, P or “bottle” shaped) of conventional urinals tend to attract a considerable amount of vandalism (hence waterless urinals would further reduce maintenance costs). Waterless urinals allow some additional advantages as they need not necessarily be connected to a sewer but can also be connected to a urine storage tank instead (important for remote locations not connected to sewers).

Obviously, water for hand wash basins and water-flushed toilets (if not replaced by waterless toilets) is of course still required in ablution facilities.

Materials:

Urinal bowls are typically made of acrylic, ceramics, stainless steel or glass-fibre reinforced polyester, but can also be made of simple low-cost plastic or concrete, provided that it has a smooth surface (for odour control). Self-construction of inexpensive waterless urinals is also possible. When using plastic urinal bowls, one option is to use linear low density polypropylene as it is among the most inert plastics (non stick surfaces). The hot production process at 180°C guarantees a smooth, non porous surface, therefore minimising bacterial biofilm growth.

Procurement options:

The following procurement options exist for waterless urinals in Africa:

- Imported waterless urinals with or without patented odour control mechanisms;
- Plastic waterless urinals manufactured locally (mould for urinal bowl could be imported if needed), and locally manufactured liquid seal or imported ESS element inserted for odour control; or
- Self-constructed waterless urinals made from plastic containers.

For low cost applications, plastic urinals may be a good option. These can be produced in a "rotation moulding" process. This is a cheap and simple process to make a single-skin type unit, which can be replicated in any country.

Converting water-flushed urinals to waterless urinals

It is in principle also possible to convert conventional water-flushed urinals to waterless urinals (depending on the bowl design), for example by using the ESS, which is also sold as a "stand alone" unit. However, it is very important to get a snug fit of the ESS into the urinal drain, according to the suppliers’ specifications.

3.6 Use and maintenance of waterless urinals

The urinal bowl should be cleaned daily, just like any other (water-flushed) urinal. There are 100% organic cleaning solutions on the market that are simply sprayed onto the urinal bowl, and not wiped off. For the waterless urinals in the GTZ headquarters in Eschborn, Germany, URIMAT MB-AktivReiniger with anionic and non-ionic tensides is used – this is a biologically active and biodegradable cleaning agent.

Any type of odour seal (be it flat rubber tube, curtain seal or sealant liquid) needs to be cleaned (or replaced if cleaning is no longer possible) in regular intervals to keep it fully functional in terms of odour control. The frequency of cleaning or replacement of the odour seal system depends on the number of uses per day, user and cleaning staff behaviour (e.g. in terms of foreign objects discarded in urinal), etc. It can therefore vary widely, e.g. ranging from once per week to once per month or once every six months.

The flat rubber tube and ESS units can be cleaned many times before having to be replaced. Some sealant liquid cartridges cannot be cleaned but need to be replaced when they fail, while for example the Uridan construction can be cleaned, and the sealant liquid replaced, any number of times.

To give an example: According to information given by Addicom, the expected 16-month life time of an ESS element can be achieved with careful maintenance, e.g. spraying the urinal bowl regularly with the cleaning agent “DestroySmell” and removing the ESS element and immersing and rinsing with diluted citric acid to slow down the formation of urine precipitates on the curtains.

Empirical evidence gathered in low-income settings in South Africa (e.g. public parks and taxi ranks in Johannesburg) since 2004 seems to suggest that the curtain seal (ESS system) can perform its functionality with *less maintenance* than the flat rubber tube. It appears that in regions where diligent maintenance of urinals cannot be guaranteed (e.g. public

[13] Hans Keller used to run the company Urimat and has the patents. But he now runs Keller Invent which bought F Ernst AG (hence Mr. Keller moved from hydrostatic float barrier to ESS).

toilets in informal settlements in sub-Saharan Africa), the ESS system may therefore be a better choice of the two.

More side-by-side comparisons between different waterless urinal types (e.g. flat rubber tube versus liquid sealant type) are required, particularly for urban, low-income areas in developing countries with a potentially high level of abuse and neglect.

3.7 User acceptance of waterless urinals

Experience worldwide has shown that waterless urinals enjoy the same level of user acceptance as water-flushed urinals do, since for the male users there is no change required in behaviour (many users do not even notice that they are using a waterless urinal). - For those men who are "shy" and do not like using urinals in public places (for lack of privacy), it makes no difference whether the urinal is water-flushed or not.

When planning the use of urinals in cultures where anal washing with water is practiced, each urinal needs to be installed in a cubicle to guarantee privacy. Many Muslims wash their body with water also after urinating, which requires water supply and separate drainage facilities. Prior to providing waterless ablutions, one has to establish whether the community in question is willing to accept such facilities.

In some instances, there may be a theoretical psychological barrier of users or cleaning staff ("if a urinal is not flushed it cannot be hygienic") - the thought that water is always equal to hygiene is an understandable misconception. However, when faced with a well-functioning, odourless waterless urinal, those fears are quickly alleviated, which is why demonstration projects can be important. Today's waterless urinals are designed to be odourless and simple to maintain.

As waterless urinals are a novelty for many communities, any smell emitted from a waterless urinal gets blamed on the new system. However a smelly water-flushed urinal is accepted as "normal" as they have a longstanding odorous history. It is a fact that any type of urinal (water-flushed or waterless) will in fact not smell if well maintained. The extent of maintenance required for waterless urinals can be higher or lower compared to water-flushed urinals, depending on the type of waterless urinal used (as explained above).

3.8 Examples of waterless urinals

For reference installations please either contact the manufactures directly or see the case study descriptions of sustainable sanitation projects on www.susana.org: many of these projects incorporate waterless urinals.

3.9 Outlook for future of waterless urinals

To reduce the capital costs of waterless urinals further, it is proposed to use a standardised, mass-produced unit for odour control, such as the patented EcoSmellstop (ESS) unit, which is already being used by three waterless urinal suppliers. This could allow waterless urinals to become more widespread for low-cost settings in the context of developing countries – for water saving and reuse of urine in agriculture. The ESS unit could also be used in urine-diversion toilets, so that a urinal could be integrated into a toilet pedestal or squatting pan, and thus enabling also the collection of urine from female users.

3.10 Unit costs and suppliers

Table 2 in the Appendix summarises relevant information about waterless urinals from several suppliers based in South Africa and Europe. The waterless urinal industry is presently very fragmented, meaning a multitude of suppliers (brands) with relatively small quantities of installations and therefore high costs. Only the first supplier shown in Table 1 is currently gearing the product price to the very low-income market bracket.

There are many success stories around the world where highly specialised companies supply components to entire industrial sectors. This allows the manufacturing of large quantities at top quality at relatively low costs for basic components used in different brands e.g. car industry and spark plugs, IT industry and memory chips, only to mention a few. The foundations to introduce a similar concept for the waterless urinal industry are available. This would allow existing brands to take advantage of a proven product at low costs.

4 UD Toilets (UDD or water-flushed)

4.1 Definition

Urine diversion (UD) toilets intend to not mix urine and faeces at he point of collection in the toilet. There are two main variants with UD toilets:

1. **UDD toilets** (urine-diversion dehydration toilets) - no flushwater at all is used. These toilets are often called "ecosan toilets" – something which GTZ does not support, since it would wrongly label one particular toilet type as the toielt to be used in ecosan projects.
2. **UD flush toilets**: Water is used to flush the faeces away, and to rinse the urine compartment. These toilets are often also called NoMix toilets (e.g. by one of the main suppliers, Roediger).

These toilets may be implemented within new sanitation systems or may complement existing systems. In any case, additional pipework such as a second pipe from toilet to holding tank becomes necessary (see Section 5).

Further design information on these toilets types is given below.

4.2 Design information for UD toilets in general

Careful planning and appropriate design is essential for successful application of UD toilets. They should be designed for the needs and the customes of the intended users. The preference of the user can be distinguished between:

- **Sitting toilets** (with pedestals): these can be wall-hung or floor mounted. Specific connection parts may be necessary for proper installation. For the installation of toilets, following the manufacturer's instructions is recommended to ensure precise fit. Easily accessible and removable connections can help in case of required replacement.
- **Squatting toilets** (with squatting pans)

Also, it needs to be investagted if the users intend to wash the **anal area with water** after using the toilets instead of using toilet paper ("washers" as opposed to "wipers"). This is customary in many Muslim cultures but is not 1:1 linked to religion, e.g. in parts of India also Christians practise this. It is therefore also linked to cultural norms, climate, availability of water, habits, etc.

Consideration of convenience of use for disabled people, elderly, children needs to be given (just like for other toilets).

4.3 Urine-diversion dehydration toilets (UDD toilets)

4.3.1 Design information

UDD toilets do not use water for flushing. They use a very simple system where the urine is captured in a bowl which is integrated in the front of the toilet pedestal or squatting pan. From here, the urine is drained off to a storage container (or leaching pit if the urine is not collected – beware of possible groundwater contamination with nitrate).

For the faeces, a straight drop (or chute if toilets are on several levels in the house) is provided from the toilet pedestal or squatting pan to a collection chamber (faeces vault) below. The faeces vault can also be in the form of a bin which is normally used for household rubbish.

A ventilation system is provided to ventilate the faeces chamber and speed up the drying process.

For the urine pipe, an odour seal may be used if the toilet is indoors and odour control is very important and especially in systems with many toilets (same types of seals as for waterless urinals can be used (see Section 3.3)). For outdoor UDD toilets, the connection to the urine storage tank is usually direct, without any odour stop device.

UDD toilets are <u>not</u> designed for composting to take place in the faeces chamber (on the other hand, composting toilets can be designed with urine diversion).

<u>Construction method and materials:</u>

- Prefabricated (ceramic, sanitary porcelain, acrylic, glass-fibre reinforced plastic)
- Self-constructed (concrete)

Except for stainless steel, metal components cannot be used since urine is corrosive.

Further design information for UDD toilets can for example be found in:

- Winblad and Simpson-Hebert 82004)
- Morgan (2007)
- Berger (2008)
- Technical datasheets of GTZ ecosan on "dehydrating toilets" or composting toilets (publications currently being revised): http://www.gtz.de/en/themen/umwelt-infrastruktur/wasser/9397.htm

Figure 4. UDDT toilet (pedestal type) in Johannesburg, South Africa at the house of Richard Holden (ecosan pioneer). Source: E. v. Münch, 2006.

Figure 5. UDD toilet (squatting type) in Ouagadougou, Burkina Faso, installed by NGO CREPA. Source: E. v. Münch, 2006.

4.3.2 Use and maintenance of UDD toilets

The main requirement when using UDD toilets is that:

Faeces vault is kept as dry as possible (no addition of urine or water; also anal washwater cannot be added to faeces vault, but needs to be collected separately)

Covering material is added to the faeces vault after each defecation. Covering material can be ash, sand, soil, lime, leaves, compost. The cover material should be as dry as possible. The purpose of adding covering material is to:

- Reduce odour
- Assist in drying of the faeces (soak up excess moisture)
- Prevent access for flies to faeces
- Improve aethetics of the faeces pile (for next user)
- Increase pH value (achieved when lime or ash is used)

Further details on use and maintenance of UDD toilets is given in Morgan (2008) or in the case studies mentioned in Section 4.3.3.

4.3.3 Examples of projects which use UDD toilets

UDD toilets are used in sustainable sanitation projects world-wide, mainly in rural and peri-urban areas, although the challenge is now to implement them also in urban areas where appropriate. They have been installed at household level but are also an increasingly popular option for schools, especially wherever there is a demand for fertiliser. As mentioned above, they can be built indoors or outdoors.

Many projects which are using UDD toilets are described in the case studies of SuSanA (http://www.susana.org/index.php/lang-en/case-studies), particularly in the Philippines, India, China, Uganda. They can also be found via the Google-Earth based tool Sanimap (www.sanimap.net).

A detailed study on the use of UDD toilets in a sewered area, in Stockholm, can also be downloaded from www.urbanwater.org, Report 2005:8.

4.4 UD flush toilets

UD flush toilets are relatively new, invented in Sweden in the 1990's (Kvarnström et al., 2006). Their application was first adopted in eco-villages and holiday homes. Today, they are also used in some housing projects and public buildings in several countries in Europe, although still only at a pilot scale (see also Section 4.4.3 which provides project examples).

A detailed study – NOVAQUATIS - on the use of UD flush toilets was conducted by EAWAG, Switzerland, and the final report provides detailed information on design and operational issues (Larsen and Lienert, 2007).

4.4.1 Design information of UD flush toilets

The UD flush toilet has a partition in the toilet bowl isolating a bowl for urine in the front, and a bowl for faeces in the back. The bowl is similar to bowls used for UDD toilets, except that for the UD flush toilet, water is used to flush the faeces away.

The flushing mechanism for the urine part is designed in one of two ways:

1. The urine pipe stays open and therefore receives a certain amount of flushing water when the bowel is flushed (see Figure 6); or
2. The urine pipe is closed by a valve and therefore receives no flushing water (this is the case for the Roediger NoMix toilets, see Figure 7).

UD flush toilets could also be combind with the concept of vacuum toilets (realised for example by the company Roediger for a pilot project in Berlin Stahnsdorf and by the company Wost Man Ecology, see Table 5). This type of toilets allows separate collection of urine and a small, concentrated amount of "brownwater" (faeces with about 1 L of flush water).

Vacuum systems are the subject of a separate technical datasheet (see: http://www.gtz.de/en/themen/umwelt-infrastruktur/wasser/9397.htm).

Materials

As UD flush toilets have so far been designed for users in high-income countries, they have so far been manufactured only in ceramic – the same material which the users are used to from conventional flush toilets.

Figure 6. UD flush toilets (left: Gustavsberg (Meppel, the Netherlands); right: Dubletten (Stockholm, Sweden)). Photos: E. v. Münch, 2007.

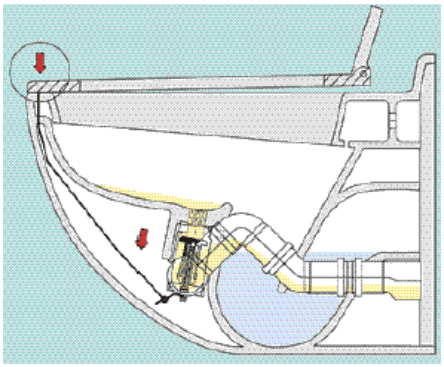


Figure 7. Schematic showing the valve on the urine pipe to collect urine without flushing water in a UD flush toilet (Roediger "NoMix toilet"). Check schematic.

4.4.2 Use and maintenance of UD flush toilets

The faeces section of UD flush toilets are cleaned in the same way as for conventional flush toilets (using a brush directly after use). This will be needed slightly more often as the faeces section is smaller.

Toilet paper is flushed away together with the faeces (a particular problem found with the Roediger No-Mix toilets is that toilet paper thrown into the urinal bowl is not flushed away with the small urine flush; and hence more than one flush become necessary – reducing the water saving effect of this toilet).

One potential problem is blockages of the urine pipe leading from the toilet to the storage tank (for causes and solutions see Section 2.4.3 and Section 5.2).

A particular problem for the Roediger NoMix toilets is that the valve on the urine pipe can get blocked over time (in this case, urine is no longer collected in the storage tank but flows to the faeces compartment of the toilet).

4.4.3 Examples of projects which use UD flush toilets

UD flush toilets are typically used rather in industrialised countries (not a low cost option), so far mainly in Sweden with some isolated projects in Germany the Netherlands, Switzerland and Austria. Some of these projects are described in SuSanA case studies in Europe (http://www.susana.org/index.php/lang-en/case-studies/europe). They can also be found via the Google-Earth based tool Sanimap (www.sanimap.net).

Some examples projects for which detailed descriptions are available on the website above are:

- Urine and brownwater separation at the GTZ main building, Eschborn, Germany (http://www.susana.org/index.php/lang-en/case-studies/europe)
- Ecosan project in SolarCity Pichling Linz, Austria (http://www.susana.org/index.php/lang-en/case-studies/europe)
- Innovative wastewater management project "Lambertsmuehle", Burscheid, Germany en-ecosan-pds-002-germany-lambertsmuehle-2005.pdf

4.5 How to choose between UDD toilet and UD flush toilet

A general guideline on how to choose between a UDD toilet and a UD flush toilet is presented in Table 6. For pro-poor approaches in developing countries, UDD toilets are more suitable than UD flush toilets, as the latter still require a sewer system and a safe treatment of the faecal water (“brown water”) to achieve good hygienic conditions.

4.6 Unit costs and suppliers for UD toilets

Information on models and suppliers can be found in Table 4 (for UDD toilets) and Table 5 (for UD flush toilets) in the Appendix.

The costs for toilets which are not yet sold in high numbers is relatively high, as there is no economy of scale. If the market for these types of toilets grows and more suppliers enter the market, then the unit costs can be expected to decline.

5 Urine piping and storage

5.1 Overview

A comprehensive description of the technical details for urine pipes and tanks is available in Appendix 2 of Kvarnström et al. (2006). Below, some key considerations are provided.

The urine which is collected by means of a waterless urinal or urine-diversion toilet, is piped to a urine storage vessel or tank. From the urine storage vessels or tanks, the urine is collected and either removed locally by the users themselves (small-scale systems) or emptied by a pump and truck arrangement (vacuum tanker would also be possible). The urine is then transported to the point of reuse (or could also be taken to a location for treatment). As mentioned in Section 2.9, urine is well suited as a fertiliser in agriculture.

5.2 Urine piping

5.2.1 Functional principles

The urine piping system connects the waterless urinals, or the urine compartment of a UD toilet, with the urine storage tank. Whilst not subject of this datasheet, it needs to be mentioned that there is also a need for a separate chute or pipe for the faeces (UDD toilet) or the faeces-water mixture ("brown water" from UD flush toilets), respectively.

Also, in regions where people practise anal cleansing with water (e.g. many Asian countries, Waste, Africa, Muslim cultures), a third outlet pipe is used, to collect the anal washwater – it is best not to mix it with the urine to keep pathogen levels in the urine to a minimum, if it is to be used as a fertiliser.

5.2.2 Design information

The urine which is collected by means of a waterless urinal (or by a urine-diversion toilet), can be collected undiluted in a urine storage tank (Figure 5 and Figure 6). These tanks are either emptied by the users themselves (small-scale systems) or emptied by a pump and truck arrangement (vacuum tanker would also be possible).

The urine is then transported to the point of agricultural reuse (or to further storage or treatment if desired). A comprehensive description of the technical details for urine pipes and tanks is available in Appendix 2 of Kvarnström et al. (2006). As urine generates a considerable amount of urine precipitates or sludge, special attention has to be given to the design and maintenance of the urine piping system (Larsen and Lienert, 2007).

Materials

Urine pipework is normally made of durable plastics such as polyethylene (PE) or polyvinyl chloride (PVC).

Pipe size and layout

To maximise the flowrate of the urine (and any resulting sediment), the insides of the pipes should be smooth and flow restrictions, e.g. sharp 90º bends, should be avoided as much as possible.

The minimum recommended diameter of the piping or sewer is 50 mm, but the optimum range is from 75 mm to preferably 110 mm.

For larger systems (several toilets connected to urine tank), the slope of the pipe should be at least 1% to minimise urine precipitation. For individual toilet systems, the slope should be at least 4%, but can be built with smaller diameter pipes, down to about 15 mm, and without any odour seal.

For inspection and cleaning, the pipes should be made accessible (by the provision of inspection openings).

As a rule of thumb: keep urine pipes as short as possible and with the highest slope as possible (having long, horizontal pipes could easily cause blockage problems).

To prevent odours, the piping system should be *only sparingly* ventilated, pressure equalization is enough (see Section 5.3.5 for more details on ventilation).

5.2.3 Maintenance

It is difficult to predict how often pre-emptive maintenance should be carried out, as this will depend on local circumstances – trial and error will lead to an optimised cleaning schedule. Experience has shown that correctly installed pipes generally need no cleaning, except for the odour seal or 90-degree bends (which should be avoided).

Detailed instructions for clearing and preventing blockages in U-bend odour seals are provided in Kvarnström et al. (2006) in Appendix 2, from where the following paragraphs are taken:

"In all installations there is a risk of blockages occurring mainly in the seal. It is a result of fibres and other particles entering the piping system and of chemical precipitation of struvite ($MgNH_4PO_4$) and calcium phosphates (Ca_{10} $(PO_4)_6(OH)_2$) from the urine caused by the increase in pH which occurs when its urea is degraded. The precipitation also forms a viscous sludge, which will slowly flow towards the tank provided that the slope of the pipes is correct.

Most blockages that occur in urine-diverting toilets are "soft" blockages caused by precipitation on hair and paper fibre. The other type is hard "blockages", caused by precipitation directly on the on the pipe wall. The blockages are removed either mechanically by a drain auger or chemically by use of strong solutions of caustic soda (2 parts of water to 1 part of soda) or acetic acid (>24%)."

It is important that the cleaning is carried out in a way so that the quality of the urine in the urine storage tanks is not negatively affected.

5.3 Urine storage

5.3.1 Functional principles

Urine storage tanks are used for one or several of the following three main purposes:

1. To bridge the time in between collection/emptying events by transport vehicle or by the users themselves.
2. To sanitise the urine: over time, pathogens in the urine tanks are killed off (increased pH due to urea conversion to ammonia; time itself also results in pathogen kill – see Section 2.8).
3. To bridge periods where plants are not fertilised: The plants' needs for urine fertiliser is not constant all year round, but mostly just before sowing and in the beginning of the growth period (see Section 2.9).

At the bottom of the urine storage tank a layer of sludge forms over time (containing precipitates and crystals – see Section 2.4.3), with high levels of nitrogen, phosphorus, calcium and magnesium. If the full nutrient value of urine is to be used for fertiliser purposes, then it needs to be ensured that also the bottom sludge layer is emptied and reused.

5.3.2 Location

The location of the urine storage tanks can be:

1. At toilet level: If the urine is to be used in the household garden, a simple construction is also possible (example: Figure 8).
2. At household/building level (several toilets together, see Figure 9).
3. At community level (several houses together) – this is possible if distances between houses are short (see Figure 9).

As the urine tanks must be emptied regularly, suitable access is required, especially if emptying is performed by a vacuum tanker.

The tanks can be located either in the cellar of the building or next to the building or below ground. Urine tanks below ground have the disadvantage that leaks from the urine tank are difficult to detect (a leaking urine storage tank could lead to groundwater pollution with ammonia and nitrate or to the tank being filled up with groundwater). Underground tanks have the significant advantage however that they are usually much cheaper and the access to the manhole is usually also easier.

Whilst the tanks are designed to minimise odour, some odour could still occur. Hence for safety precautions, the tanks should be in a well-ventilated area and away from kitchen, office and bedroom areas etc. to minimise odour complaints from users.

Sometimes a secondary urine storage tank at the point of reuse (agricultural fields) is required to enable the farmers to use the urine when they need it. As a side benefit further sanitisation of the urine would take place during this second storage period.

5.3.3 Materials

Urine storage tanks need to be 100% watertight to avoid loss of valuable nitrogen fertiliser, groundwater contamination and groundwater entering.

Urine storage containers are most commonly made of glas fibre reinforced plastic, PE, PP or PVC, but they can also be made of rubber bladders or reinforced concrete[14]. Metal components cannot be used since urine is corrosive (except for stainless steel, which can be used but would be expensive).

Plastic tanks which are used for rainwater harvesting are also suitable tanks for urine storage.

5.3.4 Tank size

The required tank volume ($V_{storage}$) can be estimated as follows:

$$V_{storage} = N_{users} \cdot p_{urine} \cdot t_{emptying} \cdot f_{timefraction} \text{ [L]}$$

with:
N_{users} = number of users
p_{urine} = specific urine production per person (~ 1.5 L/cap/d of urine[15])
$t_{emptying}$ = desired time between emptying events
$f_{timefraction}$ = fraction of the time in the premises where the toilet is.

It is obvious from this equation that if urine is flushed away with water, then a larger urine storage tank is required compared to a toilet where urine is collected undiluted.

When designing the size of the urine storage tank, consideration needs to be given to the capacity of the emptying vehicle to be used so that there is a good match. Details on tank sizes and possible emptying vehicles in the low-cost context are provided in Slob (2006).

If several tanks are installed, they should be placed in parallel, rather than in series, so that they can be filled alternately. For large installations, the use of several urine storage tanks is advisable so that one can be taken out of service if necessary.

5.3.5 Filling, ventilation / pressure equalisation

It is important that the incoming pipe to the tank goes down almost to the bottom, so that a liquid seal normally is formed preventing undue gas movement through the piping system. But we do not recommend to place a bucket here, as this might fill with the heavy sludge, and thus might introduce an undue flow restriction.

The holding tank should not be ventilated but have a mechanism for pressure equalisation in order to equalise pressure to allow for the replacement of headspace air by urine flowing into the tank and vice versa, when emptying the tank.

The storage system should however not be actively ventilated or opened more often than necessary in order to prevent odour development and ammonia-nitrogen losses.

Important points concerning the tank ventilation system:

- Normally no vent pipe is needed, provided that the main opening is not very tightly sealed.
- In places where odour control is essential, a small diameter vent pipe can be used for pressure equalizing the tank.
- If the tank is emptied by suction truck, provisions should be made for sufficient flow of air into the tank to prevent undue vacuum in the tank, which can cause tank implosion. .

The urine pipe system shall, quite opposed to other wastewater pipes, *not* be ventilated. The pipe system shall only be pressure equalized which is best done by a small hole in the tank for eualization with the urine tank pressure. The reasons why the pipe system shall not be ventilated are:

- ammonia emissions are decreased,
- ammonia smell in neigborhood is eleminated,
- risk of blockage in vertical urine pipes are largely reduced
- risk of sucking the liquid out of the liquid urine seals is largely reduced.

Two principal options are available for a simple natural ventilation system:

- The vent pipe is immersed into the urine tank so that it is about 10 cm from the base of the urine tank (it can even be placed in a bucket so that the bottom of the pipe is always submerged, even when the urine tank is emptied.
- There is a one-way valve, an orifice or a perforated diaphragm at the top of the vent pipe, so that only a small amount of pressure is required to push air out of the vent pipe (but air is not getting into the vent pipe in the other direction).

[14] There are a fair number in Sweden – cheaper for small tanks and so heavy that they do not float if the ground water gets high. Furthermore they are much better from a climate point of view – less CO_2 emitted than for plastic.

[15] plus flushing water if UD flush toilets are used, unless they have a valve like the Roediger NoMix toilet model

A one-way valve or air admittance valve placed at the top of the pipe stack can be a good option. Advantages are[16]:

1. that ammonia is not emitted
2. internal pressure is equalised ensuring proper drainage downwards to the tank (emptied urine pipes mean no standing urine and less build up of struvite)
3. the installation can be done inside the building just above the top floor urinal or UD toilet in the building so the top of the pipe stack doesn't need to penetrate the roof like old-fashioned ventilation pipes always have
4. saves on construction costs,
5. eliminates problems caused by condensation-ice and UV weathering of plastic pipes

The product is popular in Sweden for greywater and urine systems and many new houses do not have protruding ventpipes anymore (link to website of an American supplier: http://www.accentshopping.com/product.asp/P_ID/150518#tabtop).

5.3.6 Urine overflow pipe

Installation of a urine overflow pipes are not recommended, as this increases cost, introduces a risk of contamination of the urine when there is an overflow or blockage in the ordinary wastewater system and as an overflow easily leads to the urine just overflowing instead of being emptied. It is better that the urine is pumped to an acceptable disposal point with a portable wastewater pump, if the collection tank becomes too full.

5.3.7 Examples for urine storage tanks

Examples for different urine storage tanks of different sizes are shown below.

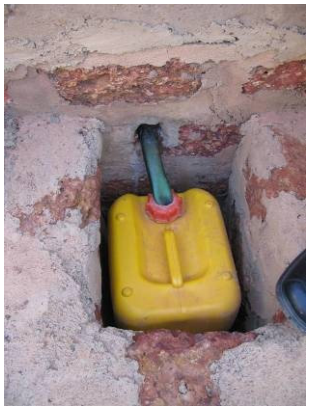


Figure 8. Low-cost solution: 20 L jerrican for urine storage at individual toilet level in Ouagadougou, Burkina Faso, Oct. 06 (photo: E. v. Münch).

Figure 9. Below-ground plastic urine storage tanks at Kullön, Sweden during the construction process. The tanks will be covered with soil. Photo: Mats Johansson. (Source: Kvarnström *et al.* (2006), page 36)

Figure 10. Urine storage tank made of a plastic bladder (3 x 150 m^3) at Lake Bornsjön near Stockholm (Sweden), Aug. 2007. Photo commissioned by: E. v. Münch.

Figure 11. Above-ground plastic urine storage tank in Ouagadougou, Burkina Faso as part of EU-funded project ECOSAN_UE, Sept. 2008 (photo: S. Rüd).

[16] Posting by Arno Rosemarin (SEI, Sweden) on Ecosanres discussion forum, August 2008.

6 References

6.1 References used in this datasheet

Austin, L. M. (2006) Guidelines for the design, operation and maintenance of urine-diversion sanitation systems, Volume 4, Report to the Water Research Commission, WRC TT 275/06, Available: www2.gtz.de/dokumente/oe44/ecosan/en-guidelines-urine-diversion-sanitation-systems-2006.pdf

Berger, W., Lorenz-Ladener, C. (2008) Kompost-Toiletten – Sanitärtechnik ohne Wasser (in German). Ökobuch Verlag, Staufen bei Freiburg (www.oekobuch.de)

EcoSanRes (2008) Closing the loop on phosphorus, EcoSanRes Factsheet 4, Stockholm Environment Institute, Stockholm, Sweden, http://www.ecosanres.org/pdf_files/ESR-factsheet-04.pdf

Energy Bulletin (2007) Peak phosphorus: readings, 13 Aug 2007, http://www.energybulletin.net/node/28720

Jönsson, H., Richert Stintzing, A., Vinnerås, B., Salomon, E. (2004) *Guidelines on the use of urine and faeces in crop production,* EcoSanRes Publications Series, Report 2004-2. www.ecosanres.org/pdf_files/ESR_Publications_2004/ESR2web.pdf

Jönsson, H. (2008) Personal communication – posting on Ecosanres discussion forum (www.ecosanres.org) on 17 Dec 2008.

Kvarnström, E., Emilsson, K., Richert Stintzing, A., Johansson, M., Jönsson, H., af Petersens, E., Schönning, C., Christensen, J., Hellström, D., Qvarnström, L., Ridderstolpe, P., Drangert J.-O. (2006) Urine Diversion - One Step Towards Sustainable Sanitation. Report 2006-1, EcoSanRes Programme, Stockholm Environment Institute, Stockholm, Sweden.
www.ecosanres.org/pdf_files/Urine_Diversion_2006-1.pdf.

Larsen, T.A., Lienert, J. (2007): Novaquatis final report. NoMix – A new approach to urban water management. Eawag, 8600 Duebendorf, Switzerland
www.novaquatis.eawag.ch/publikationen/final_report_E

Maurer, M., Schwegler, P., Larsen, T.A. (2003): *Nutrients in urine: energetic aspects of removal and recovery.* Water Science and Technology, 48 (1), p. 37-46.
www2.gtz.de/Dokumente/oe44/ecosan/en-nutrients-in-urine-energetic-aspects-2003.pdf

Morgan, P. (2007) Toilets That Make Compost - Low-cost, sanitary toilets that produce valuable compost for crops in an African context, Stockholm Environment Institute, Ecosanres Programme, Stockholm, Sweden. Available: http://www.ecosanres.org/toilets_that_make_compost.htm

Münch, E. v. and Dahm, P. (2009) Waterless urinals: a proposal to save water and recover urine nutrients in Africa. 34th WEDC International Conference, Addis Ababa, Ethiopia, May 2009

PUVeP (2008) Philippine allotment garden manual with an introduction to ecological sanitation. Periurban Vegetable Project (PUVeP), Xavier University College of Agriculture, Cagayan de Oro City, Philippines. http://puvep.xu.edu.ph/publications.htm

Rosemarin, A., Ekane, N., Caldwell, I., Kvarnström, E., McConville, J., Ruben, C. and Fogde, M. 2008.
Pathways for Sustainable Sanitation - Achieving the Millennium Development Goals. SEI/IWA. 56p. Available for order from: www.ecosanres.org

Schönning, C., Stenström, T.-A. (2004): *Guidelines for the safe use of urine and faeces in ecological sanitation systems*, EcoSanRes Publications Series, Report 2004-1. www.ecosanres.org/pdf_files/ESR_Publications_2004/ESR1web.pdf

Slob, M. (2005) Logistic aspects of ecological sanitation in urban areas. Case study in low-income community in Delhi, India. MSc Thesis, University of Twente, The Netherlands and WASTE, Gouda (mariekslob@hotmail.com)

SuSanA (2009) Urine and brownwater separation at the GTZ main office building, Eschborn, Germany. Case study of sustainable sanitation projects. Sustainable Sanitation Alliance. http://www.susana.org/index.php/lang-en/case-studies/europe

SuSanA (2008): Food security and productive sanitation systems. Fact sheet. Sustainable Sanitation Alliance.
www.susana.org/images/documents/wg05/en-wg5-factsheet-2008-05-28.pdf

Tettenborn

http://www.tu-harburg.de/aww/forschung/pdf/endbericht_tutech151009.pdf

WHO (2006) WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater. Volume 4: Excreta and greywater use in agriculture. http://www.who.int/water_sanitation_health/wastewater/gsuweg4/en/index.html

Winblad, U., Simpson-Hébert, M. (2004) Ecological Sanitation - revised and enlarged edition. Stockholm Environment Institute, Stockholm, Sweden.
www.ecosanres.org/pdf_files/Ecological_Sanitation_2004.pdf

Winker (2009) Pharmaceutical Residues in Urine and Potential Risks related to Usage as Fertiliser in Agriculture, PhD thesis, Technical University of Hamburg-Harburg, Institute of Wastewater Management and Water Protection, Germany, ISBN: 978-3-930400-41-6, http://www.tu-harburg.de/aww/english/publikationen/index.html under D&M.

Winker, M., Vinnerås, B., Arnold, U., Muskulos, A. and Clemens, J. (2008) New Fertilizers from Advanced Wastewater Treatment: Their potential Values and Risks. In: Proceedings of /13th RAMIRAN International Conference, Potential for simple technology solutions in organic manure management/, June 2008, Albena, Bulgaria, pp. 236 – 241. http://www.tu-harburg.de/aww/publikationen/pdf/winker_etal_final.pdf

6.2 Available video clips on YouTube

The following video clips are available on www.youtube.com.

Videos on waterless urinals (find video clips by entering the keyword “waterless urinal” in the search field), e.g.

Waterless urinal at UNESCO-IHE in Delft, the Netherlands (2006 and 2007):
www.youtube.com/watch?v=z0GKD3JAUOY,
www.youtube.com/watch?v=ywp4YPDeBEc,

Waterless urinal maintenance at University of Witwatersrand, Johannesburg, South Africa (Addicom):

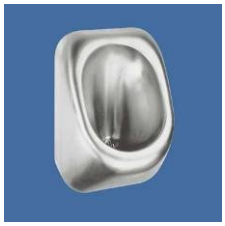
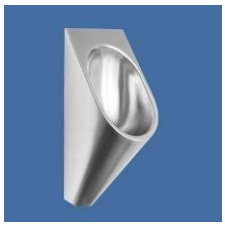
http://www.youtube.com/watch?v=nTa4yerQL1o

Videos on UDD and UD flush toilets (find video clips by entering the keywords “ecosan toilet” in the search field).

7 Appendix: Listing of suppliers for waterless urinals and urine diversion toilet pedestals and squatting pans

Note: The tables of suppliers provided here is *not a complete listing* but gives only an indication of available products. If you spot errors or omissions, please contact us at ecosan@gtz.de. All information is provided to the best of our knowledge and current for March 2009. An entry in this list does not imply a recommendation by GTZ. Prices are indicative only.

Table 2. Listing of manufacturers for waterless urinals (alphabetical by country).

Manufacturer	Urinal model name		Materials, costs (in 2008) and other information (costs without freight – for single units bought by individuals (worst case scenario))[17]
Urinals with flat rubber tube or silicon curtain (ESS) for odour control			
Austria: Franke Washroom Systems Franke GesmbH Christian Marte christian.marte@franke.com E: franke.ws@franke.com I: www.franke-ws.com	Franke model "Campus" CMPX532WF (model 1) CMPX538WF (model 2)	 	Information for both model types: • High-grade stainless steel 18/10, surface satin finished • With flat rubber tube ("membrane stench barrier") with a sieve above • Indicative unit cost (reference price for Germany, per urinal and rubber tube): model 1: € 851 €, model 2: € 573 • Model 1: on market since 2002 • Model 2: on market since 2007 • The number of units sold was not disclosed by supplier • Worldwide via agents and distributors
Germany: Keramag Roland Herkt info@keramag.de Ronald.Herkt@Keramag.de http://pro.keramag.com/?id=497&s=22	Keramag model "Centaurus"		• Ceramics • Indicative unit cost: € 505 per urinal; € 17 per flat rubber tube (for replacement) • Units sold: More than 25,000 from 2004 until first quarter of 2009 • Countries served: mainly Central Europe (Germany, Austria, Benelux, France); also some business in Asia and Ghana (pilot project at Valley View university in Accra funded by Germany's federal ministry BMBF)
México: Industrias Makech S.A. E: gosame-go@yahoo.com.mx mexisan@gmail.com I: www.industriasmakech.com.mx	Not available	Not available	• Countries served: Mexico • (awaiting further information from supplier; note: currently legal action taken by Addicom's representative due to patent violation)
South Africa: Addicom (Pty) Ltd Peter Dahm www.addicom.co.za sales@addicom.net	SVR-M urinal (with Eco-Smellstop (ESS) for odour control)		• Low density polyethylene urinal bowl (the bowl could easily be made locally in any developing country and in various materials) • Indicative unit cost: € 41 (for one urinal with ESS); cost of ESS itself: € 15 (to be added to urinal bowl above) – cannot easily be made locally but is small and light and can easily be imported • Units sold (worldwide): 32,000 (until March 2009) ESS urinals sold by Addicom, Keller

[17] Costs are highly dependent on number of units ordered. They also differ for individuals compared to traders.

Manufacturer	Urinal model name		Materials, costs (in 2008) and other information (costs without freight – for single units bought by individuals (worst case scenario))[17]
			Invent & F Ernst) - Urinals sold since 2006 in South Africa alone: 3000 • Units of "stand-alone" ESS units sold: ~ 90,000 as they are being used to convert the 100,000 F Ernst AG waterless urinals on an ongoing basis. • Countries/regions served: Europe, Africa, Mexico and environs, Israel, India
Switzerland: F. Ernst Ingenieur AG http://www.ernstsystems.com/ info@kellerinvent.com	models 5000, 7000, 8000 (with EcoSmellstop (ESS) odour control since 2006)	 Model 5000	• Mainly ceramics but also glass fibre • Pre-2006: with liquid sealant (approx. 100,000 units sold) • Converting to ESS presently at a rate of around 200 urinals per week • Since end 2006: with silicon curtain ESS system • Indicative unit cost: € 290 to 430 per urinal (dependent on number ordered) • Countries served: worldwide
Switzerland: Kellerinvent AG Hans Keller www.kellerinvent.com info@kellerinvent.com This company has a licence from Addicom to sell the ESS (but Addicom can sell to own clients worldwide).	models 5000, 7000, 8000, 9000 New model: Ki-One		• Ceramics (new polycarbonate urinals in early to mid 2009) • Indicative unit cost: € 170 (model 9000) - € 353 (model 5000) and € 157 for model Ki-One (new polycarbonate urinals in early to mid 2009) Prices • Units sold: Kellerinvent has presently sold worldwide (since active marketing in 2006): 25,000 units. - Since 2008: approx. 10,000 urinals per year. • Similar prices as F. Ernst Ingenieur AG above • Countries served: worldwide
Urinals with sealant liquid (blocking fluid) for odour control			
Austria: Hellbrok Umwelttechnik GmbH E: office@hellbrok.com I: www.hellbrok.com	Hellbrok		• glass-fibre reinforced plastic, having a very smooth gliding surface • Indicative unit cost: € 420 - 590 per urinal • € 33 per replacement trap • Units sold? • Countries sold in?
Denmark: Uridan E: uridan@uridan.com I: http://www.uridan.com/default.asp	Cadet		• fibreglass or ceramic • Indicative unit cost: € 550 per urinal • Units sold: ?? • Countries served: Europe, Canada, Brazil, Botswana, Emirates, Israel, Indonesia, Japan, Australia, New Zealand

Manufacturer	Urinal model name		Materials, costs (in 2008) and other information (costs without freight – for single units bought by individuals (worst case scenario))[17]
USA: Falcon Waterfree Technologies Randall Goble rgoble@falconwaterfree.com E: info@falconwaterfree.com I: http://www.falconwaterfree.com/	Lava		• Vitreous china or stainless steel. • Indicative unit cost: € 430-655 per urinal, includes installation and initial supplies (30% discount without installation). • Replacement cartridges are € 30 each and good for an average of 7,000 uses. • Approx. number of units sold: More than 150,000 since 2000. • Countries in which units are sold: 35 countries in Europe, Asia/Australia, South Pacific, Africa/Middle East, and the Americas • Europe (UK, France, Italy, Spain, Portugal, Germany, Czech Republic, Slovakia, Serbia, Croatia, Bulgaria, Romania, Denmark, Sweden, Norway, Cyprus, Greece, Latvia, Slovenia, Poland and Turkey) and South Africa.
USA: Waterless Co. Klaus Reichardt E: sales@waterless.com I: www.waterless.com In Germany: Waterless GmbH www.noflush.de	Waterless No-Flush™ Standard		• Ceramic and High Performance Composites (fiberglas) • Indicative unit cost: urinals range from € 146 – 364 (10 different models) • EcoTrap insert costs € 6.75 and lasts about 8,000 to 10,000 uses. • Approx. 75,000 units 1991 to current • Countries in which units are sold: USA, Germany, Ireland, UK, Canada, Mexico, Japan, Malaysia, Singapore, Australia, New Zealand, France, South Africa, Guatemala, Costa Rica, Brazil, Colombia, Jamaica, Virgin islands, Puerto Rico, Spain, Dubai UAE,
Urinals with hydrostatic float barrier			
Switzerland: Urimat Schweiz AG Marcel Näpflin Marcel.naepflin@urimat.com E: info@urimat.com www.urimat.com	Urimat model "Eco"		• Polycarbonate (unbreakable), lightweight: 4.3 kg • Indicative unit cost: € 189 per urinal, € 14 per replacement trap • CO_2 neutral production, fully recycable • Supplier did not disclose number of units sold • Available in more than 35 countries (Europe, Asia, Australia, Africa, Northamerica, South America)
	Urimat Model “compact***plus***		Same information as for model above, but: • Integrated Communication Pannel without electricity. • lightweight 3.6 kg
Urinals which are home made			

Manufacturer	Urinal model name		Materials, costs (in 2008) and other information (costs without freight – for single units bought by individuals (worst case scenario))[17]
… self-built	"Eco-Lily"[18]		• 20 L plastic jerrican (or similar container) • a light bulb, or better a table tennis ball, is placed in a plastic funnel and acts as an "odour lock" (floats up during urination) • Alterntives to the ball is to mount a hose on the funnel and let the hose extend down to almost the bottom of the container, or to initially pour a small amount of cooking oil into the container, creating a sealant layer on the urine. • € 3 or less
I lack the small cheap one from Enfirosan. This is only a few dollars, and small – saves space! (Hakan J.)			•

[18] Name coined by NGO SUDEA in Ethiopia.

Table 3. Alphabetical listing (by country) of manufacturers for UDD toilets (pedestals / sitting type).

Manufacturer	Waterless UD toilet model		Features
China: Chaozhou Meilong Ceramics China E: meilong888@vip.163.com I: www.meilongco.com – does not open	Item no. ML2037		• Drop hole for faeces sealed by lid which opens after use • Ash flushing device • Used in the Erdos Dong Sheng Project (see SuSanA case study http://www.susana.org/index.php/lang-en/case-studies/asia) • Ceramics • Indicative price: € 110
Ethiopia: Ethio Fiber in Addis Ababa E: I:	Pedestal „boxes“	Suitable photo ??	• Glass fibre • Indicative price: € 108 • Xx Oldenburg for more details
India: Shital Ceramics Works (state of Gujarat) Jayesh Sompura E: shitalcera@yahoo.com I: http://ruralsanitation.net/	Eco San European type		• Ceramics • Number of units sold: 50 • Indicative price: € 30 • Countries sold in: India
India: EEDS NGO Energy, Environment and Development Society (EEDS) Email: eeds@rediffmail.com, eedsngo@gmail.com			•
Kenya			• Steffen Blume
Mexico: Fábriza de Loza "El Anfora" E: cso@anfora.com I: www.anfora.com			• Vitrified ceramics • Indicative price: 56 US$ Ask Heike Hoffman
México: IEPSA E: ventas@iepsacv.com.mx I: www.iepsacv.com.mx			• glass-fibre reinforced plastic • Indicative price: 790 US$ Ask Heike Hoffman
Peru: No commercial suppliers yet but glass fibre inserts can be obtained via the NGO CENCA or the company Rotaria del Peru E: heike@rotaria.net I: www.rotaria.net	Not available		• Glass fibre or other materials • Details not available, but can be obtained on request

Manufacturer	Waterless UD toilet model		Features
E: XXX ? I: www.cenca.org.pe/			
Philippines: Center for Advanced Philippine Studies (CAPS) *(this is an NGO)* E: office@caps.ph I: www.caps.ph	Seat type		• Used in various ecosan projects in the Philippines, see SuSanA case studies on http://www.susana.org/index.php/lang-en/case-studies/asia • A wash bowl or bidet (sold separately) may also be added to the installation. • Material: Ceramics • Indicative unit cost: € 21 • Number of units sold: 3,000 (2005-2008). • Countries served: mostly in the Philippines. Some units were sold or sent to Austria, Sri Lanka, Uganda, Netherlands, India and Mexico.
	Bench type		• Material: Ceramics (mounted into a box or bench-like structure that houses the containers underneath) • Indicative unit cost: € 12.5 • Number of units sold: 500 (2005-2008) • Countries served: as above
South Africa: Envirosan Sanitation Solutions Mr. Dicky Schmeltzer E: envirosa@vodamail.co.za I: www.envirosan.co.za	UD Pedestal		• Plastic • Babyseat adaptor available • Indicative price: € 45 per pedestal • € 7 per babyseat adaptor
South Africa: Durban type			• Check Richard Holden e-mails
Separett AB Sweden Björn Engvall bjorn@separett.com E: info@separett.com I: www.separett.com	Separett Villa 9000-series		• Material: Impact-resistant high-gloss polypropylene • Front urinal funnel with 2-m long urine tube attached • Floor mounted • Child seat included • Electrical fan expelling odours and condensation from toilet • 220V-, 120V-, 12V-versions • Number of units sold is not disclosed by supplier • Sold in Europe (e.g.: Sweden, Finland, Norway, Denmark, France, Germany, UK, Switzerland, Czech Republic, Benelux, Ireland, Spain, Estonia, Poland), North America, Africa, Australasia, China, Russia etc. • Indicative unit cost: € 720

Manufacturer	Waterless UD toilet model	Features
Sweden: Wostman Ecology AB Sven Ingvar-Nilsson sven@wostman.se E: info@wostman.se I: http://www.wostman.se/en/index.html	EcoDry 	• Material: sanitary porcelain • Minimal rinsing flush for the urine section (0.1 L) – so urine is diluted with small amount of water • No water traps whatsoever • Urine hole is only 8 mm; the first urine hose is 3/4" and then there is a fitting for 2" • Units sold so far: 8,000 • Countries sold to: 20 (main countries are Denmark, Finland and Norway) • Indicative unit cost: € 346

Table 4. Alphabetical listing (by country) of manufacturers for UDD toilets (squatting pans).

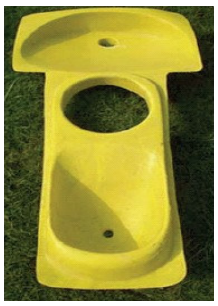
Manufacturer	Waterless UD toilet model		Features
Burkina Faso			• Check with Linus
China: Nanning Da Di Qiu Eco san Products Co. Mr. Lin Jiang E: linjiang93@hotmail.com or Ms. Hu Zhen Ying E: huzhenying2006@126.com	Squatting pan		• sliding lid offers hands free operation • sanitary porcelain or plastic • Indicative price: € 6 for plastic version? • Number of units sold? • Countries served?
Ethiopia: Awassa Ceramics Factory ??			•
Ethiopia: Tabor Ceramics E: xxx I:	Squatting pan "turkish eco-san toilet"		• Ceramics • 2-hole squatting pan • Indicative unit cost: € 25 • Number of units sold? • Countries served?
India: Mythri Sarva Seva Samithi Ecosan India mssss@vsnl.com - or Director Mr Rosario on anselmrosario@vsnl.net E: contact@ecosanindia.org – doesn't work I: www.ecosanindia.org	Squatting pan		• "3 in 1 model" – meaning it has a separate outlet for anal cleansing water • glass-fibre reinforced plastic or PVC • Indicative price: € 10 • Number of units sold? • Countries served?
India: Shital Ceramics Works (state of Gujarat) Jayesh Sompura E: shitalcera@yahoo.com I: http://ruralsanitation.net/	Eco San Indian style		• "3 in 1 model" – meaning it has a separate outlet for anal cleansing water • Ceramics (PVC feacal cover and nozzle) • Indicative price: € 11 • Number of units sold: 115 in Yemen, 300 in India • Countries sold in: Yemen, India
India: another company in Gujarat			• Annick Staub will find out. Also info from Paul Culvert to be sought
Nepal: Kathmandu			• Fibreglass • Contact via Han Hijnen
Uganda			• Steffen Blume or Elke Mülegger

Table 5. Alphabetical listing (by country) of manufacturers for UD flush toilets.

Manufacturer	Water-flushed UD toilet model		Features
Pedestal type (sitting)			
Germany: Roediger Vacuum GmbH Hans-Christian Rüster christian.ruester@roevac.com E: info@roevac.com I: www.roevac.com/	Roediger NoMix		• Material: sanitary porcelain • Urine collected undiluted by means of a valve opened by sitting on lid • 1-3 L urine flush, 6-9 L faeces flush (flushing amount can be adjusted during installation) • Units sold: approx. 420 toilets sold between 2001 and 2009 • Indicative price: € 780 • Countries served: Germany, Austria, Switzerland, Poland, Ireland, Luxembourg, Tunisia, Netherlands, India and USA
Sweden: BB Innovation & Co AB E: info@dubbletten.nu I: www.dubbletten.nu/	WC-Dubblett		• separate bowls for urine and faeces • dual flush (0.1L for urine, 5L for solid excreta) • child seat available • wall or floor mounted • sanitary porcelain • Indicative price: € 810
Sweden: Villeroy & Boch Gustavsberg AB E: info@gustavsberg.com I: www.gustavsberg.com/	Gustavsberg Nordic		• separate bowls • single 2L small flush, 4L large flush, 10% flush for urine bowl • wall mounted • sanitary porcelain • Indicative price: € 380 - 560
Sweden: Wost Man Ecology Sven Ingvar-Nilsson sven@wostman.se E: info@wostman.se I: http://www.wostman.se/en/index.html	EcoFlush		EcoFlush model: • convetional flush for the faeces. • Flush volumes: Urine 0.1-0.3 litres, faeces 2.5 litres. • sanitary porcelain • Indicative price: € 464 • Units sold: 8,000 • Countries served: 20 (main countries are Denmark, Finland and Norway)

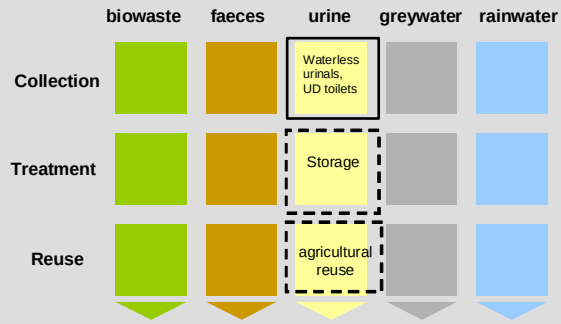
Manufacturer	Water-flushed UD toilet model	Features
	EcoVac 	EcoVac model: • Faeces are flushed by **vacuum**. • Flush volumes: Urine 0.1 L, faeces 0.7 L. • Price including vacuum unit and electronic box: € 1580 • Units sold: 400 • Countries served: same as above
Pedestal type or squatting		
China: EnviroSystems E: office@envi8.com I: www.ecosan.cn	EnviroSystems  	• separate bowls for urine and faeces • dual flush (0.2 L for urine, 6l for solid excreta) • available as seated pedestal or squatting pan • sanitary porcelain • installed in the Beijing Olympic Forest Park • price not available (April 2008)

Table 6. General comparison of UDD toilets and UD water-flush toilets

	UDD toilet	UD water-flush toilet
Advantages	• Does not require connection to water supply nor to sewer and treatment plant • Collects urine undiluted • Can be home-built, low cost, simple design • Results in easy-to-handle, dried faeces	• Requires hardly any change in user behaviour (for people used to flush toilets) • No significant odour risk if not used right • Has similar “appeal” for users as flush toilet • Allows collection of urine pure or with little flush water (depending on the model) • Can have lower water consumption compared to conventional flush toilet (since less water used to flush after urination), but the actual water use depends mainly on user habits.
Disadvantages	• Is prone to odour if users are not sensitised or unwilling to use correctly • Requires paradigm shift for those who are used to flush toilets or who aspire to have flush toilets	• Requires to be connected to reliable water supply and to sewer system (for faeces-water mixture) • Requires treatment step for faeces-water mixture (not manageable by user) • More expensive than conventional flush toilets and than pit latrines • Possible blockages in urine pipe and valve (if valve is used, e.g. Roediger NoMix toilet)
Applicable for developing countries?	• Yes - rural, peri-urban, public toilets, slums, cities	• Partially – only for wealthier segment of society (similar to application range as for conventional flush toilets)

Basic overview of urine diversion components (waterless urinals, UD toilet bowls and pans, piping and storage) - Appendix

Version: May 2009



Appendix: Worldwide listing of suppliers for waterless urinals and urine diversion toilet pedestals and squatting pans

(Draft version of 14 May 09)

Main author: Dr. Elisabeth v. Münch

Please send feedback and comments to the e-mail address given below. We look forward to hearing from you.

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
ecosan program
Dag-Hammarskjöld-Weg 1-5
65760 Eschborn, Germany
T +49 6196 79-4220
F +49 6196 79-7458
E **ecosan@gtz.de**
I www.gtz.de/ecosan

partner of
sustainable sanitation alliance
www.susana.org

Important note:

The tables of suppliers provided here are *not complete listings* but give only an indication of available products. If you spot errors or omissions, please contact us at ecosan@gtz.de. All information is provided to the best of our knowledge and current for March/April/May 2009. An entry in this list does not imply a recommendation by GTZ. Costs are indicative only.

Additional photos are available in the GTZ-ecosan team photo collection on the internet photo sharing platform flickr (www.flickr.com):

- Worldwide waterless urinals: http://www.flickr.com/photos/gtzecosan/sets/72157613881735035/
- Worldwide: Urine diversion toilet seats and squatting pans
  http://www.flickr.com/photos/gtzecosan/sets/72157612793192986/

List of Tables:

Table 1. Suppliers of waterless urinals (in alphabetical order by country).

Manufacturer	Waterless urinal model name and photo[1]		Materials, indicative costs[2] and other information
Urinals with flat rubber tube or silicon curtain (ESS) for odour control			
Austria: Franke Washroom Systems Franke GesmbH Christian Marte christian.marte@franke.com E: franke.ws@franke.com I: www.franke-ws.com	Franke model "Campus" CMPX532WF (model 1) CMPX538WF (model 2)	 	Information for both model types: • Material: High-grade stainless steel 18/10, surface satin finished • With flat rubber tube ("membrane stench barrier") with a sieve above • Indicative cost (reference cost for Germany): model 1 (being sold since 2002): EUR 851, model 2 (being sold since 2007): EUR 573 • Units sold: numbers not disclosed by supplier • Worldwide via agents and distributors
Germany: Keramag Roland Herkt info@keramag.de Ronald.Herkt@Keramag.de http://pro.keramag.com/?id=497&s=22	Keramag model "Centau-rus"		• Material: Ceramics • Indicative cost: EUR 505 per urinal; EUR 17 per flat rubber tube (for replacement) • Units sold: More than 25,000 from 2004 until first quarter of 2009 • Countries sold in: mainly Central Europe (Germany, Austria, Benelux, France); also some business in Asia and Ghana (pilot project at Valley View university in Accra funded by Germany's federal ministry BMBF)
México: Industrias Makech S.A. *(no response yet)* E: gosame-go@yahoo.com.mx mexisan@gmail.com I: www.industriasmakech.com.mx	Not available	Not available	• Countries sold in: Mexico • awaiting further information from supplier
South Africa: Addicom (Pty) Ltd Peter Dahm www.addicom.co.za sales@addicom.net	SVR-M urinal (with Eco-Smellstop (ESS) for odour con-trol)		• Material: Low density polyethylene urinal bowl (the bowl could easily be made locally in any developing country and in various materials) • Indicative cost: EUR 41 (for one urinal with ESS); cost of ESS itself: EUR 15 (to be added to urinal bowl above) – cannot easily be made locally but is small and light and can easily be imported • Units sold: 32,000 (until March 2009) ESS urinals sold by Addicom, Keller Invent & F Ernst) - Urinals sold since 2006 in South Africa alone: 3000 • Units of "stand-alone" ESS units sold: ~ 90,000 as they are being used to convert the 100,000 F Ernst AG waterless urinals on an ongoing basis.

[1] More photos are available in the GTZ-ecosan photo collection, see beginning of Appendix for website link.
[2] Costs are current for March/April/May 2009, without freight, for single units bought by individuals. Costs tend to be lower when higher number of units are ordered, and are also lower for traders compared to individuals placing orders.

Manufacturer	Waterless urinal model name and photo[1]	Materials, indicative costs[2] and other information
		• Countries/regions sold in: Europe, Africa, Mexico and environs, Israel, India
Switzerland: F. Ernst Ingenieur AG http://www.ernstsystems.com/ info@kellerinvent.com	models 5000, 7000, 8000 (with EcoSmellstop (ESS) odour control since 2006)  Model 5000	• Material: Mainly ceramics but also glass fibre • Pre-2006: with liquid sealant (approx. 100,000 units sold) • Since end 2006: with silicon curtain ESS system (converting to ESS presently at a rate of around 200 urinals per week) • Indicative cost: EUR 290 to 430 per urinal (dependent on number ordered) • Units sold: Number not disclosed by supplier • Countries sold in: worldwide
Switzerland: Kellerinvent AG Hans Keller www.kellerinvent.com info@kellerinvent.com This company has a licence from Addicom to sell the ESS (but Addicom can sell to own clients worldwide).	models 5000, 7000, 8000, 9000 New model: Ki-One 	• Material: Ceramics (new polycarbonate urinals in early to mid 2009) • Indicative cost: EUR 170 (model 9000) - EUR 353 (model 5000) and EUR 157 for model Ki-One (new polycarbonate urinals in early to mid 2009) Costs • Similar cost as F. Ernst Ingenieur AG above • Units sold: 25,000 units (during 2006-2009); since 2008: approx. 10,000 urinals per year. • Countries sold in: worldwide
Urinals with sealant liquid (blocking fluid) for odour control		
Austria: Hellbrok Umwelttechnik GmbH Heinz Konrad E: office@hellbrok.com I: www.hellbrok.com www.urinale.at	MINIMAX  	• Material: fibre reinforced synthetics • Unit cost: EUR 350 per urinal (and EUR 33 per replacement trap) • Units sold: 7000 (during 2001 – 2008) • Countries sold in: Austria, Germany, Nederlands, Belgium, France, Spain, Turkey, Switzerland, Hungary, Slovenien, United Kingdom, Ireland.
(as above)	ULTRAPLUS  	• Material: upper basin made of mineral casting, lower part made of fibre reinforsed synthetics • Indicative unit cost: EUR 399 per urinal (and EUR 33 per replacement trap) • Units sold: 3000 (during 2004 – 2008) • Countries sold in: as above
Denmark: Uridan E: uridan@uridan.com Karsten Leimstoll Karsten Leimstoll - Uridan Germany leimstoll@uridan.de I: http://www.uridan.com	KH – 6-W 	• Material: GFK (glassfibre reinforced plastic) or ceramic • Sealant liquid: 0.3 L per urinal; has to be exchanged after approx. 15,000 uses (typically after one year). Cost: EUR 20 per 0.3 L. • Unit cost: EUR 600 • Units sold: In Germany alone during 2004-2009 approx. 6,000 pieces in particular at schools, public buildings, restaurants (figures from head office in Denmark were not disclosed) • Countries sold in: worldwide (currently especially in Australia)

Manufacturer	Waterless urinal model name and photo[1]	Materials, indicative costs[2] and other information
USA: Falcon Waterfree Technologies Randall Goble rgoble@falconwaterfree.com E: info@falconwaterfree.com I: http://www.falconwaterfree.com/	Lava 	• Material: vitreous china or stainless steel. • Indicative cost: EUR 430-655 per urinal, includes installation and initial supplies (30% discount without installation). • Replacement cartridges are EUR 30 each and good for an average of 7,000 uses. • Units sold: More than 150,000 since 2000. • Countries sold in: 35 countries in Europe (UK, France, Italy, Spain, Portugal, Germany, Czech Republic, Slovakia, Serbia, Croatia, Bulgaria, Romania, Denmark, Sweden, Norway, Cyprus, Greece, Latvia, Slovenia, Poland and Turkey), Asia, Australia, South Pacific, Africa/Middle East South Africa and the Americas.
USA: Waterless Co. Klaus Reichardt E: sales@waterless.com I: www.waterless.com In Germany: Waterless GmbH www.noflush.de	Waterless No-Flush™ Standard 	• Material: ceramic and high performance composites (fiberglas) • Unit cost: urinals range from EUR 146 – 364 (10 different models) • EcoTrap insert costs EUR 6.75 and lasts about 8,000 to 10,000 uses. • Units sold: approx. 75,000 (during 1991 to current) • Countries sold in: USA, Germany, Ireland, UK, Canada, Mexico, Japan, Malaysia, Singapore, Australia, New Zealand, France, South Africa, Guatemala, Costa Rica, Brazil, Colombia, Jamaica, Virgin islands, Puerto Rico, Spain, Dubai UAE.
Urinals with hydrostatic float barrier		
Switzerland: Urimat Schweiz AG Marcel Näpflin Marcel.naepflin@urimat.com E: info@urimat.com www.urimat.com	Urimat model “Eco” 	• Material: polycarbonate (unbreakable), lightweight: 4.3 kg • Unit cost: EUR 189 per urinal, EUR 14 per replacement trap • CO_2 neutral production, fully recycable • Units sold: numbers not disclosed by supplier • Countries sold in: more than 35 countries (Europe, Asia, Australia, Africa, Northamerica, South America)
	Urimat Model “compact***plus*** 	Same information as for model above, but: • Integrated Communication Pannel without electricity. • lightweight 3.6 kg
Other basic waterless urinals		

Manufacturer	Waterless urinal model name and photo[1]	Materials, indicative costs[2] and other information
… self-built	"Eco-Lily"[3] 	• Material: 20 L plastic jerrican (or similar container) • a light bulb, or better a table tennis ball, is placed in a plastic funnel and acts as an "odour lock" (floats up during urination) • Alternatives to the ball is to mount a hose on the funnel and let the hose extend down to almost the bottom of the container, or to initially pour a small amount of cooking oil into the container, creating a sealant layer on the urine. • EUR 3 or less
South Africa: Envirosan Sanitation Solutions No answer yet Mr. Dicky Schmeltzer P.O. Box 1769, New Germany, 3620, South Africa Phone: 0027 (0)837925554 E: info@envirosan.co.za I: www.envirosan.co.za		• Material: plastic • Installed in the Durban type UDD toilets, of which some 1500 - 2000 are built every month. • Odor seal is simply the lid on top (and odor seal in the collection tank, in the form of the inlet pipe going down below the liquid surface (i.e. it should end close to the bottom) and/or a layer of oil on top of the urine in the collection tank) • intended just for small one toilet systems in a warm country (just one toilet and maybe one urinal but in the same room (therefore same air pressure))[4]. • Unit cost: awaiting information • Units sold: awaiting information

Additional notes:

1. Waterless urinals in China: 2 companies found so far with English website: http://www.sunming-jj.com and http://www.zcsm.net/En_texingNewsInfo.asp?id=22

[3] Name coined by NGO SUDEA in Ethiopia.
[4] Source: Hakan Jönsson, SEI, 5 May 2009

Table 2. Suppliers of UDD toilets - pedestals / sitting type (in alphabetical order by country).

Manufacturer	Urine-diversion pedestal model name and photo[5]		Materials, indicative costs[6] and other information
China: Chaozhou Meilong Ceramics China (no reply yet) E: meilong888@vip.163.com I: www.meilongco.com – does not open	Item no. ML2037		• Material: ceramics • Drop hole for faeces sealed by lid which opens after use • Semi-automatic ash adding device • Used in the Erdos Dong Sheng Project in Inner Mongolia, China • Indicative cost: EUR 110 • Units sold: awaiting information • Countrie sold in: China
Ethiopia: Ethio Fiber P.O. Box 6550 Addis Ababa Ethiopia E: ethfibre@ethionet.com ESE-PPP@ethionet.et I: No website available Further contact: Martin Oldenburg info@otterwasser.de	Pedestal „boxes“		• Material: glass fibre • Production was supported by a PPP scheme with GTZ • Indicative cost: EUR 150 • Units sold: 20 • Countries sold in: Ethiopia
El Salvador			• Who supplied 50,000 UDDTs?
Germany: Berger Biotechnik GmbH Wolfgang Berger info@berger-biotechnik.de www.berger-biotechnik.com	SEP insert		• Material: PE plastic • SEP urine separation insert fits with many of the commercial dry toilets as a supplement, but can also be integrated in self built units • Indicative cost: EUR 40 (relatively high costs as produced in Germany) • Units sold: 20,000 • Countries sold in: Europe, USA, New Zealand, South America, Afrika (e.g. Burkina Faso, where they are also copied)
India: Shital Ceramics Works (state of Gujarat) Jayesh Sompura E: shitalcera@yahoo.com I: http://ruralsanitation.net/	Eco San European type		• Material: ceramics • Indicative cost: EUR 30 • Units sold: 50 • Countries sold in: India
India: EEDS NGO Energy, Environment and Development Society (EEDS) Ajit Kumar Saxena saxena.ajitkumar@gmail.com Email: eeds@rediffmail.com, eedsngo@gmail.com	EEDS western type two hole pan EEDS western type three-hole pan		• Material: fibre based, lightweight concrete • Provides anal washing facility for washers • Indicative cost: (EUR 4.5 (INR 300) for 2-hole pan and EUR 15 (INR 1000) for 3-hole pan • Units sold: none so far (received few enquiries from India and outside too but not yet supplied – up to May 2009, see further notes below this table) • Countries sold in: none (so far), but India soon
Ivory Coast – see entry in Table 4 on squatting pans			

[5] More photos are available in the GTZ-ecosan photo collection, see beginning of Appendix for website link.
[6] Costs are current for March/April/May 2009, without freight, for single units bought by individuals. Costs tend to be lower when higher number of units are ordered, and are also lower for traders compared to individuals placing orders.

Manufacturer	Urine-diversion pedestal model name and photo[5]		Materials, indicative costs[6] and other information
Mexico: Fábriza de Loza "El Anfora" *No reply yet* E: cso@anfora.com I: www.anfora.com			• Material: vitrified ceramics • Indicative cost: 56 US$ (probably much higher now, otherwise only financially viable if government-subsidised) • Awaiting clarification by Ron Sawyer (SARAR)
México: IEPSA *No reply yet* E: ventas@iepsacv.com.mx I: www.iepsacv.com.mx			• Material: glass-fibre reinforced plastic • Indicative cost: 790 US$ • Awaiting clarification by Ron Sawyer (SARAR)
Mexico: CITA Cesar Añorve acua@terra.com.mx (e-mails need to be in Spanish) *No reply yet* http://www.laneta.apc.org/esac/citacating.htm			• The fiberglass molds for casting the cement pedestals --as well as fiberglass pedestals --and a UD fiberglass insert for bench type toilets -- are also available in Mexico from CITA • Awaiting clarification by Ron Sawyer (SARAR)
Peru: No commercial suppliers but various NGOs or companies can assist, e.g. with glass fibre inserts NGO CENCA (contact: Juan Carlos Calizaya) E: jccalizayal@yahoo.es (e-mails need to be in Spanish) I: www.cenca.org.pe/ or Rotaria del Peru Contact: Heike Hoffman E: heike@rotaria.net I: www.rotaria.net		No model commercially available	• Material: glass fibre or other materials • CENCA uses fibre glass urine diversion insets (probably based on Mexican model from SARAR) • Other NGOs which can be contacted are CARE Peru or CARITAS and OXFAM (they use their own seats made of cement for their own projects)
Philippines: Center for Advanced Philippine Studies (CAPS) *(this is an NGO)* E: office@caps.ph I: www.caps.ph	Seat type		• Material: ceramics • A wash bowl or bidet (sold separately) may also be added to the installation. • Used in various ecosan projects in the Philippines, see SuSanA case studies on http://www.susana.org/index.php/lang-en/case-studies/asia • Indicative cost: EUR 21 • Units sold: 3,000 (2005-2008). • Countries sold in: mostly in the Philippines and some units were sold or sent to Austria, Sri Lanka, Uganda, the Netherlands, India and Mexico.

Manufacturer	Urine-diversion pedestal model name and photo[5]		Materials, indicative costs[6] and other information
(as above)	Bench type		• Material: ceramics (mounted into a box or bench-like structure that houses the containers underneath) • Indicative cost: EUR 12.5 • Units sold: 500 (2005-2008) • Countries sold in: as above
South Africa: Envirosan Sanitation Solutions No answer yet Mr. Dicky Schmeltzer P.O. Box 1769, New Germany, 3620, South Africa Phone: 0027 (0)837925554 E: info@envirosan.co.za I: www.envirosan.co.za	UD Pedestal		• Material: plastic • Babyseat adaptor available • Roto molded plastic (moulds are quite expensive) • Fibre glass masters (was: EUR 353 – Richard Holden) • Supplier for large UDD toilet construction programme in Durban metropolitan area[7] • Indicative cost: EUR 45 and EUR 7 per babyseat adaptor • Units sold: awaiting information • Countries sold in: South Africa and others?
Sweden: Separett AB Björn Engvall bjorn@separett.com Carlos Pettersson carlos@separett.com E: info@separett.com I: www.separett.com www.separett.eu	Separett Villa 9000-series		• Material: Impact-resistant high-gloss polypropylene • Front urinal funnel with 2-m long urine tube attached • Child seat included • Electrical fan expelling odours and condensation from toilet: 220V-, 120V-, 12V-versions • Unit cost: EUR 720 • Units sold: number not disclosed by supplier • Countries sold in: Europe (e.g.: Sweden, Finland, Norway, Denmark, France, Germany, UK, Switzerland, Czech Republic, Benelux, Ireland, Spain, Estonia, Poland), North America, Africa, Australasia, China, Russia etc.
(as above)	Simpler models: Rescue seat, rescue 25, rescue camping, Privy 501, Privy 500	 Photo of Privy 500	Various models: • Rescue Seat: UD inset with integrated seat. Cost approx. 10-15 USD • Rescue 25: UD inset with integrated seat and foldable legs. • Privy 501: A UD inset with traditional toilet seat and lid attached • Privy 500: A UD inset with an attached insulated foam plastic seat, good for cold climates.

[7] Further contacts: In Durban: Teddy Gounden, Chris Buckley, Jaques Rust. In Johannesburg: Richard Holden: richarddholden@gmail.com

Manufacturer	Urine-diversion pedestal model name and photo[5]	Materials, indicative costs[6] and other information
Sweden: Wostman Ecology AB Sven Ingvar-Nilsson sven@wostman.se E: info@wostman.se I: http://www.wostman.se/en/index.html	EcoDry 	• Material: sanitary porcelain • Minimal rinsing flush for the urine section (0.1 L) – so urine is diluted with small amount of water • No water traps whatsoever • Urine hole is only 8 mm; the first urine hose is ¾" and then there is a fitting for 2" • Indicative cost: EUR 346 • Units sold: 8,000 • Countries sold in: 20 (main countries are Denmark, Finland and Norway)
Sweden: CIPAX AB Skebobruk E: info@cipax.com www.cipax.com Distributor in Europe (outside of Northern Europe) and worldwide: BERGER BIOTECHNIK GmbH Hamburg, Germany E: info@berger-biotechnik.de I: www.berger-biotechnik.de	TORP Awaiting photo	• Material: PE plastic • Indicative cost: awaiting information • Units sold: 5,000 (since 2004) • Countries sold in: awaiting information
Uganda Crestanks Ltd. P.O. Box 11381 Kampala Uganda Mobile: Plot No 86/96 6th Street Industrial Area T: 256-41-235470/348973 256-772-766574 F: 256-41-234184 E: scs@crestanks.co.ug E 2: janet@crestanks.co.ug E3: crestank@africaonline.co.ug I: www.kentainers.com	Wonderloo 	• Material: PET toilet seat • Bucket for faeces included (approx 10 Litres) • Also available in green and grey • Indicative cost: approx. EUR 45 (USH 120,000) • Units sold: data not disclosed • Countries sold in: Uganda, Kenya, Tanzania, Ethiopia, Rwanda, Southern Sudan and Burundi
(as above)	Eco-loo 	• Complete toilet (incl. plastic super structure, urine diverting slab and faeces chambers) with either toilet sitting type *Wonderloo* or urine diversion squatting slab/pan *LS-EKO* • Indicative cost: EUR 480 (USH 1,250,000) • Units sold: data not disclosed by supplier • Countries as above

Additional notes

1. **For India**: The NGO eeds in India has developed and designed an enterprise which can be given to any women /male groups to produce these pans and other sanitation facilities locally- we usually call it a "production and service unit ". The R&D has very recently completed. The pan development programme has been supported by UNICEF INDIA & SEI. - Ajit Kumar Saxena (saxena.ajitkumar@gmail.com), April 2009.

2. **For Latin America**: Further possible contacts to find suppliers in Latin America are: Kim Andersson (kim.j.andersson@hotmail.com), Elias Rosales-Escalante (Costa Rica, only in Spanish, erosales.cr@gmail.com), Jenny Aragundi (Ecuador, jennyaragundy@gmail.com) und Paula Paulo (Brazil, ppaulo@nin.ufms.br) (yet to be contacted by GTZ-ecosan team).

Table 3. Suppliers of UDD toilets - squatting pans (in alphabetical order by country).

Manufacturer name	Urine-diversion squatting pan model name and photo[8]	Materials, indicative costs[9] and other information
Burkina Faso: TCMP Bandé Abdulaye +226-70705497 +226-78841983 reseaucrepa@reseaucrepa.org (CREPA headquarters) Further info also: linusdagerskog@yahoo.fr (CREPA, Burkina Faso)	Squatting pan 2 hole + 3 hole UD-seat inset Water less urinals (male/female)  	• Material: mold is in fibre glass to make squatting pans in concrete (mold costs 38 EUR); squatting pans can also be in fibre glass • Used in large-scale Ecosan-UE project in Ouagadougou (2006 to 2009) • Indicative costs: Three hole squatting pan: EUR 30; two hole squatting pan: EUR 23; UD seat inset: EUR 23; waterless urinals : EUR 19 • Units sold: ~ 300 units of the squatting pans (200 for Togo) • Countries sold in: Burkina Faso, Togo and other West African countries
China: Nanning Da Di Qiu Eco san Products Co. No answer received yet Mr. Lin Jiang E: linjiang93@hotmail.com or Ms. Hu Zhen Ying E: huzhenying2006@126.com	Squatting pan 	• Material: sanitary porcelain or plastic • Sliding lid offers hands free operation • Indicative cost: EUR 6 for plastic version? • Number of units sold? • Countries sold in: China, Ukraine and other CIS countries (?)
China: Beijing Zhongke Long-tai Biotechnology Co. Ltd., Beijing No answer received yet E: sales@zhongkelongtai.com I: http://www.zhongkelongtai.com/ (website in Chinese only)		
Congo: CREPA Congo Samuel ADJETY, Head of workshop : tél 00242 538 15 12 : 00242 669 73 16, crepa_cncg@yahoo.fr Further info also: linusdagerskog@yahoo.fr (CREPA, Burkina Faso)	Slab for UDDT 	• Material: concrete • Further information on request

[8] More photos are available in the GTZ-ecosan photo collection, see beginning of Appendix for website link.
[9] Costs are current for March/April/May 2009, without freight, for single units bought by individuals. Costs tend to be lower when higher number of units are ordered, and are also lower for traders compared to individuals placing orders.

Manufacturer name	Urine-diversion squatting pan model name and photo[8]	Materials, indicative costs[9] and other information
Ethiopia: Ethio Fiber P.O. Box 6550 Addis Ababa Ethiopia E1: ethfibre@ethionet.com E2: ESE-PPP@ethionet.et I: No website available Further contact: Martin Oldenburg info@otterwasser.de	Urine diversion squatting pan 	• Material: glass fibre[10] • Was supported by a PPP scheme with GTZ: GTZ paid for construction of the master form to incorporate GFK mats • Indicative cost: EUR 15 • Numbers of units sold: 50 • Countries sold in: Ethiopia
(as above)	Urine diversion squatting pan 	• Similar model as above
Ethiopia: Tabor Ceramics Products Share Company Awassa Ethiopa E1: taborceramic@ethionet.et E2: ESE-PPP@ethionet.et	Squatting pan "turkish eco-san toilet 	• Material: ceramics • 2-hole squatting pan • Was supported by a PPP scheme with GTZ: GTZ provided material to manufacture the moulds (gypsum) • Units sold: 50 • Indicative unit cost: EUR 25 • Countries sold in: Ethiopia
India: Mythri Sarva Seva Samithi (NGO which obtains its pans from a private supplier) No answer yet Anselm Rosario msss@vsnl.com www.ecosanindia.org	Squatting pan 	• Material: glass-fibre reinforced plastic or PVC • "3 in 1 model" – meaning it has a separate outlet for anal cleansing water • Number of units sold? • Indicative cost: EUR 10 • Countries sold in?
India: Shital Ceramics Works (state of Gujarat) Jayesh Sompura shitalcera@yahoo.com http://ruralsanitation.net/	Eco San Indian style 	• Material: ceramics (PVC faecal cover and nozzle) • "3 in 1 model" – meaning it has a separate outlet for anal cleansing water • Indicative cost: EUR 11 • Number of units sold: 115 in Yemen, 300 in India • Countries sold in: Yemen, India
India: EEDS NGO Energy, Environment and Development Society (EEDS) Ajit Kumar Saxena saxena.ajitkumar@gmail.com Email: eeds@rediffmail.com, eedsngo@gmail.com	3-hole ecosan pan 2-hole ecosan pan  3-hole ecosan pan	• Material: lightweight concrete, in various colours • Indicative costs: o Onsite casting 3-hole ecosan pan (local cast: EUR 15 (INR 1000) including squatting plate o Squatting type pre-casted - micro concrete/fly ash 3-hole ecosan pan: EUR 2 (INR 130) o Squatting type pre-casted - micro concrete /fly ash 2-hole ecosan pan:

[10] Manufacture requires more manual labour than ceramic toilets and is less automated (hence quality of workmanship can be variable) but allows for changes to be incorporated quite easily.

Manufacturer name	Urine-diversion squatting pan model name and photo[8]	Materials, indicative costs[9] and other information
		EUR 1.5 (INR 100) • Number of units sold: received few enquiries from India and outside too but not yet supplied (see further notes for EEDS in Table 3)
India: Sustainable Technologies in the Community No reply yet Trivandrum, Kerala, India Paul Culvert ecopans@eco-solutions.org www.eco-solutions.org		• E-mail sent 24 April 09
India – Prakash Ceramic (in Gujarat state) Vagadia Road, Thangadh 363530 Phone: +91(02751)220856 Mobile: 9825231856 Fax No.:+91(02751)220859 prakasceramic@yahoo.in	EcoPan and RuralPan Washset 	• Material: ceramics • 2-piece Model: urine diversion squatting pan and washset for anal washing • Indicative cost: EUR 5 (including ecopan and washset for anal washing). • Units sold: awaiting information • Countries sold in: India
Ivory Coast Artisan : TIOYE BE Entreprise : APAP : Atelier de Polyester et des Arts plastiques 04 BP 64 Abidjan 04, Côte d'Ivoire Telephone : 00(225) 07 40 26 14 crepa-ci@reseaucrepa.org Further info also: linusdagerskog@yahoo.fr (CREPA, Burkina Faso)	Squatting pans (polyester and concrete) UD seat (polyester and concrete)  	• Materials: fibre glass, polyester, concrete • Indicative costs: o UD squatting pan in fibreglass: EUR 13 o UD seat in polyester :EUR 19 o UD seat in concrete: EUR 13 • Units sold: not known • Countries sold in: Ivory Coast
Kenya - Kentainer Embakasi Rd. Off Airport North Road, Nairobi T: +254-20 8235136 www.kentainers.com Mrs. Fara Waliji M: 0721 306 127 I: fara_waliji@kentainers.com	Urine-diverting squatting pan (for double vault UDDT)  	• Material: plastic • Squatting pan for double-vault-UDD toilet (two holes for faeces) • Production was initiated through PPP project between Kentainer and GTZ • Indicative cost EUR 35 (KSH 3,500) for squatting pan incl. two lids and urine pipe • Units sold: not known • Countries sold in: Kenya
Mali Mr Boubacar Coulibaly Bamako, Mali tél. : (00223) 66 91 66 19 crepa-mali@reseaucrepa.org Further info also: linusdagerskog@yahoo.fr (CREPA, Burkina Faso)	Three hole squatting pan 	• Material: ferro cement • 3-hole squatting pan (3rd hole for anal waswhater) • Indicative cost: EUR 15 • Units sold: not known • Countries seved: Mali

Manufacturer name	Urine-diversion squatting pan model name and photo[8]		Materials, indicative costs[9] and other information
Nepal: Kayo Fiber Glass Udyog, Kathmandu Name: Manoj Siddi Email: kayo@wlink.com.np Further contacts: Nam Raj Khatri namraj@enet.com.np Han Hijnen hanheijnen@gmail.com			• Material: fibreglass • In Nepal so far 1000 ecosan UDD toilets have been constructed since 2000[11]. • Indicative cost: awaiting information • Units sold: numbers not available from supplier • Countries sold in: Nepal
Uganda: Crestanks Ltd. P.O. Box 11381 Kampala Uganda Mobile: Plot No 86/96 6th Street Industrial Area T: 256-41-235470/348973 256-772-766574 F: 256-41-234184 E: scs@crestanks.co.ug E 2: janet@crestanks.co.ug E3: crestank@africaonline.co.ug I: www.kentainers.com	LS-100-EKO Urine-diverting squatting pan		• Material: PET • Toilet slab with urine diverting squatting pan • hole for vent pipe included • Size for LS 100: 121 x 106 x 11 cm (length by width by height) • Indicative cost: EUR 70 (180,000 USH The following information applies to all models in this range: • 15% discount possible if linked to gtz PPP projects • Number of units sold: information not disclosed by supplier • Available also in Kenya,Tanzania, Ethiopia, Rwanda, Southern Sudan and Burundi but for different costs (applies to all models in this range)
(as above)	LS-180-EKO Urine-Diverting sub structure (incl. slab, chamber and steps)		• Material: plastic • Urine diverting slab inclusive chamber for urine/faeces and steps • Indicative cost: EUR 130 (USH 338,000)
(as above)	EcoPan		• Material: polyethylene • Size: 70 x 32 cm (length by width) • Indicative cost: EUR 10 (USH 25,000)

Additional notes:

1. **For India** see also the new Indian Sanitation Portal: http://www.sanitationindia.org/org/
2. **Burkina Faso**: Linus Dagerskog, CREPA (30 April) 09 about ecosan EU-CREPA project in Ouagadougou: In the Ouaga project it is the squatting pan that is promoted for the double vault toilet. In the single vault (integrated into the house or a smaller toilet in the yard) it is seated position. This is less popular and the project makes also less promotion because frequent faeces collection makes it trickier, and the households also have more trouble since they are supposed to take their faeces bag from the toilet to the black empty oil-barrel from where the collector then takes it to the eco-station.

[11] At the begining the pan was fitted in the slab itself. Then after urine diverting cement pan was produced in Kathmandu. Since 2005 (approx) fibre glass pans are being produced (for urine diverting wet toilet, i.e. faeces is flushed into pit and urine is utilised.

Table 4. Suppliers of UD flush toilets - sitting type (in alphabetical order by country).

Manufacturer	Water-flushed UD toilet model name and photo[12]	Materials, indicative costs[13] and other information
China: EnviroSystems (a sino-german company for ecosanitation, composting technique and flue gas desulphurication) Lily Zhang Lily.zhang@envi8.com E: office@envi8.com I: www.ecosan.cn	EnviroSystems 	• Material: sanitary porcelain • Separate bowls for urine and faeces • 0.2 L for urine flush, 6 L for faeces flush • Available as seated pedestal or squatting pan (see Table 6) • Installed in the Beijing Olympic Forest Park, China[14] • Indicative cost: only provided on request • Units sold: not disclosed by supplier • Countries sold in: China
Germany: Roediger Vacuum GmbH Hans-Christian Rüster christian.ruester@roevac.com E: info@roevac.com I: www.roevac.com/	Roediger NoMix 	• Material: sanitary porcelain • Urine collected undiluted by means of a valve opened by sitting on lid • 1-3 L urine flush (flushing amount can be adjusted during installation of toilet) and 6 L faeces flush • Indicative cost: EUR 780 • Units sold: approx. 420 toilets sold between 2001 and 2009 • Countries sold in: Germany, Austria, Switzerland, Poland, Ireland, Luxembourg, Tunisia, Netherlands, India and USA
Sweden: BB Innovation & Co AB Bobby Bogdan Mrozowski bobby@dubbletten.nu E: info@dubbletten.nu I: www.dubbletten.nu/ Inventor and constructor is Bibbi Birgit Söderberg from Swedish Inventor Association	Nova Toaletta Dubbletten 	• Material: sanitary porcelain • Separate bowls for urine and faeces • 0.1 L for urine flush, 4 L for faeces flush • Child seat available (integrated in adult seat) • Wall or floor mounted • Indicative cost: EUR 523 • First installation was in 1992; Swedish patent granted in 1994 • Units sold: “thousands” – exact number not disclosed by supplier • Countries sold in: Sweden, Denmark, Finland, Poland, Italy, Switzerland, Mexico, Australia, Czech Republic, Japan, Germany.
Sweden: Villeroy & Boch Gustavsberg AB Berger Biotechnik GmbH Wolfgang Berger (distributor for Gustavsberg toilets in Germany and other countries) E: info@gustavsberg.com I: www.gustavsberg.com/	Gustavsberg Nordic 	• Material: sanitary porcelain • 2 separate bowls • 2 L small flush for urine, 4 L large flush of faeces • Wall mounted • Urine pipe made from stainless steel (external to toilet bowl), acts also as odour seal: designed very flat, so that pipe is filled by 0.2 L of flush water, which is 10% of the urine flush • Indicative cost: EUR 380 – 560 • Units sold: Awaiting information • Countries sold in: Awaiting information (also used in Australia (eco-village)

[12] More photos are available in the GTZ-ecosan photo collection, see beginning of Appendix for website link.
[13] Costs are current for March/April/May 2009, without freight, for single units bought by individuals. Costs tend to be lower when higher number of units are ordered, and are also lower for traders compared to individuals placing orders.
[14] For case study description on this project: http://www.susana.org/index.php/lang-en/case-studies/asia

Manufacturer	Water-flushed UD toilet model name and photo[12]	Materials, indicative costs[13] and other information
		Currumbin and Ghana (Valley View University in Accra)
Sweden: Wost Man Ecology Sven Ingvar-Nilsson sven@wostman.se E: info@wostman.se I: http://www.wostman.se/en/index.html	EcoFlush 	EcoFlush model: • Material: sanitary porcelain • Flush volumes: Urine 0.1-0.3 L, faeces 2.5 L (faeces flushed by gravity). • Indicative cost: EUR 464 • Units sold: 8,000 • Countries sold in: 20 (main countries are Denmark, Finland and Norway)
(as above)	EcoVac[15] 	EcoVac model: • Faeces are flushed by **vacuum**. • Flush volumes: Urine 0.1 L, faeces 0.7 L. • Indicative cost: EUR 1,580 (including vacuum unit and electronic box) • Units sold: 400 • Countries sold in: same as above

Additional notes:

1. About **Gustavsberg toilet** (by Wolfgang Berger 6 May 2009, Ecosanres discussion forum):
The 1/2" urine pipe, which is about 50 cm long and is designed as a trap, needs to be cleaned by some water pressure to remove slimy residues, which may grow by urine-water mixture and may block the urine flush. To prevent blockage of the pipe system, I recommend to use a dilution of lemon acid or vinegar (no concentrate) to reduce crystalline deposit. We use it for the cleaning of dry toilets and dry urinals as well and it is easy to apply by a spray bottle. Its low pH acts as a disinfectant. In case there is some blockage, the urine pipe is easy to remove, because the installations are outside the bowl. To avoid blockage by tissue paper, we deliver a sieve, also made from stainless steel.

[15] Same model name is used for vacuum toilet without urine diversion.

Table 5. Suppliers of UD flush toilets - squatting type (in alphabetical order by country).

Manufacturer	Water-flushed UD toilet model	Materials, indicative costs[16] and other information
China: EnviroSystems Lily Zhang Lily.zhang@envi8.com E: office@envi8.com I: www.envi8.com (in Chinese) I: www.ecosan.cn (in Chinese)	EnviroSystems 	• Material: sanitary porcelain • Separate bowls for urine and faeces • 0.2 L for urine flush, 6 L for faeces flush • Available as seated pedestal or squatting pan • Installed in the Beijing Olympic Forest Park, China[17] • Indicative cost: only provided on request • Units sold: not disclosed by supplier • Countries sold in: China

[16] Costs are current for March/April/May 2009, without freight, for single units bought by individuals. Costs tend to be lower when higher number of units are ordered, and are also lower for traders compared to individuals placing orders.
[17] For case study description on this project: http://www.susana.org/index.php/lang-en/case-studies/asia