

Editorial Manager(tm) for IWA Conferences
Manuscript Draft

Manuscript Number: IWA-4173R1

Title: Three years of operation of the urine-diversion system in GTZ headquarters in Germany; user opinions and maintenance challenges.

Article Type: Full Paper

Corresponding Author: Mrs. Martina Winker, Dr.-Ing.

Corresponding Author's Institution: German Development Cooperation

First Author: Steffen Blume

Order of Authors: Steffen Blume; Martina Winker, Dr.-Ing.

Manuscript Region of Origin: GERMANY

Three years of operation of the urine-diversion system in GTZ headquarters in Germany; user opinions and maintenance challenges

S. Blume* and M. Winker*

*German Development Cooperation (GTZ) GmbH, Sustainable sanitation - ecosan program, Postfach 5180, 65726 Eschborn, Germany.

(Email: steffen.blume@gtz.de; martina.winker@gtz.de)

ABSTRACT In the main office building of GTZ in Eschborn, Germany a resource-oriented sanitation system containing urine-diversion toilets and waterless urinals is in operation since 2006. After 2.5 years of operating the system, a first overall evaluation of the system and its acceptance amongst users and cleaning staff was conducted. The overall result is that most of the users appreciate the resource oriented sanitation concept (recycling of nutrients and water savings) but have problems with the technical design. Also, it is difficult to convince the cleaning staff of the necessity of special cleaning routines. Hence, before such systems can be widely spread, clear cleaning routines and maintenance documentations are required as well as certain technical modification to ease optimise the separation in the toilet bowl as well as the change of spare parts of the toilet.

Keywords acceptance, resource oriented sanitation system, source control, UD flush toilet, urine diversion, waterless urinal

INTRODUCTION

The GTZ headquarters consists of four buildings and is located in Eschborn near Frankfurt, Germany. The main building ("Building 1") was renovated from 2004 to 2006 after being in use for 30 years. As part of this renovation, principles of environmentally friendly construction for the water and energy management of the building were included. This contained a urine separation and collection system.

The background of this ecosan initiative is described in SuSanA (2009) and the objectives were to demonstrate the implementation of such a resource-oriented sanitation system, to reduce the amount of water used in the GTZ building, and to research important aspects for Germany such as social acceptance and reuse of urine in agriculture. This third objective started recently within SANIRESCH, an accompanying research project funded by the German ministry (since mid 2009) and was initiated by the former head of GTZ's ecosan program, Christine Werner.

Operation of the system started in 2006 and the experiences gained since then with user behaviour, user acceptance, and with the technical components are described in this paper.

MATERIALS AND METHODS

Implemented technologies in Building 1 of GTZ headquarters

The urine separation system consists of:

- 50 water flushed urine-diversion toilets for the waterless collection of urine ("NoMix Toilet" of Roediger Vacuum). The toilets have two compartments for urine and faeces respectively. The urine is collected undiluted by means of a valve located under the toilet seat, triggered when the user sits down. This toilet

consumes about 1-2 l for the urine flush and 4-6 l for the solids flush (Figure 1). v. Münch et al. (2009) describes this toilet type in more detail.

- 25 waterless urinals equipped with a patented “flat rubber tube” smell stop system of the Centaurus model of the German company Keramag (Figure 1), for further details on the mechanism see v. Münch and Dahm (2009).
- 4 x 2.5 m³ PE urine storage tanks located in the underground car park of Building 1.

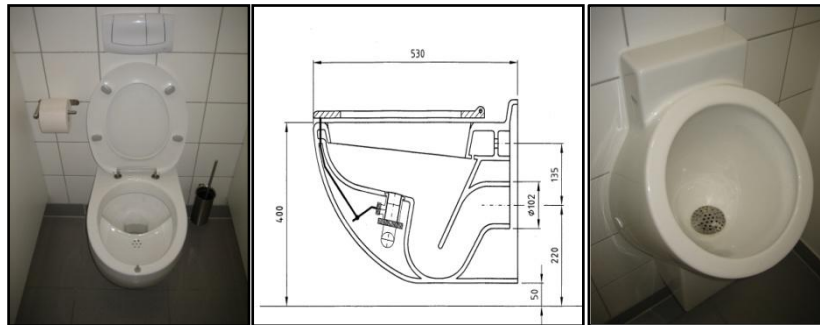


Figure 1: Left: UD flush toilet and its schematic side view; right: waterless urinal.

The toilets and urinals are located in the core part of the building in the restrooms closest to the canteen and the large meeting rooms (Figure 2). In the wings in each floor (aside the top floor) are bathroom equipped with conventional toilets and urinals available. Therefore, persons have the choice between the two different options aside those in the top floor where bathrooms are only located in the core section. The usage is that of typical office building which is mainly frequented from Monday to Friday from 9 am to 5 pm. On average around 120 l of urine is collected per day in the separation system.

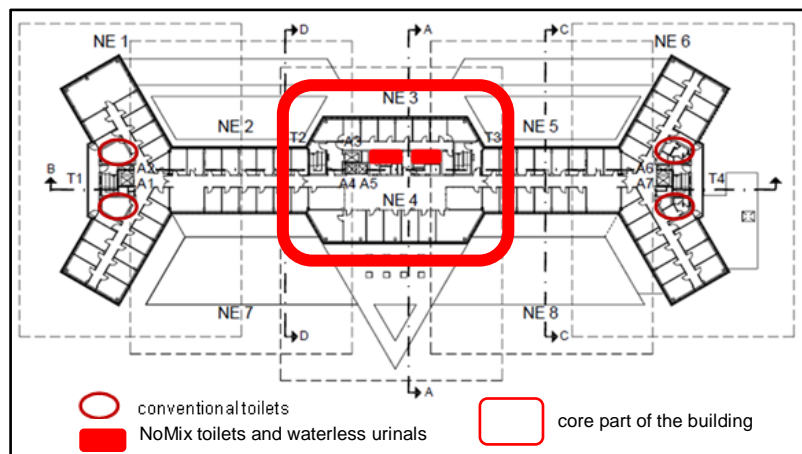


Figure 2: Schematic design of the restroom locations at an average floor of the 10-storey building which is double-Y shaped.

User surveys with questionnaires

Two user surveys were undertaken since the operation started in 2006. The first one was carried out in September 2008 to evaluate the general acceptance of the toilets by the users. The second survey was performed in May 2009 and had a more specific focus on toilet hygiene issues as a result of the earlier questionnaire.

Both surveys were conducted electronically (using the websites Surveygizmo and SurveyMonkey). In the first one, about 900 GTZ employees working in the headquarters were contacted independently of their office location within the four GTZ buildings at this site. All contacted employees were employed within the Department of Planning and Development, which is GTZ's department for the worldwide technical support of its programs. The questionnaire took approx. 5 min to complete. Apart from statistical parameters about the employees and the general perception of reuse oriented sustainable sanitation systems, it covered topics of toilet design, hygiene, odour, ease of use and acceptance of reuse.

As mentioned earlier, the second questionnaire (in May 2009) was focussed on hygienic aspects and an improvement of the hygienic situation. This questionnaire was sent to approx. 50 GTZ employees, whose offices are located close to the respective restrooms in the core of Building 1 (Figure 2), only. This selection was intended to focus on employees who use the UD flush toilets and waterless urinals daily. It was designed so that it could be answered within 3 min. Apart from statistical information such as distance to the toilets, regularity of usage, age and gender, the questions tried to determine what measures could encourage users to sit down on toilets in an office building, which is necessary for proper use of these toilets (see Figure 1).

Attitudes of cleaning and maintenance staff

The cleaning staff (employed by an external service provider) and GTZ facility management staff were contacted regularly in connection with user feedback and technical problems. As the waterless urinals and UD flush toilets were new, the personnel had to find out how to maintain the system. In fact, it took some time to discover the crucial aspects and to rectify technical problems.

RESULTS AND DISCUSSION

Survey 1: Employees' views

In the first survey 24% of the contacted employees responded (218 of 900 people). 53% of the people were within the age of 30-50 years, 29% were younger, and 18% were older than 50 years. When comparing the UD flush toilet and the conventional toilets regarding optical appearance, cleanliness, odour, and ease of use, results showed that the majority of the participants felt that the cleanliness of the UD flush toilets and odour of the urinals were worse (Table 1). The conventional toilets were rated better in almost all parameters (Table 1). 52% of respondents mentioned that the UD flush toilets have problems with flushing, and 48% stated that it needs two or even more flushes after each use (12% of respondents).

Table 1: Parameters used for measuring of the users' acceptance by comparing the source separating with a conventional system. Numbers show percentages (%) of total answers (218) for toilets and (88) answers of the male urinal users.

Perception compared to conv. system	UD flush toilets			Waterless urinals			Both Ease of use
	Optical appearance	Cleanliness	Odour	Optical appearance	Cleanliness	Odour	
Better	12	5	7	17	14	8	5
Same	76	45	61	77	52	32	56
Worse	12	50	32	6	34	60	39

When asked for their private decisions, about 48% of respondents stated that they would move to a flat with UD flush toilets whilst 27% are not sure and 25% would not. 17% would even pay a higher price for buying such an apartment (40% maybe and 43% not). Asked about the waterless urinals, 37% would support that other GTZ offices install waterless urinals, 41% had no opinion and 22% would not support such measures.

Although the technical functionality and hence acceptance of the UD flush toilets is not good, a remarkable 90% of the participants are positive towards the idea to collect urine and faeces separately from each other and to use them as fertiliser in agriculture. 71% would even buy crops which have been fertilised with human excreta according to WHO guidelines (WHO, 2006). Even more people (82%) would buy none-edible products which have been fertilised with human excreta. When asked for their opinion if urine should be allowed as fertiliser for organic agriculture, 46% agreed and 42% might agree while 12% do not support this concept. On a personal level, one third of the participants would use and further 39% said they might use urine for their own balcony plants.

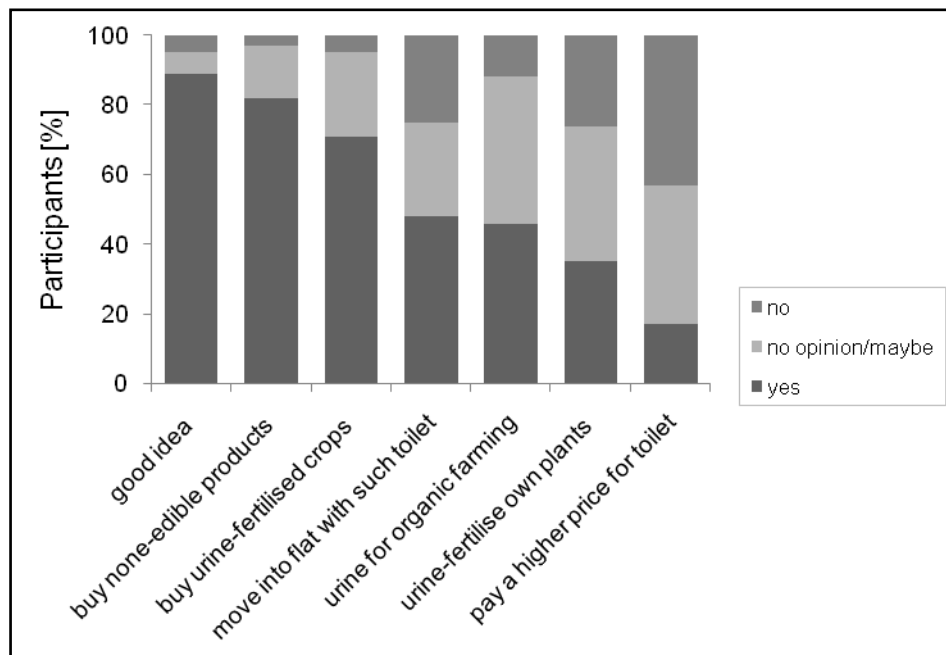


Figure 3: User opinions regarding the resource oriented sanitation in GTZ Building 1 according to Survey 1 (total of 218 participants).

The reactions for acceptance of food fertilised with urine is in line with other similar investigations. Muskolus (2008) interviewed inhabitants in Berlin as well as people with an agricultural background, and 62% of both groups stated that they would buy food produced with urine as fertiliser. Also in Switzerland, 72% of different user groups (also partially users of UD flush toilets) consider these techniques as a good idea and 86% would even move into a flat equipped with such a concept (Lienert et al., 2006; Larsen and Lienert, 2006). This is a much higher percentage than found in Survey 1 undertaken at GTZ and is most likely due to technical and maintenance problems (see below).

Survey 2: User views regarding sitting on toilets

This survey investigated the enhancement of the hygienic perception by the users to encourage them to sit on the toilet. Age distribution of the participants was similar to Survey 1, and 40% of the respondents were female and 60% male. As only 25 people responded (out of 50 approached) the survey results are not necessarily representative but provide a general idea. 52% of respondents said that they used the UD flush toilets on a regular basis.

They employees were asked which hygienic devices they would prefer to entice them to sit on the toilet. Sitting is necessary in order to activate the urine valve (otherwise urine flows to the faeces section and mixes with the brownwater). Almost 50% of respondents would prefer disinfection spray which is applied with toilet paper to clean the toilet seat, 8% would favour paper covers and 35% other devices. The respondents stated that they would apply these hygienic devices either on a regular basis (26%), only if the toilets were not clean (21%) or not at all (17%).

The participants were also asked if they would sit down on the toilet if the above mentioned hygiene devices were available (results summarised in Figure 4). The question was a restatement of the earlier ones to receive more precise information of users' attitudes towards sitting on a public toilet. The results confirmed that most users would prefer a disinfection spray (52%) or a paper cover (48%), and 35% of users find it sufficient to use toilet paper used as cover. The willingness to sit is 52% of respondents if they had a disinfection spray available compared to only 17% of respondents if no hygiene device was available.

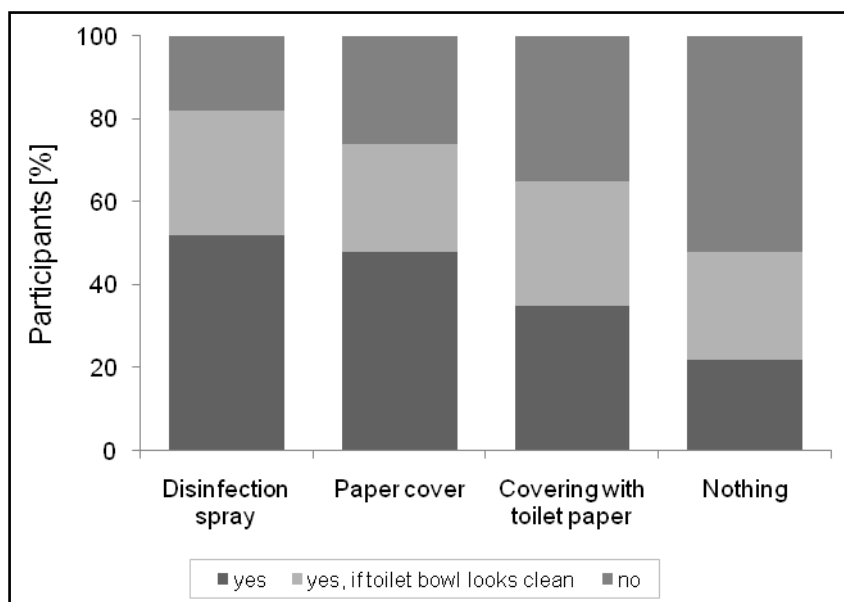


Figure 4: Survey 2 results: Employees' willingness to sit on the UD flush toilet if certain hygienic devices were provided (at the moment, none of these are provided). Total number of respondents was 25.

These results on attitudes regarding sitting on public toilets are interesting and should be researched further since they relate to users' (partly irrational) fears of "catching a disease" when sitting on a public toilet. The findings from the small Survey 2 are in contrast to earlier findings in Switzerland where 72% of the respondents stated that

they are willing to sit when it is required (Larsen and Lienert, 2007) – although there is naturally a major difference between toilets at home and toilets outside of the home environment. The monitoring of the system installed in the Eawag building (Zurich, Switzerland) has not shown discrepancies to this statement so far (Goosse et al., 2009). On the contrary, it seems that female users in that building tend to flush the toilet while sitting which causes dilution of the urine with flush water.

Technical problems and solutions

Experiences with waterless urinals

In the beginning of the operation in mid 2006 it was found that urine accumulated on the ground underneath the urinals. Further checks showed that the urinals had sunk slightly down (only a few millimeters). As the discharge pipes were fixed in the wall, this resulted in pressure on the joint where the urine pipe is connected with the urinal. Due to this pressure a gap developed between the inlet and the urinal, and urine leaked to the inner part of the urinal and down the outlet pipe. Bad odor occurred as a result of this small vertical movement of the urinal (this might be a reason for the worse perception of waterless urinals (stated by 60% of respondents, Table 1) compared to conventional ones conducted in Survey 1). Hence, the screws need to be checked regularly to prevent vertical movement of the urinal (it has not occurred again since that initial event).

To avoid odor problems with the waterless urinals different cleaning agents were tested. Best results were achieved with the “*MB Aktivreiniger*” of Urimat. This is an environmentally friendly cleaning agent with microbiologically active ingredients. Furthermore, a permanent deodorant air diffuser was installed in the toilet room in the first floor.

There is quite a high turn-over of cleaning staff employed by an external company who is responsible for the cleaning in the GTZ buildings in Eschborn. As a result, the cleaning staff was not trained perfectly and thus urinal sieves and smell stops in some of the restrooms were not cleaned for many weeks or even months. This led to the accumulation of urine precipitates, well as pubic hair and slime deposits which then caused odour problems. Thorough cleaning staff instruction and supervision is crucial but difficult due to high staff turn-over. Even for the (in Germany) quite widely spread waterless urinals, awareness raising and training is still required for the cleaning staff when they are not familiar with such urinals. Additionally, Keramag introduced an improved design for the smell stop in 2007 which has less dirt accumulation and is easier to clean.

Experience with the urine-diversion (UD) flush toilets

The installed type of UD flush toilet has two main weaknesses:

1. Design of the bowl: Toilet paper thrown into the front part of the bowl (urinal section) is not flushed away with the small urine flush and hence more than one flush becomes necessary – negating the possible water saving effect. And even for the faeces sometimes 2-3 flushes are required. Similar findings were reported for the installations at Eawag: in 17% of all cases a second flush was necessary (Goosse et al., 2009).
2. Urine valve: The valve on the urine pipe can get blocked over time (Figure 5). In this case, urine is no longer collected separately but flows to the faeces section of the toilet. Alternatively it can result in the fact that the valve does not close anymore,

causing odour problems in the restroom and dilution of the urine. Therefore, the cleaning staff needs to carry out preventative maintenance which can be done by adding citric acid to the valve once per month that remains there for 24 hours. Our experience showed that if this maintenance is neglected, these valves stop working after approx. 2 years of use.



Figure 5: Left: Soft urine precipitations inside a urine valve. Right: the same valve after cleaning soaking in citric acid for several days (source: L. Ulrich, 2009).

Low nitrogen content of the collected urine

Low nitrogen concentrations were observed in the urine collection tanks at GTZ: With $2,800 \text{ mg l}^{-1}$ the measured nitrogen concentration for the stored urine is two thirds less than typical literature values for pure urine of $8,000 \text{ mg l}^{-1}$ (Meinzinger and Oldenburg, 2009). The main reason for this is probably that nitrogen loss occurs in the form of ammonia gas being emitted through the tank's ventilation system, which has also been reported at the Eawag building (Goosse et al., 2009). Urine tanks should not be ventilated, only pressure equalized (v. Münch et al., 2009) but in this case, a 10 mm vent pipe from the urine tanks goes all the way to the top of Building 1, causing more ventilation than desired. It is also possible that the urine is diluted with flush water if users flush while being seated or if the urine valve is broken.

Recommendations for maintenance

Based on the three years of experience, now the following maintenance routines (supervision that they are really being adhered to is crucial and not always easy) are recommended:

- Every evening the waterless urinals have to be cleaned (wiped down manually).
- On highly frequented toilets (on ground floors close to canteens and meeting rooms) additional cleaning on an hourly base is recommended using a wet cloth and subsequently spraying the detergent containing fragrant substances as well.
- The smell stops (flat rubber tubes) have to be taken out daily and cleaned with detergent and rinsed with water.
- As the rubber of the smell stops fatigues and then sticks together, the smell stops have to be replaced about once per year.
- The daily cleaning routine for UD flush toilets is in principle the same as for conventional ones although it is more time consuming to clean away faeces stains due to the more complicated bowl design.
- For precipitation prevention the urine valve needs to be soaked once per month with citric acid for a period of 24 hours. This is done by filling 200 ml of the citric acid into the open valve (seat pressed down to open the valve).

- Annually, the functionality of the urine valves should be controlled and once per year clogged valves should be cleaned or replaced.

CONCLUSIONS

The overall result from the user surveys is that the users appreciate the resource oriented sanitation concept (recycling of nutrients and water savings) but are unhappy with the inconveniences caused by the technical design of the UD flush toilets. Furthermore, it was shown that a crucial point for users is perceived or actual toilet hygiene: People's willingness to sit down on the toilet could be raised significantly if disinfection devices were available.

For a wider acceptance, further technical development of the UD flush toilets would be necessary. A high turn-over in cleaning staff and different cultural/lingual backgrounds makes it difficult to communicate the necessary cleaning routines which take a little bit more extra time and are new for the cleaning staff. Hence, before such urine-diversion flush toilets can be widely spread, clear cleaning and maintenance routines are required.

On a positive note, this demonstration and research project has attracted wide attention for the ecosan approach within GTZ (implementing development cooperation projects worldwide) and outside of GTZ. Each year, many international delegations and student groups take part in guided tours of the installations, which raises their awareness about resource oriented sanitation systems.

ACKNOWLEDGEMENTS

The authors wish to thank Christine Werner (AGIRE programme, GTZ, Morocco) for initiating the project in her position as team leader of the GTZ Ecosan team, Lukas Ulrich (former GTZ intern; now: ETH Zurich, Switzerland) for devising and conducting the second survey and Dr. Elisabeth von Münch for critical review of this paper.

REFERENCES

- Goosse P., Steiner M., Udert K. & Neuenschwander W. 2009. NoMix Toilettensysteme. Erste Monitoring Ergebnisse im Forum Chrisbach. *GWA* 7, 567-574.
- Larsen T. and Lienert J. 2007. Novaquatis final report. NoMix - A New Approach to Urban Water Management. Eawag, Dübendorf, Switzerland. URL: <http://www2.gtz.de/Dokumente/oe44/ecosan/de-Nomix-Toilettensystem-erste-Monitoringergebnisse.pdf>.
- Lienert J. & Larsen T.. 2006. Considering user attitude in early development of environmentally friendly technology: A case study of NoMix toilets. *Environ. Sci. Technol.* 40(16), 4838-4844.
- Lienert J., Thiemann K., Kaufmann-Hayoz R. & Larsen T. 2006. Young users accept NoMix toilets - a questionnaire survey on urine source separating toilets in a college in Switzerland. *Wat. Sci. Technol.* 54(11-12), 403-412.
- Meinzing F. & Oldenburg M. 2009. Characteristics of source-separated household wastewater flows - a statistical assessment. *Water Sci. Technol.* 59(9), 1785-1791
- SuSanA (2009). Case study of sustainable sanitation projects. Urine and brownwater separation at Eschborn, Germany. Sustainable Sanitation Alliance. URL: <http://www.susana.org/images/documents/06-case-studies/en-susana-cs-germany-eschborn-house-1-2009.pdf>.
- v. Münch E. & Dahm P. 2009. Waterless Urinals. A Proposal to Save Water and Recover Urine Nutrients in Africa. In: *34th WEDC International Conference*, Addis Ababa, Ethiopia. URL: <http://www2.gtz.de/Dokumente/oe44/ecosan/en-waterless-urinals-a-proposal-to-save-water-and-recover-urine-nutrients-in-africa-2009.pdf>.
- v. Münch E., Olt, C. and Winker M. 2009. Technology review | Urine diversion components. GTZ, Eschborn, Germany. URL: <http://www.gtz.de/en/dokumente/gtz2009-en-technology-review-urine-diversion.pdf>.
- WHO. 2006. *WHO Guidelines for the Safe Use of Wastewater, Excreta and Greywater*. Vol. IV, Excreta and Greywater use in Agriculture, WHO/UNEP/FAO. URL: http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html.