Implementation of urine-diverting dry toilets in multi-storey apartment buildings in Ethiopia

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Abstract: The Ethiopian government currently pursues a large-scale housing programme based on multi-storey houses, so-called condominium buildings. Providing water and sanitation services to these houses is very often a challenge. Therefore, alternative approaches to sanitation based on dry toilets are investigated. The implementation of urine-diverting, dry toilets (UDDT) and the use of human excreta products have been successfully demonstrated in several locations in Ethiopia. The challenge faced now is the integration into higher density areas. In contrast to other implementations of UDDT into multi-storey buildings using long chutes, the approach of double-vault toilets is piloted in one multi-storey block of apartments in Awassa, Ethiopia. This paper describes the technical design and the required operation and maintenance of the system. A cost comparison shows the advantages of the dry system in terms of cost savings for flushing water as well as decreased construction and operation costs compared to the conventional septic tank system.

Keywords: UDDT, Ethiopia, multi-storey buildings

Introduction

According to the WHO and UNICEF [1] Ethiopia is one of the countries in the world with the lowest sanitation coverage. Less than 15 % of the population have access to improved sanitation. Although the percentage is higher in urban areas than in rural areas, it is the fast growing cities where the most pressing problems with regard to sustainable sanitation exist. Like in the majority of countries in Africa urbanisation is increasing, thus, appropriate provision of infrastructure in the urban agglomerations becomes more and more urgent. The urban annual growth rate in Ethiopia is considered to be about 4% and the number of urban dwellers is expected to double within the next 15 years [2]. The Ethiopian government decided to tackle this challenge by supporting the construction of large condominium housing programmes all over the country. In 55 cities across the country about 400,000 so-called condominium houses are going to be constructed [3]. These condominium housing programmes differ from conventional housing areas due to the high population density and the implementation of multi-storey apartment houses.

The multi-storey buildings regularly face problems related to water-supply and wastewater management. Water supply is irregular, which makes the use of water-flushed toilets inconvenient. Lack of transporting and treatment facilities for septage pose hygienic risks to people and the environment. Centralised sewerage systems are usually not within reach of the municipalities due to the high costs for sewers and treatment facilities. For example, the sewerage system in Addis Ababa caters only for about 3% of the city's population. In addition, many Ethiopian cities face difficulties in implementing a water-based sanitation system (i.e. water-flushed toilets) as a result of water shortages and inappropriate water supply systems.

Thus, alternative sanitation concepts are required and a project called “Ecological Sanitation Ethiopia” was established to develop alternative sanitation solutions (i.e. dry, urine-diverting toilets) for the condominium sites and to implement these in cooperation with the Ministry of Works and Urban Development. “Ecological Sanitation Ethiopia” is a public-private-partnership (PPP) project funded by the German agency for technical cooperation (GTZ). The project has been working on urine-diverting dry toilets and the management of the waste products in Ethiopia since beginning of 2006. It is implemented by different partners from Germany in cooperation with Ethiopian organisations. First activities included the construction of demonstration toilets and the use of urine and composted faeces in agriculture. The acceptance of the sanitation facilities as well as the results of the agricultural trials have been very promising so that an extension to multi-storey condominium buildings is underway.

UDDT for multi-storey buildings

The implementation of dry toilets in multi-storey buildings still remains a challenge. Only a few examples such as some four-storey buildings in Bielefeld in Germany as well as the Erdos Eco-Town project in Dongscheng in Inner Mongolia exist so far. In these locations long chutes that connect the waterless toilets with collection containers in the basements are used. The innovation that was developed for the Ethiopian case is based on the so-called double-vault system with urine diversion. Two vaults are used alternately on every storey to allow storage and dehydration of the faecal material.

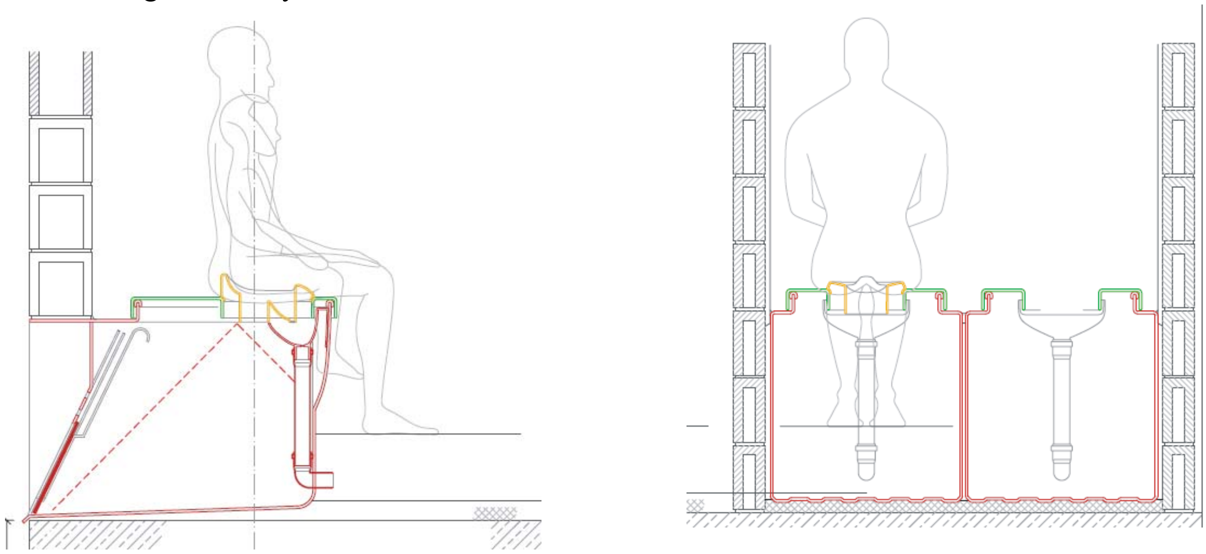

Figure 1: Schematic view of a urine separating toilet in multi-storey buildings (left: side view, right: sectional view) (Drawing: O. Jebens)

The sitting-type toilets are made out of fibreglass and are produced in Ethiopia. The toilet is designed as a box (see figure 1) allowing the on-site storage of faeces and drying additives such as ash. Two such boxes are installed in every bathroom (see figure 2). Urine is diverted and collected in $5m^3$-storage tanks outside the buildings. In order to prevent smell from the urine containers entering into the bathrooms, a smell trap (i.e. made by rubber) is integrated into the urine pipe. The boxes for collection of faeces are dimensioned in such a way that a family of five persons can use one box for half a year. Households are advised to use ash, which is widely available as a result if Ethiopian cooking habits, or other dry material like dry soil for covering the faeces after every use and improving the drying process. After the first box is filled, the second box is used while the contents of the first box are allowed to dry. During this time the first toilet may be used as a urinal by addition of a urinal bowl.

Figure 2: Double vault system in the bathroom

Ventilation is ensured by switchable ventilators at the back of the toilet box as well as by a wind-driven ventilator on top of the shaft (see figure 3). When the second box is full, the contents of the first box are emptied via a shaft at the rear of the toilet and collected at the bottom of the shaft in containers. Access for emptying the toilet box is via the removable lid at the top of the box. Micro and small enterprises will be responsible for the emptying and transport of the dry matter as well as of the urine. Post-processing such as co-composting of faecal matter and organic waste will be carried out before the human excreta products are used in local agriculture.

Figure 3: Collection shaft with ventilator at the outside

Besides urine and faeces, households generate greywater from using water for washing, cleaning and cooking. This water has only a relatively low nutrient content and does not pose any substantial health risk. It can therefore be easily treated in decentralised constructed wetlands, which are foreseen in the immediate surrounding of the houses. Therefore, they do not need extensive piping and contribute to a green environment.

Operation & Maintenance

Since for large-scale projects the households cannot be expected to carry the responsibility and additional burden of the operation of the sanitation system, external service providers are required. Similar to micro and small enterprises (MSEs) active in the field of waste collection, the operation of the sanitation system and marketing of the human excreta products can be carried out by small scale providers. This contributes to employment and income generation. The tasks of these MSEs include:

- Emptying of the urine container (on a regular basis, e.g. every four months)
- Transport of the urine to the agricultural end-users
- Intermediate storage (if required)
- Emptying of the toilet boxes in the condominium houses (e.g. every six months)
- Collection of the dry faeces and transport (e.g. by trucks or donkey carts)
- Further processing of faeces, i.e. compost production
- Marketing of the products

In contrast to the desludging of septic tanks, no expensive and high-tech equipment like vacuum trucks is required. The operation and maintenance tasks with respect to large-scale ecological sanitation systems are rather labour-intensive and accomplishable with low-tech equipment (e.g. hand pumps, donkey carts etc.). The MSEs are financed on one hand by the households who receive an "emptying service" for their sanitation system and on the other hand by farmers who receive fertiliser for their production. However, this becomes only viable with large enough scales for profitable operation. The MSEs therefore play a crucial role in the value creation chain of marketing human excreta as fertiliser.

Costs & Benefits

To check the economic viability of the source-separating sanitation system, a cost comparison is carried out for seven blocks of houses with six flats each, which is equal to about 210 inhabitants in total. The dry sanitation system using urine separating toilets is compared to the conventional water-based system with septic tank. The lifetime of all investments is assumed to be 10 years and the interest rate is assumed to be 10%. Costs for further processing of urine and faeces as well as treatment of septage from septic tank are not included in the analysis. However, the investment costs for on-site storage and treatment (e.g. greywater treatment in constructed wetlands) as well as emptying costs are considered. The analysis shows that the costs of sanitary installations inside the houses are more expensive for the source-separating system compared to the conventional system (see table 1). Yet, the costs for construction of septic tanks are saved. In addition, operational costs of the ecological sanitation system are lower due to savings in water for toilet flushing and reduced collection costs of urine and faeces compared to the expensive hiring of vacuum trucks for emptying the septic tanks. All in all, the urine separating system shows cost advantages against the conventional system. Even assuming that the septic tank is not going to be emptied by vacuum trucks, the conventional system is slightly more expensive than the source separating system. Taking into account the expensive hiring costs for a vacuum truck service as operational costs the total costs of the source separating system (investment and operation) are only about 85% of the costs of the conventional system. A sensitivity analysis with varying interest rates shows that the source-separating system is always favourable compared to the conventional system. Even the neglect of emptying costs for the septic tank does still result in slightly lower costs for the source-separating system.

Investment costs of the ecological sanitation system are expected to further decrease when urine separating toilets, which are still relatively expensive, can be produced as a mass product and economies of scale can be applied.

Table 1: Cost comparison between source-separating system and conventional system (as annuity with interest i=10%)

		Costs (expressed as annuity)	
		ecosan	**conventional**
Investment			
Inside the house	[€/a]	3,393	2,347
Outside the house	[€/a]	890	2,435
Sum Investment	[€/a]	*4,283*	*4,782*
Operation			
Water for toilet flushing	[€/a]		149
Emptying septic tank	[€/a]		576
Emptying UDDT system	[€/a]	423	
Sum Operation	[€/a]	423	725
Total	[€/a]	**4,706**	**5,507**

Another factor not yet considered is the economic benefit of the human excreta products. Due to rising energy prices for the production of fertiliser as well as the fact that phosphorus is a limited resource, the retail price of inorganic fertiliser in Ethiopia is seeing yearly increases of up to 20%. Despite this, the demand for fertiliser in Ethiopian agriculture is increasing [4]. Since urine and faeces are not yet accredited fertilisers, their monetary value cannot be offset against the occurring costs. However, given the good results from agricultural trials and the positive attitude shown by farmers and agricultural experts, it is expected that soon the economic benefit will be realised. Therefore, it is worthwhile to have a closer look at the economics of urine and faeces use in terms of monetary value.

Using the recommendations for fertiliser application in the Southern Region, about 12 m^3 of urine are required on average to fertilise one hectare of agricultural land. Converting this amount into economic value by comparing it with average fertiliser prices, this means that one jerry can of urine with 20 litres has an equivalent value of about two birr[1], respectively about 100 Birr/m^3 or 7€/m^3. This might not seem a lot, but considering that Ethiopia ranks among the poorest countries in the world, the value of human urine to Ethiopian agriculture becomes obvious.

Faeces can be composted together with organic waste and used as organic soil conditioner. Although compost is not yet widely used commercially in Ethiopia, there are companies

[1] One Ethiopian birr (1 ETB) equals about EUR € 0.07

starting up compost production and selling the product for a price between three and five birr per kg. However, increased marketing of compost as soil conditioner is still required.

Current status

The project activities are currently focussing on Awassa, which is the capital of the Southern Region of Ethiopia and has a population of about 120,000. In one of the condominium construction sites one block with six apartments is equipped with dry, urine-diverting toilets in a pilot project. In addition, there is another block of condominium buildings with UDDT under construction in Boditi, which is a smaller town with about 24,000 inhabitants in the Southern Region. In Awassa, the first block of apartments with this alternative sanitation system is currently handed over to the inhabitants, who are expected to move in by August 2009. Workshops and close follow-up are planned in order to achieve high sensitisation and acceptance of the new system by the inhabitants. Several local stakeholders such as the local Housing Project Office, the municipal agricultural department as well as the MSE department are supporting the project. Training of farmers and crop trials, which already have been carried out to promote the use of urine and compost as fertiliser and soil conditioner in other areas, are going to be extended. The first pilot project has only a relatively small scale in order to achieve close cooperation and proper monitoring. In case the system is not accepted or some kinds of failures are occurring, there are easy ways to re-equip the apartments with conventional sanitation facilities. Challenges that have been encountered so far include, for example, frequent change of responsibilities within cooperating institutions, poor workmanship as well as delays in construction and transfer of the apartments due to several reasons. However, concerning the viability of dry, urine-diverting toilets and the recycling of human waste products in Ethiopia, positive experiences in terms of acceptance by users and farmers have been made.

Conclusions

The implementation of water-less, urine-diverting toilets in the condominium housing program in Ethiopia show an alternative approach for dry sanitation even in multi-storey buildings. Experiences with regard to general acceptance of UDDT and the use of human excreta products in agriculture to this day are promising and encourage the further dissemination of this technology. The double-vault toilets are already integrated into three storeys of one block of buildings in Awassa. But since the transfer of the houses to the inhabitants is not finalised, operating experiences are yet to be gained. The cost comparison between the implemented source-separating system and the conventional system for condominium houses (septic tanks) shows an advantage for the new approach due to savings of water for toilet flushing as well as reduced costs for the treatment of the mixed wastewater in septic tanks.

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