From pit latrine to nutrient conservation –
Design and construction of an optimised public dehydration toilet in Ghana

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Abstract
Dry toilet systems, like the Kumasi Ventilated Improved Pit Latrine (KVIP), are very common in Ghana, but are also one reason for unhygienic conditions like smell, flies and unpleasant handling of faecal sludge. The following solutions for improvement are part of a research project and concentrate on an easy to clean and easy to manage dry toilet system, which avoids hygienic risks as far as possible. A public dehydration toilet building for about 250 male students was constructed on a campus as a first step, to find out about acceptance, function and treatment conditions.

After 6 months operation, good function and acceptance can be confirmed. Most of the students prefer the dry toilet to the flush toilet that they share with each 8 students at the dorm. A cleaner was trained for maintenance and managing the system too. Hygienic pre-tests by co-composting faecal sludge from a KVIP and implementing test bacteria into the process resulted into safe compost.

Further tests are going on and user acceptance is documented. The results until now will lead into a more pre-fabricated and cost-effective construction. Thus it may be a model for many possible construction varieties and a business opportunity for local construction enterprises.

Keywords
Public toilet, dehydration, faecal composting, urine separation, agriculture, Ghana

Introduction
The research project “Ecological development at Valley View University in Accra, Ghana”, supported by the German Federal Ministry of Research and Education, started in 2003 and is ending in 2009. A master plan was developed by the Bauhaus University of Weimar, Germany, together with the Ghanaian partner Valley View University in Accra and the Ecological Engineering Society (project leader). This private university is increasing from 1.200 students now up to 10.000 until 2015. The construction and research activities focussed to make use of all water and nutrient inputs to support agriculture as a central and sustainable element in closed loop recycling management. The other German partners as University of Hohenheim (agriculture), Palutec (grey water treatment and storm water harvesting) and Berger Biotechnik (water-saving and waterless sanitation) are involved as sub-projects in implementation and research (Berger et al., 2008).

As a first step for basic supply of irrigation, nutrients and organic matter, water saving devices as well as separation flush toilets and dry urinals were applied. As water supply in this area is an uncertain factor and to provide hygienic conditions also in times of water shortage or breakdown, the need for improved dry toilet facilities was obvious and demanded. As a condition, the Ghanaian partner wanted a high standard in construction and design to raise acceptance.

Methods

Respecting the KVIP design, which is very accepted in Ghana as a whole, alternatives were developed as part of a master study (Weselmann, 2007). The concept provides broad self-sufficiency by using waterless toilets, dry urinals, stored rainwater for hand washing and floor cleaning, as well as solar energy for night-time illumination of the building and for drying faeces.

Concept and building design

The concept and the final draft is a refinement of previous solution approaches for waterless toilet systems with urine diversion in different parts of the world (GTZ, 2009). The building design is constructed at ground level to make operation and discharge easier than at latrine buildings with underground pits. The half-height basement contains storage chambers for faeces bins, urine tanks and additives. If not built on a slope, users walk up steps to enter the above floor, where toilets, urinals, hand-washing basins and rainwater storage tanks are installed. Construction materials can be solid or lightweight, as long as they are structurally engineered. The multifunctional design of the building ensures that it can flexibly meet a variety of different demands and conditions at the same time such as capacity, interior equipment, building material etc.

The prototype BBT* design provides access from the left and right front to allow continuous operation during short-term interruptions (e.g. for maintenance and cleaning), during which only one half of the building is used. It also can be easily divided for separate use of the two halves by male and female users. The BBT* is also designed to provide two different options for faeces storage and removal:

- Option 1 uses storage bins on wheels. Each chamber has space for two bins, which are used alternately as described below under "Operation and maintenance".
- Option 2 makes use of two chambers without storage bins. The symmetrical arrangement of the floor plan makes it possible to alternate between two chambers to store the faeces. This option is advantageous, if cost saving is an issue or if the bins used in Option 1 cannot be transported. The dried faeces then need to be removed by shovel and wheelbarrow or similar methods.

Solar drying and enforced ventilation

The BBT*-building is orientated with its backside to the south, so the cover of each chamber operates as a heat absorber to rise air temperature. The inside walls of the chambers are painted black and the floors tiled. For research reasons, three of the six chambers are equipped with black aluminium covers and the other three with transparent acrylic glass. A scientific monitoring program was implemented in cooperation with the project partner University of Hohenheim, to investigate the efficiency in respect to odour and pathogen control. Each chamber is vented by an exhaust pipe that extends up above the roof and is equipped with a wind-operated fan to improve air draught. Evaporation is enforced and airflow is enhanced by solar heating, providing a permanent odour trap, even when there is no wind. The residual moisture content of the faeces is absorbed by adding sawdust regularly (e.g. once a day).

Operation and maintenance

All toilets are equipped with urine diverting devices and membrane traps, so faeces can be collected separately in movable under-floor 240 l-dust bins, which are connected to the toilets by 8" diameter down-pipes. Each chamber contains one bin underneath the toilet down-pipe and a second bin in front. When the first one is filled with faeces, it is replaced by the second empty bin and then undergoes a further drying stage. When the second bin is full, the first one is emptied for composting and is returned to replace the second one. This procedure avoids the mixing of dried material with fresh faeces (double-vault system).

Faeces composting and urine application

As part of the agricultural segment of the research project, vented brick compost chambers are placed in nearby locations for subsequent thermal co-composting of faeces and grass clippings. To verify the composting process and its disinfection potential, the survival of experimental germs in the final product is validated, and the temperature profile and ventilation are tested and analysed. After the material has been turned periodically and has undergone repeated self-heating, the treated compost is ready for fertilizing trees and non-leafy vegetables. Urine from the separation toilets and from dry urinals is collected for storage in 1000 l tanks and transported to larger storage tanks for subsequent recovery in the nearby agricultural area before being used as a liquid fertilizer for crop production (University of Hohenheim et al.).

Results and Discussion

After a six month test period, collected data and opinion poll results were evaluated and discussed in order to optimise the concept. Good function and acceptance can be confirmed, if the system is maintained properly. A cleaner was trained also for maintenance and managing the system. Many of the students prefer the dry toilet to the flush toilet that they share with each 8 students at the dorm. To their opinion, a dry toilet is more clean.
Hygienic pre-tests by co-composting faecal sludge from a KVIP and implementing test bacteria into the process resulted into safe compost.
Further public facilities with urine diverting dry toilets are intended to be built on campus as well as in villages, schools and other public places to improve sanitation and re-use of nutrients for agriculture. The results until now will lead into a more pre-fabricated and cost-effective construction. Thus it may be a model for many possible construction varieties and a business opportunity for local construction enterprises.

Conclusions

Experiences from other projects show that well meant and innovative sanitary solutions may fail, if they are not attractive to the user and to the operator as well. To raise public awareness on toilet facilities, the general standard has to be increased together with training of toilet management staff and public information about function and benefit of new sanitary systems. This means more investments in construction and education for safe long-term operation and acceptance. Building design has to respect changes and development of new toilet systems to be flexible for the future.

* Berger Biological Toilet

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