Urine diversion dehydration toilets at Valley View University in Oyibi, Greater Accra region, Ghana

Fig. 1: Project location

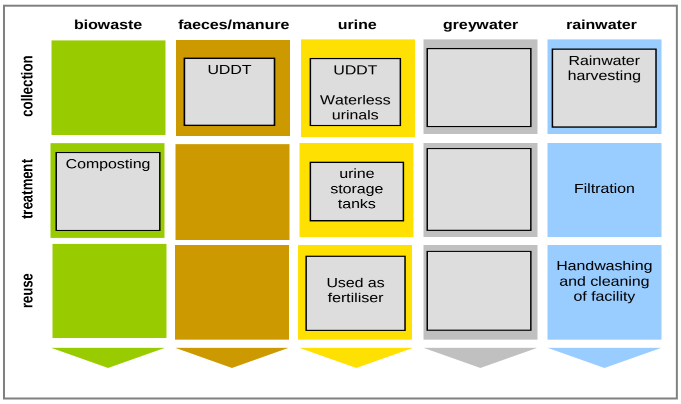


Fig. 2: Applied sanitation components in this project

1 General data

Type of project:
Co-financed, university ecological development project

Project period:
Start of construction: 2008
End of construction: 2009
Start of operation: 2009

Project scale:
Number of people covered: approximately 260 students
Number of toilets (a total of 6 toilet units) as well as 4 composting chambers

Total investment: EUR5, 769 (EUR4, 750 for building materials and EUR1009, for workmanship (excluding cost for composting chambers)) Construction costs and workmanship was paid by VVU, all costs for toilet systems were sponsored 50% by the Berger Biotechnik GmbH and 50% cost sponsored by BMBF.

Address of project location:
Valley View University (Bediako Hall), Oyibi /Accra, Ghana

Planning institutions:
-Berger Biotechnik, Hamburg (subproject partner),
-S. Weselmann, Hamburg (diploma student HCU)
-Valley View University (VVU) - Oyibi, Ghana
-Ecological Engineering Society (IOV) - Augsburg, Germany (project leader of the overall BMBF-project)
Valley View University (VVU) - Oyibi, Ghana
Bauhaus University Weimar - Weimar, Germany

Executing institution:
Berger Biotechnik, Hamburg and Valley View University, Oyibi/Accra, Mitterer, A. Gangkofen (contractor)

Supporting agency:
BMBF (Federal Ministry of Education and Research, Germany)

2 Objective and motivation of the project

The overall goal of the ecological development at Valley View University project was to help solve incumbent water-related infrastructural and environmental problems on the university campus, through the implementation of various ecological technologies in making VVU the first ecological university in Africa.

3 Location and conditions

The capital city Accra, is located south of Ghana under latitude 5° 36' N and, and longitude 0° 12' W with an approximate elevation of 65m above sea level, in the Greater Accra Region. Approximately 30km (19miles) north of the city of Accra, the Oyibi settlement where VVU is situated, can be found within Accra's plains. Known as the "Ghana dry zone", Oyibi falls in the coastal savannah region of Ghana (IOV, 2010:2:02).The University is bordered to the west by the Aburi-Akuapem Mountain range, to the east by emerging residential buildings and hostels of the Oyibi community, to the south by the Adenta municipality which is a suburb of Accra and to the north (about 16km/10 miles) by the Dodowa township. The area has meagre annual rainfall ranging from 600 to 1150mm (Vollmert et al., 2003, cited in IOV, 2010: 2.07)

Fig. 1: Berger Biotechnik Toilet (BBT) at the Bediako male hostel on VVU campus (source: Okan-Adjetey. P, September, 2011).

The predominant soil types found in the university's area consists of deeply "well-drained savannah ochrosols" (Adjei-Gyapong and Asiamah, 2002, cited in Germer et al., 2011: 235) or "Ferric Acrisols/Ferric Lixisols" FAO, 1998, cited in Germer et al., 2011: 235). Ground water at VVU lies at relatively low tables of up to 30m deep (Sebald 2004, cited in IOV, 2010 2.07). Hence, the groundwater is depleted making it difficult to obtain water.

As at 2011, the hostel student executives reported approximately 260 students, resident at the Bediako hostel. The students come from different African countries and as reported[1], appear to come from relatively high to middle income families. Most of the students are usually denominationally affiliated to the Seventh Day Adventist (SDA) church which owns VVU.

4 Project history

Advances for solving the water-problem in the university stem as far back as 1992, as the SDA church (proprietors of the University) welfare office had threatened to shut down the university due to lack of water (Okan-Adjetey, 2012: 4.26, 28). The University was not connected to Ghana's public water supply system and had to supply water by a water tanker. To lower the associated cost, measures including saving and recycling were evaluated.

One of such measures took place in the year 2000, following the preparation of a master plan; in a quest to upgrade infrastructure and at the same time solve some of the universities water-related problems. These efforts amongst others evolved into the Research and Development (R&D) Project at VVU (Okan-Adjetey, 2012: 4.26, 28).

The R&D project, dubbed "Ecological development at Valley View University in Accra, Ghana", was initiated by the Ecological Engineering Society (IOV) and Bauhaus University Weimar and was expanded by the integration of UHOH (University of Hohenheim), Berger Biotechnik GmbH, Palutec GmbH and CIM (Centre for international Migration and Development)

This project/aspect understudy (UDDT) constitutes a part of the holistic ecological technologies[2] employed to help curb the infrastructural needs of the university. Except the BBT, the installations outside buildings were financed 50% Palutec GmbH and 50% BMBF. All inside installations were financed 50% Berger Biotechnik GmbH and 50% BMBF. An early proposal to commence with UDDTs was rejected as authorities of the university at the time wanted to have so called "future toilets" (Okan-Adjetey, 2012: 5.56).

The initiative to develop a specially adapted UDDT, the so called Berger Biotechnik Toilet began in 2008, as a revised alternative, as frequent lack of water and electricity made water closets – at least sporadically – unviable.

[1]Interviews conducted as part of a master thesis by the author on "*Ecological sanitation efforts in Africa, lessons learned and recommendations for future project design. A case of Valley View University, Accra"*
[2]Other technologies were established, which do not form part of this case study, for more information see: http://www.berger-biotechnik.com/downloads/ecological-cycle-management-at-valley.pdfand https://www.uni-hohenheim.de/respta/vvu.php

5 Technologies applied

The UDDT unit or BBT as it is called was designed by Berger Biotechnik GmbH as a product of a thesis[3]. The unit was designed to be locally affordable, easy to build and tactically committed to high urine and hygienic faecal matter collection, immediate separation and further composting for use as fertilizer (BERGER, 2009). Four different sanitation components were applied in the design and construction of the BBT:

(1) urine collection, treatment and reuse,
(2) rainwater collection, treatment and reuse,
(3) Urine and faecal matter separation and collection (UDDT), treatment and part use and
(4) Co-composting

Urine (1) was collected from 6 UDDT pedestals and 3 waterless urinals (see fig 3a) in the toilet unit. They were all fitted with membrane traps [4](see fig 3a (X)), and connected to flow through plastic pipes to 2 x 1000 litre capacity plastic storage tanks (see fig 3b) placed underneath the superstructure of the entire toilet unit. Treatment of the urine was done simply through storage for about a month, after which it was collected with the help of suction pumps and later transported approximately 400 meters away to the university's farms to be specifically applied to trees and non-leafy vegetables (This method was subsequently modified (see7)).

Rainwater (2) on the other hand was collected with the help of rainwater aluminium panelled gutters placed at the lee side of the clay-tiled roof of the BBT. The rainwater will then flow first to a filter for treatment, and then through plastic pipes to a second storage tank. The water was then used for the cleaning and maintenance of the toilet unit and for washing of hands. To further save water, the wash and basins were fitted with pneumatically controlled (8 second flow) taps, to regulate the amount of water needed to wash hands and prevent lavish use.

Fig. 3: Waterless urinal (a) with membrane trap (x), and pure urine storage tanks (b) at the VVU farms campus (source: (a) Berger, W., (b) Germer, J., (c) Höner, G. in: IOV, 2010: 5.29, 5.32

Faecal matter (3) is separated[5] from **urine (3)** due to the design of the UDDT toilet basin, which allows the immediate diversion of urine to the storage tank and faecal matter to

[3] https://www.uni-hohenheim.de/respta/poster/PB_0004.pdf
[4]A vented device designed to trap odor and prevent smell
[5]Separation is based also on the sitting posture of users on the toilet seat. A correct upright sitting posture will enable separation, otherwise (e.g. squatting) will cause a mix of the urine with the faecal matter.

wheeled bins (240litre/0.24m^{3}volumes) for later transportation to the composting chamber. There are 2 wheeled bins in each chamber, one for storage, one for drying after being filled (in an alternating system). Prior to transportation, the faecal matter was applied with saw dust on a daily basis to serve as an "absorbing" material to keep moisture low (WHO, 2006: 83). Using large size "pomo tomato" steel tins, a care taker in charge of the toilet will sprinkle saw dust on the faecal mixture; this helped the mixture to desiccate. The bins were placed under the toilet facility in such a way as to expose it to solar irradiation for further drying (see Fig. 5). At the first time of installation, the care taker of the facility reported that it took about 3 months for each of the bins to be full, after which the mixture was transported to the **co-composting (4)** chambers for further composting with grass or other bio-degradable matter.

The co-composting chambers are situated about 100 meters away from the toilet facility. As part of a subproject research conducted by the University of Hohenheim, different materials were used for the construction of the composting chambers[6].

Fig 4: UDDT with faecal and urine separation (a) by means of membrane trap (X), wheeled bins for transport of pre-faecal compost (b) and Chambers for composting (c) (source: (a) Berger W., (b, c) Germer, J.).

Each time the bins were brought from the BBT, they were simply emptied in the composting chambers to allow for decomposition. Unfortunately, the compost generated from the BBTs were not being used at the time of the visit for this study, concerns or fears related to pharmaceutical residues and heavy metals were cited mainly as the stumbling block. As further research is still ongoing, personnel responsible for the maintenance and application will prefer to see the outcome of tests conducted with heavy metals and pharmaceuticals to verify the safety of the compost before further application (Okan-Adjetey, 2012: 5.48).

The immediate target group for the construction of the BBT (UDDT) facility was the male students of the Bediako hostel. Prior to the construction of the BBT, students were consulted on an informal basis about their preference for the type of toilet (whether sitting or squatting). Half of the students wanted sitting and the other half wanted squatting, as a result, a hybrid model was designed to cater for both sitting and squatting but university authorities overruled the choice by deciding they wanted sitting toilets, and this was constructed in effect (Okan-Adjetey, 2012: 5.56). Also, initial reports indicate that students were trained on how to use the toilet facility and its application which was confirmed at the time this study was being conducted; however the training process as reported by the students was somehow discontinued as the project ended in 2009.

[6] See design information

6 Design information

The design of the dry toilet (UDDT) was an output of Berger Biotechnik GmbH in collaboration with a diploma thesis, which customized existing dry toilet systems to come up with an archetype (Weselmann, 2007). The design sought to "raise interest and awareness in neighbouring communities"[7], upon successful acceptance and operation of the Bediako hall BBT model, the project intended to be replicated in nearby areas.

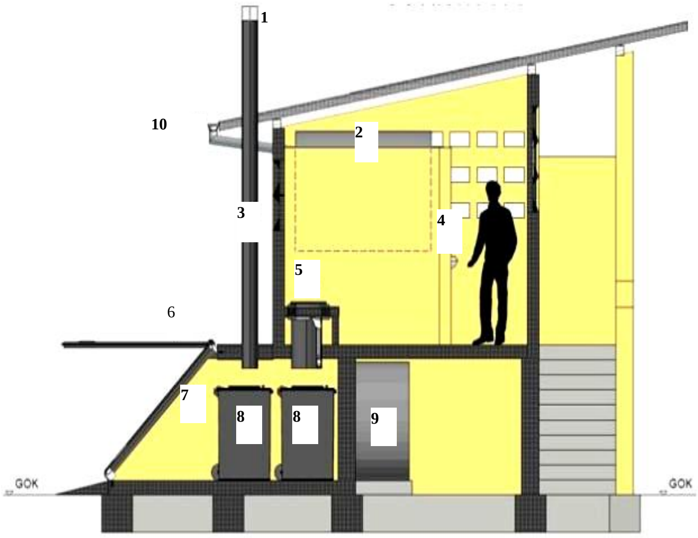


Fig. 5: Berger Biotechnik Toilet (BBT) at the Bediako male hostel on VVU campus (source: Weselmann, 2007).

Design features installed on the UDDTs can be identified according to the different numbering from 1-10 (see figure 5); a wind powered ventilator (1), to keep the air circulation fresh in the toilet units to prevent odour. Rain gutters (10), to harvest the rain water into a rainwater tank (2) with 2 x 1000 litre volume (2m^3) for storing the harvested rainwater which was used as water for the washing of hands through installed hand wash basins (4) after using the toilet facility, also for other cleaning purposes on the facility. A solar heated vent pipe (3) to ensure the escape of excessive heat from the saw-dust faecal matter mixture to speed up under pressure in the ventilation system, sitting toilets (5) with urine/faeces separation, a chamber flap (6) for closing the substructure chamber (7) unit to prevent the entrance of flies and for housing the exchangeable mobile bins (240 litre volume) (8) and a urine storage tank (9) with 2 x 1000 litre volume/2m^3 (Weselmann, 2007).

The design of the BBT

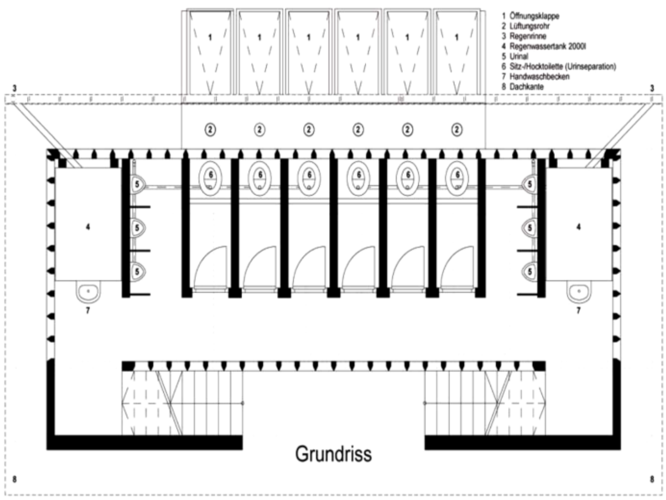
The design of the BBT (fig 6a & d) emanated partly from the local KVIP (Kumasi Ventilated Improved Pit Latrine) concept. The major differences are that the BBT does not have underground pits, allows for separation of urine and faecal matter for further use in agriculture as well as the incorporation of better and safer maintenance cultures (for e.g. the direct dislodging of faeces after the KVIP is full, where people will literally have to scoop the raw

[7] https://www.uni-hohenheim.de/respta/poster/PB_0004.pdf

urine/excreta mixture with a bucket/with a pump). Furthermore, the design of the building is done symmetrically: on the right and on the left side are tanks for rainwater (upstairs) and tanks for urine collection (downstairs). So one half can function, while the other half can rest for maintenance, cleaning and so on (source: Berger, W. in IOV, 2010, p. 5.26).

The toilet pots and hand wash basins (see figure 5b, c) were constructed locally together with Berger Biotechnik GmbH and a Ghanaian artisan, purely made from concrete (terrazzo) as the toilets imported from Europe for the administration and sanitary block were too expensive.

Floor plan (Source: Weselmann (2007): 86)



Construction materials used
(source: Weselmann, 2007)

6 Toilet downpipes (diameter 300 mm, made of PVC)
6 Toilet doors with transoms (wood material)
6 dry urinals
2 sinks with pressure taps on the tank
urine and gray water pipes (diameter 50 mm)
2 rainwater tanks (2000 litres capacity)
2 urine tanks (capacity 2 x 1000 litres)
12 wheeled bins (2 per drying chamber)
6 chamber doors with louvers (black for sunlight absorption)
6 gill-shaped grille for the chamber doors[8]
6 Vent pipes for the chamber (PVC, black, diameter 200 mm)
6 wind-driven fans
27 aluminium roof panels (1.20mx 2.50 m)
3 Transparent roof panels (1.20 x 2.50 m)
gutter (length 13.00 m)
2 for gutter downspouts
lines for urine and Hand wash
Electric lighting (12V solar)

[8]Transparent for comparison of effectiveness of solar heating towards black aluminium sheets (GERMER (2011)

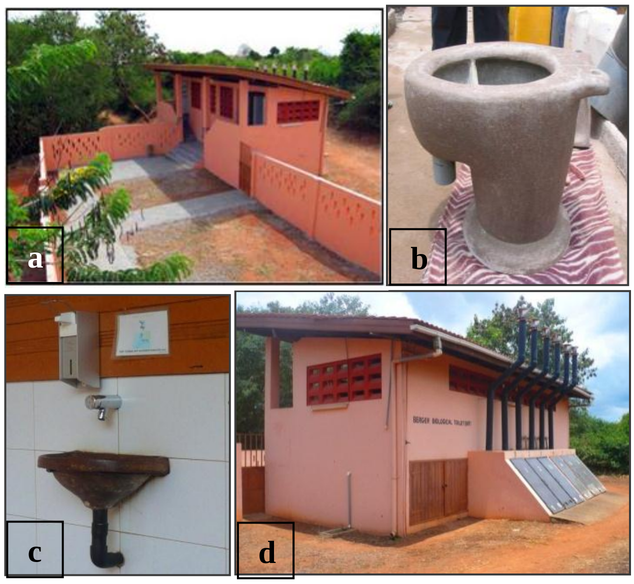


Fig. 6: BBT unit top inclined view (a) and back view (d), terrazzo handmade toilet pot and hand wash basin (c) (source: Berger, W. [a&b]; Okan-Adjetey. P, July, 2011 [c &d]).

7 Type and level of reuse

All collected components were reused apart from the faecal matter generated from the UDDT[9]. Urine however, was being applied to trees and non-leafy vegetables (green pepper (paprika), oranges, okra and mangoes); it used to be collected with the use of suction pumps and transported 400m away to the university farms to be stored in larger "polytank" containers. The suction pumps, due to the acid content were sometimes jamming up the pumps as they were originally meant for water. However, after dismantling the pumps and cleaning them with water it was good enough to use again. Urine according to some of the university's farmers interviewed, were applied to trees and plants two weeks after planting, with a lineal buffer of 6cm to the plant, application was redone each other recurring month:

"I believe the Urine gives more yields, because we did tests with chicken manure, Cow dung, urine, faecal matter and compost (just rotten grass) and urine was the best. At every stage after two weeks you should start cutting the trees, we did the same for chicken manure, Cow dung, urine, faecal matter and compost and after that we look at the growth trend. We measure with tape measure before we also have control, that is that has not been applied with anything and we observed that the one with nothing applied had very low and small yields, but what we applied the urine to, you will realize that the leaves after two weeks become very big and the length was longer than the others, and that's what we used to observe, and every two or three weeks, we go to the field to prune all of them we did up to 90 plots, and the plot size was 7 by 5meters, so we will walk through and prune the small ones and the big ones too and observe. We also

[9]Due to existing health concerns especially about heavy metals that may exist even after the treatment of human fecal compost, local technicians deem it necessary to clear all health doubts about composting before they will be confident to utilize the human fecal composts from the UDDTs.

recorded all the data and it's with our boss. So that is how we observed that the urine does better with the yield. Also, after the yields, after harvesting you will realize that the urine fertilized ones have larger harvest than the others" (VVU farmer, September 2011).

8 Further project components

The holistic ecological development project of VVU intended to focus on different aspects of ecological development to make it the first ecological university in Africa (IOV, 2010: 1:03), the project's ecological aspiration sought first; through the establishment of an ecological master plan to guide broad areas of planning, technical implementation and managerial aspects (Okan-Adjetey,2012:3.20,21 ; 5.40)[10].The master plan was to follow concepts which allow spatial developments to be done in an ecological manner, incorporating important socio-cultural and economic human living requirements.

Discussing the extensive activities of the holistic project will be too broad to accomplish. However, under planning, were two major elements of urban planning and landscape planning. Urban planning incorporated so called "stadtschaft" and cell model which bridged the connection between urban and landscape planning (source: subproject partner Bauhaus Uni. Prof. Glücklich)[11]. Landscape planning on the other hand included agricultural ecological cycles and measures for the protection of the environment on the VVU campus. A part of that aspect of ecological cycles and measures is the UDDT project understudy (GERMER (2010, 2011)

Technical implementation encompassed ecological buildings, roads, open space and fields, for e.g. some buildings were built to be less energy demanding making use of solar lighting, natural ventilation and rainwater harvesting and storage.

Within the managerial sector of the project, were efforts of consensus building, monitoring and evaluation and some cost effective measures realized within a "Holistic quality management" (IOV, 2010:3.06, 07; 8.04) structure.

9 Costs and economics

The following capital cost breakdown after (Weselmann.S, 2007: 99), have been converted from the former cedi to euro's according to a stipulated exchange rate derived simply by dividing the euro total 4,750 by the cedi total 95,000,000 (rate of 20,000 old cedis)[12]. Using a recent exchange rate of the new Ghana cedi may give a close estimation of current item prices.

Table 1: Roofing and workmanship cost in Euros

Roofing cost				
Item	**Unit**	**Quantity**	**Unit price (EUR)**	**Total cost (EUR)**
Rafter 2,5" x 6", length16 feet *(6/16)*	LF	210*21	4.50	94.5
Roof sheets, 1,2m x 2,5m	m^2	27*55	3.50	94.5
Nails	C		6	12
Workmanship cost				
Roofing labour				75
Excavating labour				45
Plumbiing labour				30

Item	**Unit**	**Quantity**	**Unit price (EUR)**	**Total cost (EUR)**
Construction materials cost				
Design blocks	m^3	148.5	0.45	66.825
Painting	m^2	399.47	0.75	299.6
Plastering	m^2	399.47	1.80	719
Divider panels for urinal (timber)	m^2	6	7.50	45
Doors & ironmongery		6	75	450
Pipes (50mm)	LF	3,5 *67	4	14
Solid sandcrete block wall(450/150/225mm)		13151*199.7(m^2)	6.90	1378
Concrete reinforced, slab (150 mm)	m^3	6,53	45	294
Concrete reinforced Foundation (400 mm)	m^3	1*9,80	40	392
Wawa board (5/10cm)		25	1.75	44
Sheathing boards (30cm)	cm	40	3.25	130
Concrete chamber floor (platform)	m^3	1*0,63	40	252.7
Steel rebar (12.5mm)	t	1*1		280
Support columns (concrete)	m^3	21*1,47	45	66
Total cost Roofing+ workmanship + materials				**4,769**
Installation cost				
Tank (Hippo 200)	m^3	4*	159.50	638
Bin for faeces (Otto)		12	50	11
Urinals		6	29	175
Gutter				5
Vent pipe		6	30	180
Overall cost				**EUR 5,769**

Table 2: Cost of construction materials and installation

**Total costs for bins and concrete chamber platform need verification from source.*

[10]This classification of aspects of the project is as identified by the author in Master thesis elaboration

[11] http://ioev.dev-test2.de/fileadmin/user_upload/veroeffentlichungen/Booklet%20Inhalt.pdf

[12]Ghana has since adopted a new currency system see http://en.wikipedia.org/wiki/Ghana_cedi [last accessed December 28th 2012]

10 Operation and maintenance

A caretaker was put in charge of the BBT; his responsibility apart from cleaning the facility included transporting the solar dried faecal matter to a nearby composting chamber. Every morning, the caretaker will sprinkle saw dust in each of the toilet bowls to serve as an absorbing material for the faecal matter from the previous day. This will help keep the moisture low.

To avoid mixing the faecal matter and urine with chemical disinfectants, vinegar with water was used as a cleansing agent for the toilets because it disinfected the toilet units and urinals and did not alter the nutrient potency of urine and the pre-composting mixture before co-composting (IOV, 2010:5.29). The cleaning was simply done first by cleaning off toilet stains with water and then using a rag dipped in vinegar to clean the second time. With regards to the toilet bowls and dry urinals, so called “membrane traps” were disassembled and cleaned also with vinegar.

No tariff was collected from the students as it was built purposely for the perusal of the students as school infrastructure, part of the requirement for any university or institution. Sometimes, as mentioned by the caretaker, the BBT facility was abused by some of its users by defecating “indiscriminately“ in and around the UDDT bowl which caused the place to stink and produce flies. As a result, the place was shut off from the users for a number of days (2-5) to allow the flies and the stench to leave before it was cleaned to permit use again.

11 Practical experience and lessons learnt

With the help of open ended questions, the caretaker and students were questioned on the kind of problems they were facing in their use and experience with the toilets.

From the caretaker’s perspective, students currently residing in the hall in July 2011 at the time this study was conducted (as compared to those of 2008/9) appear not to use the toilets as it was designed to function, they urinate into the faecal bowl mixing up the faecal matter and urine, hence causing the toilets to stink and produce flies. Initially, whiles the project was still active in 2009, students at the time were somehow[13] educated on the proper use and benefits of the UDDT (probably making them understand and appreciate the rules regarding the use then), but have as it appears since then graduated and left.

It seems, the same “training” was not done for the current students and most of them interviewed almost did not know anything about Ecosan and the entire concept behind. This causes some of the students to squat on the sitting toilets which cause a mix up of the urine with the faecal matter, in addition to indiscriminate defecation sometimes on the chamber floors as reported by the caretaker.

The caretaker underwent practical training on how to clean and manage the toilets, the method used by the project staff was the “learning by example” strategy by the leaders of the project, this method can be said to be very effective in helping the people fully accept any practical procedures used in maintaining the BBT facility.

Authorities in charge of managing ecological infrastructure in the University mentioned that posters were placed at the toilet facility giving details about use, some of which were still existent at the time of the study, however some students mentioned:

“Sometimes also due to pressure with visiting the facility I think people just disregard the rules and just do their own thing because if you have to go you don’t really consider rules, all you want to do is ease yourself”” (VVU Bediako hall student, September 2011)

Originally, the design of the BBT was specially made to close only one half of the building, so it can be used in an alternating manner. However, at the time of the visit for this case study, the operational strategy used for the toilets’ was to lock up the place, to allow the stench and flies to leave, consequently resulting in non-use when the facility gets closed. This, coupled with misuse of the toilets ultimately generates little quantity of the expected urine fertilizer and faecal composts. Hence, caused some students to defecate on free range:

“When it was done initially, using it was like freeing yourself in an outside environment like going to the bush, because you could feel some good breeze from beneath at first, but this time there are some scents” (VVU Bediako hall student, September 2011)

As part of the managerial aspect of the project, education and training was done for some institutions and communities on the concept of Ecosan for agriculture. A follow up on one of such institutions trained revealed that they had stopped the use of urine for agriculture. They mentioned that they had practiced the collection and application of urine on their farms at some point, but had to stop collection and use of the urine and grey water for fertilizing their crops because they were summoned to court by local health regulatory institutions who regarded it as a threat to the health of the people who will consume such farm produce. Mention can however be made of the fact that, some farmers at the time of the project got free mineral fertilizer from the state for one year, such initiatives affected the readiness to make use of Ecosan technologies.

With lessons learnt from other sanitations facilities on campus such as the WSFT’s (Water Saving Flush Toilets) installed at the university’s sanitary block, faculty buildings and administration, whose construction materials were mainly imported from Europe, the BBT as much as possible tried to make use of locally available materials due to future maintenance, yet still some components such as the membrane traps for trapping odour, as reported by university authorities and toilet caretakers mainly contributed to the smell that was existent at the time the study was being conducted. Some parts of the toilet bowls, such as the toilet seats could be easily replaced as they were locally available.

Moreover, in the case of using local materials, existing environmental and physical conditions should be considered in the choice of materials for construction and location of compost chambers. One could observe the actions of

[13]This is because authorities seem to confuse the idea of practical training with education and most students gave account of education and not practical training

termites which caused the dilapidation of the compost chambers built for composting the pre-faecal matter from the BBT.

Summary of lessons learnt:

1. An integral part of ensuring the proper function, collection and quality of Ecosan toilets and toilet products is extensive, continuous awareness-raising with hands on training and education and not simply education or orientation to stimulate a sense of ownership amongst users. This doesn't seem like an easy task, however the benefits after a longer term can compensate for the efforts or measures to be or implemented.
2. On the side of the misuse of BBT toilets at the Bediako hall, such as the squatting on sitting toilets, there have been debates by different experts on ecological toilet technologies; whether squatting toilets are better than sitting toilets or vice versa (EcoSanRes forum, 8/12/2011-28/12/2011). From the study at VVU as well as the authors personal use of the BBT toilets, one can conclude that both toilets can be useful, depending on the given situation, that is whether public or private. More suitable for public places (like VVU) however will be both squatting and sitting toilets and sitting toilets for private places. The argument for the first recommendation is that, a public facility could rather exclusively reserve say one or two sitting toilets for the elderly or the disabled and there should be some form of control to strictly reserve those for the elderly and disabled as they cannot squat for long periods.
3. From the VVU experience, the students decided mainly to squat on the sitting toilets (even though some reported preference for sitting toilets), the author realized that apart from education and training, this is mainly because the previous user always left the toilet unit in a bad condition and because they don't want their bodies to come in contact with the toilets seats (mostly there could be old "shit or piss stains" not properly wiped off), for fear of contracting some disease from the previous user and as the previous user can't be guaranteed to have sat like you intend to do, you will be very hesitant to sit on it yourself.
4. Conversely, on the private side, sitting toilets is rather accepted in a private setting where only one household uses a toilet facility. In that situation one can be assured that your brother, mother, father or sister will not squat on a sitting toilet and since you already share so many other facilities in the household, one will be confident to sit comfortably. Alternatively, there can also be the installation of hybrid toilets, which allow for both sitting and squatting.
5. To the further up scaling of Ecosan UDDT toilets especially in public places, there is the need especially for UDDT sitting toilet systems research into establishing some sought of control mechanism (perhaps electronically). The author proposes the "Adjeteysan control principle" that cautions or controls how users use a toilet facility properly, for e.g. an electronic device that beeps, or lights red when sitting and not squatting on sitting toilets. Alternatively, there could always be a toilet referee to first tell people how the toilets work, receive a small deposit of money as collateral before users use a toilet facility and goes to control to make sure the toilet is in good condition as before, before releasing the collateral to users, to ensure a good condition for the next user and hence avoiding vandalism or any other form of misuse of the toilet facility by others.

Identified barriers related to the use of Ecosan technologies

1. Mechanical- this constitutes maintenance functions directly related to the type of construction materials and Ecosan toilet components used in the construction of UDDTs. The more local materials and components used, the more easily future maintenance can be done. With regards to the BBTs at VVU, even though local toilet components were used, the barrier in maintenance was mainly due to the only foreign component used in the BBT facility being the membrane trap from South Africa.

2. Socio-cultural, this involves the attitudinal behaviour of local stakeholders to some of the established components of the VVU ecological systems. This is mainly informed by the individual customs, values and beliefs of VVU workers who came from different tribal backgrounds, which did not tally well with the handling of some of the components of the Ecosan technologies in VVU, such as grey water generated from the female sanitary facilities. This comprises a barrier that was innovatively overcome by the research project staff. Without the innovative way of addressing the issue, in another setting such as a local community, this could have potentially deterred the realization of that aspect of the Ecosan technologies.

3. Managerial- The strategy for solving the problem of smell in the operation of the BBTs and other ecological toilet facilities in the university at the time of the Master thesis study was conducted, was to lock up the toilets, anytime they were left in a mess, to allow the flies and stench to leave. This constitutes a barrier to the amount of faecal composts generated and does not constitute a technical problem, but on the management decisions taken to solve the problems encountered with the BBTs. In the long run, the non-use or little use of the technology affects the availability of compost fertilizers that can be used in the farms to close the nutrient cycle loop.

4. Health- Non- use of the UDDT faecal composts in at VVU farms was mainly due to fears of heavy metals and pharmaceuticals in final faecal composts. This mainly has prevented the use of human faecal composts in the Agricultural farms and constitutes one major barrier to the use of the Ecosan technologies.

5. In the conduct of participation, education and training for consensus building and acceptance for Ecosan projects, a useful tool could be to capitalize on any existing practices or traditions with relation to yet to be implemented project measures. This was one of the strategies used by the VVU project partners in conducting training for local farmers in the environs of VVU which facilitated the acceptance of the Ecosan technologies according to some of the project partners.

6. Furthermore, learning by doing is an effective way of training for acceptance and ensuring trust among local stakeholders or target groups. The 'learning by doing' approach was used to train the farm staff on the preparation of compost and its application on crops. Farmers mainly reported their satisfaction and approval

of the way the training was done, and the fact that they could practically explain quite vividly.

7. Moreover, from the findings of the study, even though composting was not done with faecal matter from the UDDTs, the most suitable in terms of maintenance and operation as observed from the study is the UDDTs, in terms of collection and ease of transportation of urine and faecal matter. An important condition for its operation however is the constant training of users and workers who will use and run the facility, in order to ensure a more secured source.

8. With regards to acceptance for the UDDTs, it can be seen from the perspective of the caretaker or students. From the caretaker's perspective, one can conclude that acceptance is really high; this is because in terms of operation and maintenance, the health risks involved such as the transportation of faecal matter is appears to be low. On the part of the users, acceptance is closely tied to the proper functioning of the UDDTs, the higher the functionality, the higher the acceptance and the lower the functionality, the lower the acceptance. The unit was designed to be locally affordable, easy to build and tactically committed to high urine and hygienic faecal matter collection, immediate separation and further composting for use as fertilizer. The only aspect not achieved is the continuous reuse of the compost generated replication cannot also be recorded yet; however interest and awareness on the entire concept can be said to be activated in those communities and institutions that were educated on the concept of Ecosan, even though they currently experience some difficulties in practicing the concept, the interest can clearly be seen, as they intend to carry on with the technology practice after the restrictions from authorities have been lifted.

12 Sustainability assessment and long-term impacts

A basic assessment (Table 1) was carried out to indicate in which of the five sustainability criteria for sanitation (according to the SuSanA Vision Document 1) this project has its strengths and which aspects were not emphasised (weaknesses).

Table 3: Qualitative indication of sustainability of system. A cross in the respective column shows assessment of the relative sustainability of project (+ means: strong point of project; o means: average strength for this aspect and – means: no emphasis on this aspect for this project).

	collection and transport			treatment			transport and reuse		
Sustainability criteria:	+	o	-	+	o	-	+	o	-
• health and hygiene	X			X				X	
• environmental and natural resources		X		X			X		
• technology and operation	X			X			X		
• finance and economics	X				X		X		
• socio-cultural and institutional		X			X			X	

Sustainability criteria for sanitation:

Health and hygiene include the risk of exposure to pathogens and hazardous substances and improvement of livelihood achieved by the application of a certain sanitation system.

Environment and natural resources involve the resources needed in the project as well as the degree of recycling and reuse practiced and the effects of these.

Technology and operation relate to the functionality and ease of constructing, operating and monitoring the entire system as well as its robustness and adaptability to existing systems.

Financial and economic issues include the capacity of households and communities to cover the costs for sanitation as well as the benefit, such as from fertiliser and the external impact on the economy.

Socio-cultural and institutional aspects refer to the socio-cultural acceptance and appropriateness of the system, perceptions, gender issues and compliance with legal and institutional frameworks.

For details on these criteria, please see www.susana.org: the SuSanA Vision document "Towards more sustainable solutions" (www.susana.org).

Impacts of project

- A local NGO REDF and Pecs educational institute located at Nsawam, Accra have acquired some knowledge in the use and application of Ecosan technologies. REDF is a local NGO in Nsawam in the Eastern region of Ghana where a number of local farmers were educated on the practical use and application of urine and grey water for agricultural purposes.
- VVUs BBT project has facilitated the replication of UDDTs at a beachside guest house located at Kokrobitey in Accra.
- With help from the research project staff, an orphanage (Orphanaid Africa) was able to upgrade their dry toilet systems, by adopting the Ecosan UDDT principle of using absorbents such as sawdust. Also, the erection of an underground water tank, connected to rainwater harvesting channels, which supplement the orphanages water demand.
- Ho municipal assembly in the Volta region of Ghana currently engages in the training of farmers on the reuse of urine and greywater in agriculture.

13 Available documents and references

References

IOV (ed.). (2010). *Ecological cycle management at Valley View University in Accra, Ghana (Final Report).* Augsburg: Ingenieurökologische Vereinigung e.V. (ed).

WHO. (2006). *WHO guidelines on the safe use of wastewater, excreta and greywater. Volume IV.* France: WHO.

Weselmann, S. (2007). *Beispielhafter Entwurf und Bau einer optimierten öffentlichen Trockentoilettenanlage in Ghana-Teilprojekt im Rahmen des BMBF-Verbundprojektes „Ecological Cycle Management, diploma thesis, HarbourCity University,* Hamburg, Dep. Civil Engineering (in German)

RESPTA. (2009). *respta*. Retrieved October, 2013, from https://www.uni-hohenheim.de/respta/prog.php

Okan-Adjetey, P. (2012). *Ecological sanitation efforts in Africa: Lessons learned and further recommendations for future project design. The case study of Valley View University in Accra – Ghana.* Freising-Germany: *Master thesis.* http://susana.org/lang-en/library?view=ccbktypeitem&type=2&id=1691

Berger, W. (2009). From pit latrine to nutrient conservation – Design and construction of an optimized public dehydration toilet in Ghana, 3rd International Dry toilet conference 2009 in Tampere, Finland
http://www.sswm.info/sites/default/files/reference_attachments/BERGER%202009%20From%20Pit%20Latrine%20to%20Nutrient%20Conservation.pdf

Project websites

- *https://www.uni-hohenheim.de/respta*
- *http://www.ioev.de/*

Link to photo sets on flickr

- Photo sets of the BBT on flickr http://www.flickr.com/photos/gtzecosan/sets/72157625222640345/
- Power point presentation by Berger, W. http://www.yumpu.com/en/document/view/8516352/from-pit-latrine-to-nutrient-conservation-design-and-construction-of-

Link to videos

- Presentation of the Berger Biological Toilet at Valley View University http://www.youtube.com/watch?v=mHC5h0cAj6E&feature=player_embedded

- Overview of ecological developments at Valley View University http://www.berger-biotechnik.com/downloads/-projects/dw-tv---ghanas-eco-university---global-ideas.php

Related documentation

Berger, W. (2010).Schlussbericht BMBF Verbundvorhaben „Valley View University: Ökologische Kreislaufwirtschaft“, Teilprojekt 2: Sanitärtechnik innerhalb von Gebäuden/ Berger Biotechnik (in German)
http://susana.org/lang-en/library?view=ccbktypeitem&type=2&id=810

Geller, G., & Laryea, S. (2008). Cycles in the ecological development of Valley View University, Accra, Ghana. *33rd WEDC International Conference, Accra, Ghana, ACCESS TO SANITATION AND SAFE WATER GLOBAL PARTNERSHIPS AND LOCAL ACTIONS* (p. 9). Accra: WEDC.
http://www.susana.org/docs_ccbk/susana_download/2-328-geller-layrera-2008-accra-ghana-project-description-wedc.pdf

Germer, J. (2011). Effect of transparent covers for collection chambers of urine-diverting dry toilets on dehydration of faecal waste. *IWA* , 11.

Germer, J. (2009). *Schlussbericht BMBF Verbundvorhaben „Valley View University: Ökologische Kreislaufwirtschaft“ Teilprojekt 5 „Landwirtschaft“.*UHOH (german)
http://susana.org/lang-en/library?view=ccbktypeitem&type=2&id=1009

Germer, J., & Joachim, A. S. (2011). Response of grain sorghum to fertilisation with human urine. *Elsevier* , 8.

Germer, J., Yongha Boh, M., Shoeffler, M., & Amoah, P. (2010). Temperature and deactivation of microbial faecal indicators during small scale co-composting of faecal matter. *Elsevier* , 7.

14 Institutions, organisations and contact persons

IÖV, Dipl.-Ing. Gunther Geller (Coordinator of the entire project)
Postfach 102229, D - 86012 Augsburg, Germany
Völkstraße 3, D - 86150 Augsburg
Telefon: +49 (0) 821 - 575165
Telefax: +49 (0) 821 - 582472
E-mail: info@ioev.de
Internet: http://www.ioev.de

Role: Project coordination and quality management for entire project.

Berger Biotechnik GmbH, Dipl.-Ing. Wolfgang Berger,
Bogenstr. 17, D-20144 Hamburg, Germany
berger@berger-biotechnik.de
E-Mail:info@berger-biotechnik.de
URL: www.berger-biotechnik.de

Role: Project/team leader for sanitation concepts and design, final realization of sanitation installations.

Project team:
- Weselmann, Simon, diploma student civil engineering, Hamburg (final design, planning, presentation);
- Mitterer Toni, building contractor,Gangkofen (construction supervisor, consultancy, realisation);

- Dr. Germer, Jörn, agronomist, University of Hohenheim
(test supervisor, secondary research)

Case study of SuSanA projects

Urine Diversion Dehydration Toilet at Valley View University in Oyibi, Greater Accra region, Ghana.

SuSanA 2013

Authors:
Okan-Adjetey Paul (okanadjetey1@yahoo.com)

Editing and reviewing: Wolfgang Berger, berger@berger-biotechnik.de

This document is available from:

www.susana.org