Case study of sustainable sanitation projects

Peri-urban urine diversion dehydration toilets (abandoned) Koulikoro, Mali - Draft

Fig. 1: Project location

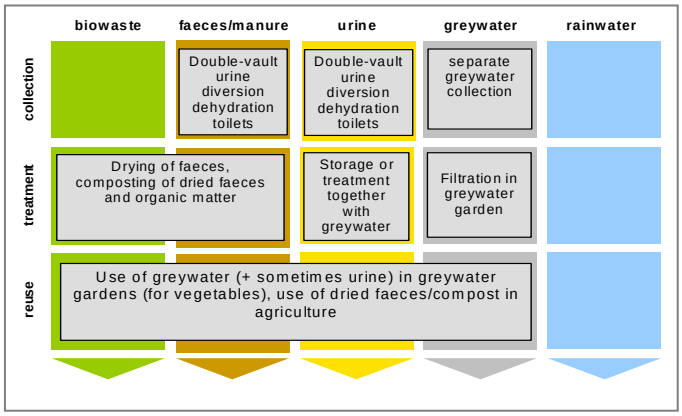

Fig. 2: Applied sanitation components in this project

1 General data

Type of project:
Small-scale peri-urban upgrading project (demonstration project)

Project period:
Start of construction: April 2000
Start of operation: Dec 2001 (currently mostly abandoned)

Project scale:
11 Urine diversion dehydration toilets and greywater infiltration gardens, each for approx. 10-25 inhabitants

Address of project location:
Koulikoro, Mali, West-Africa

Planning institution:
OtterWasser GmbH, Lübeck, Germany

Executing institution:
Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Eschborn, Germany
BOATA GmbH, Mali

Supporting agency:
German Federal Ministry for Economic Cooperation and Development (BMZ) via Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ)

Update in March 2009:

In March 2009, Stefan Hofstetter[1] visited this project site. Only two local persons could be contacted during the visit. Those were Mr. Souleymane Keita who is the "Agent Voirie Mairie Koulikoro" and Prof. Dr. Sidiké Gabriel Dembelé from the University IPR/IFRA at Kalobougou. Mr. Hofstetter took photos, talked with the people who knew of the toilets and with people involved in the project. Based on this information, we updated this case study. The original text (from the GTZ project data sheet published in 2005) has mostly been left unchanged (some minor updates), and the new observations are added in each chapter after the heading *March 2009*.

[1] Stefan Hofstetter is an independent consultant, e-mail address: stefan.hofstetter@ieee.org

2 Objective and motivation of the project

- Establish a pilot and demonstration project to introduce ecological sanitation (ecosan) to West Africa in general, and Mali in particular.
- Establish an appropriate low-cost sanitation system which is easy to operate.
- Reduce the pollution and health risks caused by the lack of a functioning wastewater system whilst the water supply system for the town of Koulikoro is being extended.

3 Location and conditions

Koulikoro is the capital of Mali's second region with 26,000 inhabitants and is located 60 km east of the capital Bamako, on the river Niger. The town is spread across the sandy river valley up to the neighbouring rocky plateaus.

Fig. 3: Ecosan UDD toilet in Koulikoro with shower and greywater garden in 2002 (source: GTZ, 2002).

Around the year 2000, the central water supply system in Koulikoro was extended (with support of German development cooperation organizations KfW and GTZ), but no functioning wastewater management system existed. Due to geographical and economic reasons a centralised wastewater treatment plant was not considered (e.g. rocky ground, operational costs estimated to be twice of town council's budget). Open wastewater flows thus exposed the entire

community, especially children, to health risks.

Since 1995 the German Technical Cooperation project of GTZ, funded by the German ministry BMZ, "Improvement of the municipal water and waste management" consulted the local government, unfortunately without relevant results in the wastewater sector.

The initial situation in Koulikoro can be described as follows: Only 3% of the households have water flush toilets and septic tanks, which are poorly designed and built. About 25% of the households are equipped with soak pits or so called "puisards" (collection and infiltration pits for wastewater), most of these are simply a hole in the street or a collection basin. All attempts to infiltrate wastewater into the ground turned out to be extremely difficult due to the high groundwater table in the vicinity of the river and the rocky underground.

Nearly all households have traditional pit latrines including a showering area. Faeces and water used for anal cleansing (most of the people are Muslims) go into the pit through the defecation hole ("trou"). The urine and the shower water usually flow over the latrine floor and into either the "puisard" outside the compound, the open storm water drains or directly onto the street.

Most people live in spacious compounds (300 to 400m²), and income levels are very low. The average household size is around 10 persons, however up to 25 people often share the compound and use a single sanitation facility.

Koulikoro's agriculture area is close to town. The soil is sandy and poor in nutrients (type Sahel condition) and suffers from severe erosion during the rainy season. Untreated faeces from pit latrines are traditionally used for fertilization as farmers are dependent on affordable soil improvement.

Additional observations in March 2009:
The average household size seems to be higher now than reported in 2005 - all of the visited toilets are regularly used by more than 20 persons. Four of the toilets visited are toilets within a traditional family court and all of them are located on the plateaus of Koulikoro. A large toilet building is located at the "Lycée du Seminaire Pie XII", a school in Koulikoro.

More ecosan UDD toilets were not found, and our guide, Mr. Souleymane Keita (Agent Voirie Mairie Koulikoro), did not know any more locations (perhaps the large toilet building was counted as seven units, so that the total reported number of UDDTs is 11?).

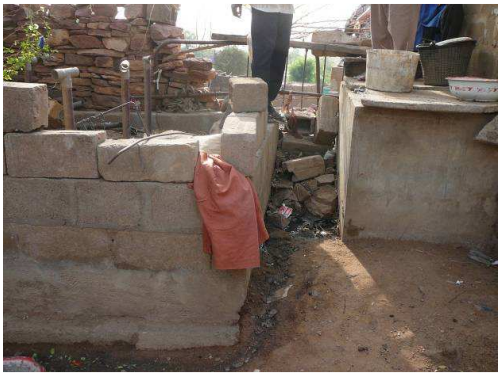

Fig. 4: The same location as Fig. 3: greywater garden on the left side with leaking water from broken pipe (source: Stefan Hofstetter, March 2009).

4 Project history

The ecosan pilot project began operation in mid 2001. But due to the very poor cooperation of the Koulikoro municipality with the Technical Cooperation measures of GTZ, the larger GTZ project (of which the ecosan pilot project was a part of) was aborted ahead of time in late 2001. This made it quite difficult to keep the ecosan pilot project running well and many operational problems occurred (described later in this document).

In the time between 2001 and 2004, field visits by members of the GTZ ecosan team to the project site were carried out on several occasions, and the project experiences were documented (mostly in internal documents). An overview of relevant reports can be found in section 13.

5 Technologies applied

After a detailed feasibility study was carried out to investigate the options for wastewater management in Koulikoro, it was found that an ecosan system with closed loop, low tech sanitation units seemed to be the most appropriate solution. Different pilot facilities, all more or less modified versions of locally used facilities, were tested. They were distinguished by:

- a separation of urine and faeces at the source using special latrine slabs / squatting toilets
- double-vault dehydration toilets for the drying, storage and hygienisation of faeces (for later use) with a controlled drainage of seepage water
- a separate collection, storage and utilization of urine
- greywater treatment using planted soil filters ("greywater gardens").

For urine treatment, two technologies were tested: Urine was separated by the latrine slab surface and either:

- led to a collection canister for storage followed by use, or
- led to a greywater garden (small on-plot plant nourished by treated greywater or experimentally by greywater mixed with urine).

For the faeces collection, under the local climatic conditions (high average temperatures, long dry season and short rainy season) and geological circumstances (high groundwater table or rocky underground) the two chamber desiccation latrine (double vault UDDT) with both faeces chambers above ground seemed to be the most simple and appropriate solution.

Fig. 5: Faeces vault of UDDT with opening to remove the dried faeces (source: GTZ, 2002).

Additional observations in March 2009:

- The technologies applied are not the reason for the failure of the pilot installations; various possible reasons for failure are listed in the following sections below.

6 Design information

Treatment of urine:
To prevent odour and loss of nitrogen any dilution of urine with water must be avoided. The profile of the latrine floor and drainage pipes leads the urine to a closed plastic collection canister. Pure urine is nearly sterile and can be used as a fertilizer (storage is recommended to reduce pathogens from cross-contamination with faeces)[2].

Fig. 6: Latrine urine-diversion squatting pan, where urine drains away to the drainage at the right (source: GTZ, 2002).

Treatment of faeces:
The two latrine chambers (toilet vaults) are used on an annual rotation basis to enable a full drying and hygienisation of their content before emptying. However this process was hampered by the considerable amount of water used for anal cleansing that drained into the latrine chamber. This problem was minimized by:

- Ensuring a drainage system in the chambers by sloping the floor and covering it with a layer of gravel. All liquids are drained directly into the bottom of an evapo-transpiration-basin filled with gravel, earth and plants with a high water consumption outside of the chamber.
- Providing the chambers with aeration pipes and south facing black iron access doors that increase the temperature in the chamber.
- Adding ash after using the latrine. This also served to minimize odour and protect against fly breeding.
- The design of the toilet floor allowed the urine and greywater from showering to be separately discharged, and not enter the faeces chamber.

Treatment of greywater:
The greywater garden is a suitable treatment solution, particular if enough space is available and for hot climates. Its design should encourage high-rate aerobic processes and the reuse of nutrients in the greywater by feeding the microorganisms living in the soil. The garden is enclosed in a walled area of approx. 8 m² and 50 cm depth. The dimensions however depend on factors such as the volume of water to be treated and the climate. It is filled with 3 layers – 1 gravel, 1 sand and 1 soil.

As the greywater is distributed in the irrigation system by perforated pipes it is essential to remove all solid particles that could clog them. It is therefore first decanted and filtered in a charcoal-gravel filter to remove solids such as fibre, sand and dust before distributing it below ground. Several aeration pipes are incorporated. The gardens have produced very good results with above ground plants such as okra, bananas, baobab, pepper and papayas. It is essential to fence in the garden to prevent damage by domestic animals and to monitor the filter regularly to prevent overflowing.

Additional observations in March 2009:

- In family courts many persons (often more than 20) use the toilet, and the temptation to use both toilets conjointly is very high. A lot of comprehension and discipline would be necessary to prevent this. The design of the two toilets should be altered in such a way, that only one toilet (with two holes, one covered, and one operational) exists.

Fig. 7: A former greywater garden, which was once planted with lots of banana plants (source: Stefan Hofstetter, March 2009).

7 Type and level of reuse

The hygienic and fertilizing qualities of all wastewater fractions were scientifically researched in co-operation with the local university. Although the agricultural field trials have only been carried out for a period of two years (conclusive results can only been drawn after a minimum of three years) positive tendencies have been noted.

- Faeces are hygienised after one year of natural drying in the latrine collection chamber, which is supported by the adding of ash by the users. After that period it is collected

[2] Note in 2009: See also relevant WHO Reuse Guidelines from 2006: http://www.who.int/water_sanitationhealth/wastewater/gsuww/en/index.html

manually by the users without any health risk and utilized for agricultural soil improvement.
- The separated urine is used as liquid fertilizer in agriculture. Experimentation has also been carried out to air dry urine, for example by spreading it over a large solid surface in the sun, to obtain a crystalline form of fertilizer (these experiments were however not successful).
- Alternatively urine has been used to humidify and enhance compost produced from organic waste. The best fertilising results (equivalent to that of mineral fertilizers) were achieved by a mixture of compost, dried faeces and urine.
- Greywater treated by a gravel filter is collected and used for irrigation or infiltration.

Additional observations in March 2009:
- In a municipal environment such as Koulikoro reuse of dried faeces and collected urine can only function if a recipient (at best a paying consumer) exists. The university nearby (IPR/IFRA Institut Polytechnique Rural de Formation et de Recherche Appliquée) stopped reusing dried faeces and collected urine a long time ago.

8 Further project components

Further components of the project included solid waste management, additional research on social and economic issues and up-scaling activities.

9 Costs and economics

The investment for the double-vault toilets was approx. EUR 270 to EUR 414 in the year 2001 - about double that of a conventional pit latrine (according to figures of the Koulikoro administration and depending on conditions such as ground and materials used).

Evacuation can be performed easily by the users themselves (traditionally a worker has to be paid every 3 years to empty the pit and to transport and discharge the faecal sludge). The recovered resources are valuable and hygienically safe fertilizers and irrigation water which promote additional food production for the household (e.g. estimated to be worth approx. EUR 25 per year based on Sorgho).

Estimates in 2001 calculated that the additional investment costs for a farming family of an ecosan UDDT in a simple layout is equal to the positive financial effects in the long run. Families without immediate agricultural advantages bear however additional costs.

An area-wide ecosan system (for the entire city of Koulikoro) was estimated to require approx. 10% of the investment and operational costs of a centralized conventional solution.

Additional observations in March 2009:
- This ecosan pilot project was part of a larger water and sanitation program carryout out by GTZ-Mali. It has thus not been possible to determine the exact costs of the ecosan pilot project separately from the larger GTZ project.
- Today owners of UDD toilets do not invest any money into maintenance of their toilet units, and no help seems to be available from the municipality.

10 Operation and maintenance

The system requires careful management following certain utilisation rules. If these rules are followed, then operational maintenance can be done by the users themselves. It covers:
- Collection and use of the urine.
- Emptying of the desiccation (drying) chamber and use of the dried faeces.
- Maintaining the filter, decanter and greywater garden, and removing solids and foreign material.
- Maintaining and harvesting the plants.
- Monitoring and controlling if necessary the volume of water in the greywater garden.
- General cleaning

Additional observations in March 2009:
- Maintenance and repair seems to have been neglected since a long time. Collection of separated urine is no longer operational either: The urine collection seems to have been out of operation for a long time for all UDD toilet units.
- The drying of the faeces is still working properly only for one UDD toilet. This is also the only unit where a single toilet is used during a one year period, and the annual rotation seems to work. All other three visited court toilets are conjointly used (both vaults are used at the same time) - proper drying of faeces is therefore no longer possible.
- Two of the visited court toilets have altered the desiccation chambers into regular pits - to be emptied by pump - those toilets cannot be called UDD toilets any longer.
- If the large toilet building at the “Lycée du Seminaire Pie XII” ever had desiccation chambers is not clear, - today this toilet building is a toilet building with pits to collect the faeces, and to be later pumped empty if they are full.
- Only one greywater garden is still operational; however the pipe into the greywater basin is broken and water leaks into the ground. Wherever else greywater still gets separated and collected in own pits, it is either directly poured onto the street to drain away, or pumped to be used in gardens.

Fig. 8: Former desiccation (drying) chambers of UDDTs have been converted into pits to collect faeces and to be pumped empty when full (source: Stefan Hofstetter, March 2009).

Fig. 9: Rusted iron covers of faeces chambers are falling apart, - no more drying of faeces is therefore possible (source: Stefan Hofstetter, March 2009).

11 Practical experience and lessons learnt

The combination of sanitation and reuse of human waste in agriculture/gardening is a promising approach for both agriculture and sanitation. Decentralized closed loop systems have two main requirements:

- high interest in recovering fertilizers and food production
- high degree of awareness and motivation, a consistent external support by experienced manpower and some initial financial support are needed.

The subject was intensively discussed with all stakeholders and the installations were developed in close cooperation with the future users and all concerned parties. Still, the above mentioned requirements were underestimated or insufficiently considered in Koulikoro. This led to a steady deterioration of most of the project facilities over the years[3].

The reasons that contributed to the failure of the facilities over a longer period are as follows:

- **Lack of interest/demand:**
  With the field visits in 2002 - 2004 it became obvious that Koulikoro was the wrong village as there was very little interest among the people. Another village was very interested, but for administrative reasons the money was fixed for this place. This was shown by a very low user commitment and a lack of awareness for the need of maintenance: Most users did not understand the importance of fencing off the greywater garden to protect it against animals. A fence was often neglected or it was not durable. The plants degenerated, the greywater was not used and there were overflows or by-passes. Similarly, decanters, filters and vertical pipes were improperly built, lacked maintenance and finally clogged. Such pilot projects should only be carried out at locations where authorities and users are interested.

- **Municipality cooperation:**
  The cooperation of the Koulikoro municipality was very low throughout the entire project and the fluctuation within its authorities was very high. This has caused the Technical Cooperation measures to be aborted ahead of time end of 2001 (the low cooperation was not specific to the ecosan pilot project but applied to the larger GTZ water and sanitation program as a whole)

- **Project scale**:
  The project scale was too small so that there was not enough urine for usage, even though the nearby agricultural university was very interested. The scale was also too small to create a small operating company because due to the lack of an existing infrastructure the collection and transport of the liquid urine was economically not viable. Pilot projects should be of a size where at least a one-person company can take care of the operation and organize the reuse. A possible scale-up should be foreseen.

- **Operating scheme:**
  An operating scheme must be found and implemented aiming at emptying, collecting and reusing the recyclates for those users who do not have the possibility to reuse them. In this project, operating schemes were investigated and discussed with the stakeholders but they were not realised due to the low number of installations.

- **Planning:**
  An alternative decentralised sanitation concept which has to integrate into existing structures and practises, requires a sensitive planning and individual adaptations to every particular context. The toilet and greywater systems were kind of forced on to the project long before the participatory discussion was developed. And this project showed that the households were not going to make it alone without long-term support.

- **Design:**
  For Koulikoro, a drying pan for urine was designed that did not work because in particular women used lots of water to wash after urinating. The separate collection of this washwater into the washwater drain was however not included in the user instructions.

In the technical regard the following observations are pointed out:

- The drying of faeces and their use is possible in Muslim countries. The issue of anal cleansing water can be solved through an appropriate construction, such as a 3-hole squatting pan, where anal washwater is collected separated and treated in a soil filter.
- The greywater garden system is a possible solution for families with a sufficiently large compound. The immediate improvement of the household´s nutritional situation was appreciated by the families in Koulikoro (although not enough so that they would invest the required time for proper maintenance).
- Urine fertilization is very productive, but was only applicable if agricultural areas are nearby, as the transport of rather high amounts of liquid on bad roads with donkey carts proved difficult. A volume reduction of collected urine would be desirable to ease handling and storage (but suitable systems, such as solar urine desiccation, have not yet been found, mostly due to odour problems).
- The use of urine for composting (household waste or agriculture residues) is a good approach in arid regions and is a promising alternative to the direct use of liquid urine. However composting in the Sahel region can be

[3] Section 11 was entirely updated in 2009, compared to the earlier version (GTZ project datasheet) of 2005.

difficult due to the dry climate and the low availability of compostable organic waste, which is instead consumed by livestock.

Additional observations in March 2009:

- Technically the approach is still valid and good. Conjoint use of both toilets should be technically inhibited to guarantee annual rotation of drying chambers.
- Ongoing support of a sanitation system is crucial for making it sustainable. Much more emphasis shall be laid on the social, cultural and educational aspects.
- The families have either not fully understood the principle of the system or they could not maintain it by themselves (e.g. cleaning or replacement of the gravel filter, repair of the greywater garden fence). People did not appreciate the value and benefit of the collected urine, as food production was not important to them.
- All plastic tubes (for air ventilation, as well as for the drainage of urine) should be protected against sunlight (e.g. covered by earth or wrapped in bonding foil), otherwise they will break very fast. Iron coverings must be regularly coated, otherwise they will corrode.
- The IPR/IFRA University at Katabougou (at 30 minutes walking distance from Koulikoro-Est) would be an ideal place to start with new ecosan UDD toilets again. This university educates about 700 students to become agronomists and foresters, and many young, educated individuals from various African countries could learn more about sustainable sanitation. Afterwards they could use their acquired knowledge and help to promote the knowledge about sustainable sanitation in Africa. Furthermore with 700 persons there would be enough fertilizer material to do long-term field trials, deliver valid scientific results and perhaps discover new things.
- More French documentation on the subject should be made available (although CREPA is already doing so in West Africa).
- At present, only one family still uses and operates a UDDT (drying faeces only, see Fig. 3 and 4). This family does not have to pay for emptying the pit, and manually empties the drying chambers themselves. The “chef de famille” Yussuf Traoré describes his ecosan UDD toilet as ingenious, he would miss it, and he wishes the project to be continued, or rather to be restarted again.
- To (re)build a longer lasting pilot installation it is crucial to have an organisation in place to support the users, to help doing maintenance, to educate, and to collect the urine and the dried faeces. Ideally the collecting organisation pays the users (even a small amount is enough for poor people to get them better involved) for correctly dried faeces and properly collected urine.

Fig. 10: Former urine collection of the toilet building at the school "Lycée du Séminaire Pie XII" (source: Stefan Hofstetter, March 2009).

12 Sustainability assessment and long-term impacts

March 2009:
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).

This project has **not been sustainable**, mainly because institutional and financial sustainability criteria were severely neglected, for the reasons described above.

Table 1: 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.

Sustainability criteria for sanitation (cont.):

Financial and economic issues include the capacity of households and communities to cover the costs for sanitation as well as the benefit, e.g. from fertilizer 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 the SuSanA Vision document "Towards more sustainable solutions" (www.susana.org).

With respect to long-term impacts of this project:

- There are no immediate impacts for Koulikoro as a whole, except for some individuals that may have had a benefit for a limited time from having a UDDT available.
- On the other hand, the Koulikoro UDD toilets pre-date any other attempt at ecosan in West Africa. So it served as a regional model which introduced the idea to quite a few people and thus served to lay the groundwork for what came next - without which arguably there would have been much less ecosan in West Africa. So from an awareness raising point of view it was quite successful[4].

13 Available documents and references

- Kraus, S. (2004) Basisstudien zum kreislauforientierten Abfall- und Abwassermanagement in Mali. Presentation of an intern's experiences at the GTZ "Programme d'Appui aux Collectivités Territoriales (PACT)", November 2003 – March 2004 (in German). http://www.susana.org/images/documents/06-case-studies/external-documents/kraus-2004-baseline-study-on-wastewater-management-mali.pdf
- Bark, K. and Oldenburg, M. (2003) Ecosan Modules – Adapted Solutions for a Medium Sized City in Mali. In: 2nd International Symposium on ecological sanitation, Session G (Feasibility Studies). Lübeck, http://www2.gtz.de/Dokumente/oe44/ecosan/en-feasibility-studies-papers-presented-at-ecosan-symposium-2003.pdf
- Otterwasser GmbH (2003) Projekt-Kurzbericht Ecosan in Mali, German and French versions, http://www2.gtz.de/Dokumente/oe44/ecosan/de-kurzbericht-ecosan-projekt-2003.pdf (in German), http://www2.gtz.de/Dokumente/oe44/ecosan/fr-rapport-de-projet-ecosan-2003.pdf (in French)
- Lohmann, T. (2003) Evaluation of ecological sanitation pilot facilities in Senegal and Mali. Project work at Technical University of Hamburg-Harburg, http://www.susana.org/images/documents/06-case-studies/external-documents/lohmann-2003-tuhh-evaluation-of-ecological-sanitation-pilot-facilities-senegal-mali.pdf

More photos from March 2009 are available here: http://www.flickr.com/photos/gtzecosan/sets/72157618823828820/

[4] Observation by Patrick Bracken, currently independent consultant in Niger (pocb123@yahoo.com).

14 Institutions, organisations and contact persons

Planning:
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Execution (local NGO):
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Case study of SuSanA projects

Peri-urban urine diversion dehydration toilets (abandoned)

SuSanA 2009

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Appendix :

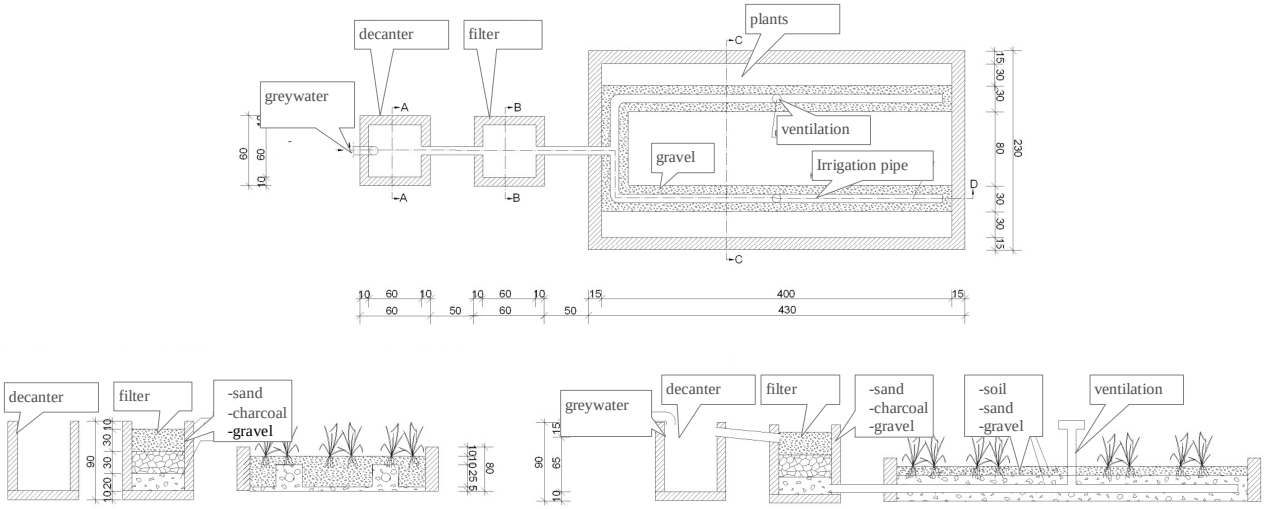

Fig. 11: Plan view and cross sections of the greywater garden (source: OtterWasser, 2003)