sustainable sanitation alliance


# Compilation of 24 SuSanA case studies

## Pre-Print for the 10th SuSanA meeting






Last updated: 10 August 2009

Cover photos:

Left column:

1 Philippines, 2007 (P. Feiereisen)
2 Mali, 2009 (S. Hofstetter)
3 Tanzania, 2009 (D. Schäfer)

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4 Kenya, 2009 (S. Blume)
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# Preface

The SuSanA publishes case studies of sustainable sanitation projects to demonstrate the wide range of possible systems for sustainable sanitation systems. The case study collection comprises project examples from developing and industrialised countries, high and low tech systems, urban and rural locations, pilot and large scale applications and different cultural settings. These case studies are useful for decision makers, planners, engineers and the interested public.

The SuSanA collects descriptions of success stories as well as of "failed projects" so that we can learn from our own and other people's mistakes.

For the collection of case studies we depend on your support and we therefore kindly invite you to contribute to this collection by making use of the case study template which is on the SuSanA website (http://www.susana.org/lang-en/case-studies).

All currently existing case studies are compiled together in this one document and there are five tables of contents for the following five categories:

1. Region
2. Technology
3. Setting (rural or urban)
4. Reuse type
5. School sanitation system

We thank all the authors of these case studies for their contributions. If you spot any errors or omissions please e-mail us on info@susana.org. We look forward to receiving your feedback and comments.

This document should be seen as a starting point for further discussions and further work. It is important that aspects and technologies in the context of sustainable sanitation which are not yet covered in these existing case studies, are described in future case studies (for example CLTS, small-bore sewer systems, hygiene education programmes, sanitation marketing and financing, public toilet schemes etc.). Therefore, we look forward to hearing from you and receiving new case studies to add to this collection.

Dr. Elisabeth von Münch
and the GTZ-ecosan team
(on behalf of the SuSanA secretariat)

Eschborn, 10 August 2009

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**Table 5: School sanitation systems** page

Case study of sustainable sanitation projects

# Community–led Water and Ecosan Programme Shaanxi Province, China

**Figure 1:** Project location

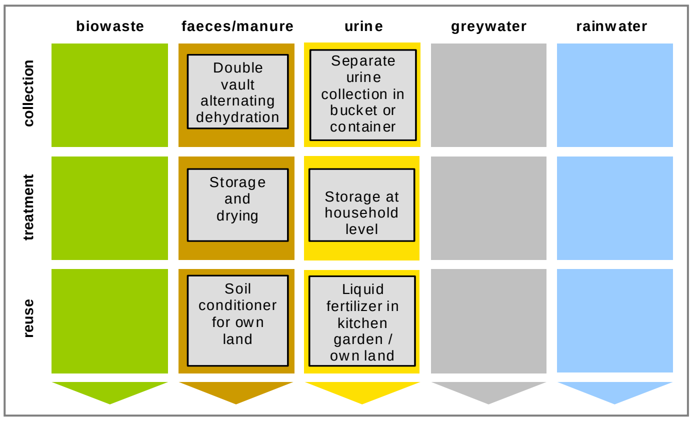



**Figure 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

Large-scale community-led water and environmental sanitation improvement in rural area.

**Project period:**

Start of planning: Jan. 2005

Start of construction: July 2005

Start of operation: Jan. 2006

End of Project: June 2009

**Project scale:**

196,000 beneficiaries up to June 2007 (mid term of the project) based on base line survey for WES program of Plan China.

Total investment: € 1.8 million up to June 2007

**Address of project location:**

Villages in Pucheng, Chunhua, Xixiang, Chenggu, Jia Xian and Yulin Counties of Shaanxi province, China

**Planning institution:**

Plan China

**Executing institution:**

Respective Village Development Committees facilitated by Plan China Program Units

**Supporting agency:**

Government Township Project Offices

## 2 Objectives and motivation of the project

- Deliver sustainable health and hygiene benefits to the children and their families through improvement in water supply and environmental sanitation.
- Promote eco-sanitation methods to reduce water consumption and recycle nutrients and organics.
- Improve household income through time savings and income earning opportunities particularly for women.
- Support processes that can nurture self-empowerment of individuals or groups. The ultimate aim is the empowerment of the community, giving it the decision-making power and access to resources.
- Promotion of ecological sanitation option integrated with health and hygiene education.

## 3 Location and conditions

Despite China's remarkable growth and development, significant pockets of poverty remain in many regions. The development of poor communities is constrained by lack of access to services, unsustainable use of natural resources and unhygienic environmental conditions (e.g. fixed point open defecation, no garbage disposal, unmanaged domestic wastewater disposal, low water quality, mosquitoes breeding, unplanned disposal of animal excreta).

Rural and western China is particularly affected by this inequality. In rural China, only 68% of the population has access to safe drinking water and 29% to adequate sanitation (UNDP data from 2006; although JMP figures are higher). The absence of safe water supply systems and adequate sanitation is one of the most important problems for people in western China.

In the project area, in Shaanxi Province (in the North-West of China), lack of safe water supply and basic sanitation is closely associated with livelihood and other social issues. Poor economic conditions and lack of participation has hampered the initiation of developmental work. Due to a “top down approach” for community development projects, there is little or no participation from the community.

Annual income per capita is in the range of € 100-150. Farming and fruit orchards are the primary source of income in the programme area. Human excreta are used as fertilizer for crops and vegetables. This is an old practice in China. In many houses toilets are made in such a way that the excreta of all members of the family are collected in buckets, which are taken to the fields periodically and are diluted with water and applied raw on the crops. When one bucket is filled up another one is placed in its place. Furthermore, water is not used for anal cleaning as the habit is wiping. The availability of water resources per capita in Shaanxi province is only half of the country’s average. Droughts and low rainfall level, 400 – 600 mm per year, are faced by all rural communities in Shaanxi.

Shaanxi province is among the most under-developed regions in China and a survey conducted by Plan China in 2004 highlights this disparity. 25% of children under three years old suffer regularly from diarrhoea, due to poor access to water supply and sanitation (based on a single survey done by Plan China - a final survey will be conducted after completion of the entire project in 2009 to assess the changes due to project implementation).

A second Plan China baseline survey reveals that only 2% of families have access to potable water and 8% of families dispose excreta in a sanitary manner.

Communities in the programme area are affected by a very high incidence of water borne diseases, particularly diarrhoea and viral hepatitis. After conducting initial health and hygiene awareness raising activities in Shaanxi province and through participatory planning and discussion sessions with the target communities, the inhabitants identified three main needs:

1. The lack of safe drinking water forces families to use contaminated water sources that expose them to a range of water borne pathogens. These water sources are often located far from homes leaving women and children with the duty of collecting water.

2. The lack of access to basic sanitation increases the contamination of local water sources, degrades the local environment and promotes the spread of disease.

3. The lack of knowledge about the relationship between hygiene, water quality and good health increases the vulnerability of families, especially young children, to water-borne diseases.

The project area is most suitable for the promotion of ecological sanitation (in the form of urine-diversion dehydration toilets) based on the following:

- This sanitation practice is not new in China. Chinese people have a long history of using this type of sanitation in which urine is diverted from faeces.
- The same is true for the reuse concept. Since ancient times, Chinese are using human excreta as fertilizer in agriculture, thus the attitude is positive.
- Cleaning habit in China is wiping thus facilitating the dry separation of urine and faeces.
- The shortage of water calls for a solution which does not require water for flushing.

The project has targeted children, their families and the community. The target area covers 247 communities in the counties of Chunhua, Xixiang, Chenggu, Pucheng, Jia Xian and Yulin of Shaanxi province in North-West China.

## 4 Project history

The WES (Water and Environment Sanitation) programme of Plan China started in 2005 to cover 500 communities and 200 schools in Shaanxi province with a grant from Plan Netherland and supported with a matching amount from child sponsorship which is collected by Plan worldwide. Prior to this, the WES programme was implemented with sponsorship money and the project interventions were limited. The WES programme integrates the water supply, sanitation with hygiene promotion and education with further linkage to health and livelihood.

The first urine diverting toilets of the project were piloted and demonstrated in Sanyong village in Pucheng County during May/June 2005 and later it was piloted in other programme counties. After the successful pilot of urine diverting toilets in all counties, the construction of these systems in larger numbers began in July 2005. The number of toilets constructed in 2006 was impressive, confirming that the community accepted this new technology in large numbers.

The main reasons of the acceptance of this technology by the community are:

- The effective promotion by Plan programme units,
- Low price in comparison to other toilets (eg. biogas, flush latrines and twin pit series latrines),
- Simplicity of usage and maintenance and
- The individual household subsidy provided by Plan China.

The respective government departments (Water Bureau, Health Bureau, Poverty Alleviation and Township Offices) also accepted the fact that this type of toilets can be promoted on a large scale in rural areas since they are hygienic and present a compelling alternative for use by rural households. Subsequently ecosan UDD toilets have been included as the standard type of systems promoted by the Chinese government for on-site treatment, disposal or reuse of human excreta. These standard types are:

- Three compartment latrines
- Twin pit series latrines
- Biogas toilets
- Urine diversion dehydration toilets (UDDTs)
- Elevated dry compost latrine

In this respect the work done by Jiu San Society, a leading social organization, for promoting ecosan in China and also for advocating at national level is laudable. Ecological sanitation is high on the agenda of the Jiu San Society national action plan.

## 5 Technologies applied

Three types of latrines have been presented to the community to choose from in the programme area:

a) Urine diverting dehydration toilets

b) Biogas toilets

c) Twin pit series latrines (double urn toilets)

The communities were informed about the benefits and cost of all three types of latrines as well as the financial support available from Plan China.

**a) Urine diverting dehydration toilets (UDDTs).** The major difference between urine diverting toilets and other sanitation systems is that the toilet has two outlets and two collection systems. One is used for urine and one for the faeces, in order to keep these excreta fractions separate (Figure 3). There is a cover for the faeces compartments to protect the latrine from flies and other insects as well as to reduce potential bad odour. The latrine used in the programme area is based on the Vietnamese double vault latrines to enhance the dehydration of faeces and allow the use of urine as fertilizer.

The urine collection pipe is normally a plastic pliable pipe with the diameter of 40 mm. It connects the urine hole in the front of the squatting pan and the urine storage tank. The length of pipe should have sufficient reserve to facilitate the chamber change by turning the squatting slab by 180°. In colder climates, however, the pipe should not be too long to avoid freezing and blockage. The urine storage tank can be bought locally, and comes in various forms, such as barrel, bucket, kettle etc. with lids.

**Figure 3:** Household urine diverting dehydration toilet in Shaanxi Province (source: Plan China)

The faeces vault is normally built above ground. A faeces vault with a volume of 0.30 m³ can meet the requirement of a family of 5 to achieve a storage time of one year. There are normally two vaults to be used alternatively. The dimensions of the opening for emptying are about 25 cm × 25 cm. It can be sealed with a wooden board, metal board or bricks because the emptying takes place only once per year. The best way to seal the opening is with a black metal board which can effectively absorb solar energy to dry the waste faster (if the toilet is exposed to the sun).

When the first vault is full, the squatting pan is turned 180° and the other vault comes into use. The full vault is sealed for a minimum of 6-8 months for drying and hygienisation. The retention time and the elevated pH level results in die-off of pathogens and allows safe handling for use as fertilizer.

When the second vault is full, the first vault is emptied from the opening provided in the structure, and it then comes into use. The operation and maintenance is explained in Section 10.

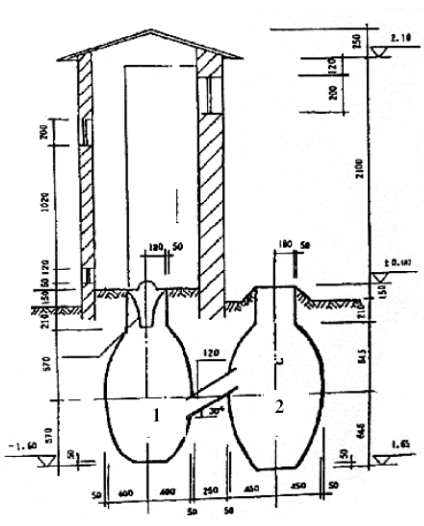
**b) Biogas toilet.** This kind of toilet consists of a squatting pan, faeces inlet, faeces pipe, biogas reactor (including fermentation chamber and biogas tank) and faeces storage chamber. In order to avoid the escape of biogas, sealing of the innner layer of the fermentation chamber should be done carefully. A squatting pan is normally installed, needing 2.5 to 3 litres for flushing the faeces by pouring water from a bucket.

Under the toilet the faeces pipe is connected. The faeces pipe can be bifurcated to have another inlet which is used for adding animal excreta based on the users' demand and availability of livestock.

c) **Double pit series latrine (double urn toilet).** This toilet has two urns built underground, which are constructed of brick or pottery. There is a concrete squatting slab with an inlet hole for the excreta and with foot rests and a super-structure for privacy and protection from the weather (Figure 4). The squatting pan is fitted on top of the pit without water seal and little water is required for flushing.

The two urn storage tanks are named according to their shape. The front urn is smaller and is normally constructed under the ground. It is mainly used to receive and store faeces. The retention time is generally over 40 days. The excreta can be completely digested to eliminate pathogens such as bacteria and parasite eggs (40 days retention period in first urn and after that carried to second urn through connection pipe to further eliminate the pathogens).

After the digestion in the front urn, effluent of this urn flows into the rear urn via a connection pipe. The rear urn is mainly used for storage of the effluent. A concrete slab is used to cover the outlet of the rear urn which prevents odour from escaping and rainwater from flowing into the urn.



1. Front Urn; 2. Rear Urn

**Figure 4:** Side view of a double urn toilet (source: Plan China)

65% of the constructed systems in the project area up to June 2008 are urine diverting dehydration toilets (UDDTs), as can be seen in Table 1. The promotion of UDDTs is quite successful in the Plan China programme area particularly in the central plain and south. There is still an operational problem in the North where harsh winter conditions cause frequent freezing of urine pipes.

**Table 1**: Number of toilets constructed in Shaanxi Provence under the Plan China WES programme

| Period | UDDTs | Biogas | Double urn |
|---|---|---|---|
| July 2005-June 2006 | 8,457 | 1,214 | 1,650 |
| July 2006-June 2007 | 6,410 | 1,369 | 3,072 |
| July 2007-June 2008 | 3,189 | 1,020 | 1,500 |
| Total | 18,056 | 3,603 | 6,222 |

## 6 Design information

The design information in this section is only for the UDDTs since they are the most used option in the programme area. Expected average quantity (from Swedish literature) of faeces and urine per adult is:

- 400 - 500 litres urine per year i.e. 1.10 -1.36 litres per day.
- 50 kg wet faeces per year

Whilst these figures were derived for Swedish diets, they seem to also work for the Chinese UDD toilets built with these design parameters.

In the UDD toilets promoted in the Plan China programme area, the urine is collected in a separate container which is often placed under the stairs for safety and efficient space utilization. The construction of these types of toilets is quite simple and there is no risk of leaking from the vault - hence, water proofing of the vaults is not required. The flood risk in the Plan China program area is minimal. However in flood prone areas, water proofing is must.

The toilet can be constructed entirely above ground. Due to separation of urine and no flush water, the volume of potentially hazardous materials becomes smaller and the toilet requires less space for construction.

- For a household of 5 persons the unit should consist of two processing chambers, each of a volume of 0.25 $m^3$ (50 kg per person per year x 5 (No. of adults) x 1 year = 250 kg ≈ 0.25 $m^3$).
- The entire construction is above ground and the vaults are placed on a solid floor. The size of a vault may be 0.9 m x 0.7 m x 0.4 m (depth) = 0.25 $m^3$. 0.2 m of free space is provided, i.e. total depth = 0.4 + 0.2 = 0.6 m. Thus, final vault size is 0.9 m x 0.7 m x 0.6 m. For a smaller household the size may be reduced.
- Two openings of size 0.25 m x 0.25 m are provided in each vault for the removal of dried faeces.
- One vent pipe (diameter 10 or 15 cm) extents from the vault to above the roof for ventilation and is equipped with lids to stop rain water. Vent pipes should be as straight as possible as bends reduce air flow, and should be minimum 50 cm above the roof. If necessary the vent pipe can be fitted with a small electric fan (price: € 3).

**Setting/location of UDDTs:**

- Location of a UDDT can be done in several different ways depending on the availability of space, its location inside or outside the house, convenient position/space for openings for the removal of dehydrated material and urine collection (the location is selected in consultation with the households).
- The vent pipe should be provided in the middle. Where it is not possible to provide a pipe in the middle then two vent pipes, one in each vault, should be provided at the edges especially in warmer/humid areas. Generally in the toilets constructed inside the house, it is not possible to provide vent pipes in the middle as this would encroache on leg space. If the vent pipe is provided in the middle without bend then due to optimal size of surface area of squatting it will cause inconvenience in squatting and getting up.
- Where the plinth level of the house (in dry areas) is substantially higher than ground level (around 1-1.5 m higher than ground level), and the location selected for the latrine has access to an external wall in which an opening for collecting dehydrated material can be provided, the UDDT can be constructed partially/fully underground (the vault opening would be above ground from the outside and can be emptied easily). In this case the urine container can also be placed outside the house. This arrangement will save space needed for stairs but extra precaution should be made to avoid dampness. Excessive dampness will negatively affect the dehydration of faeces.
- The steps of the stairs can be 200 mm or 150 mm. For children and elderlies the steps should be ideally 150 mm. Number of steps should not be more than 3 in case of 200 mm and 4 in case of 150 mm thus limiting the depth to 0.60 m. Higher depths require more space for stairs and are not safe for children and elderly.
- The stairs can be constructed in the middle or in the sides depending on the availability of space. Stairs should be by the side of toilet if it is constructed together with the bathroom otherwise it will obstruct the bathroom use.
- In extremely cold conditions, insulate the urine pipe so that it will not freeze. Urine pipes should be attached to the container in such a way that all urine passes to the container and that it is free of any residues (stagnant urine) after use (Figure 5). This will help the urine pipe not to freeze in extremely cold conditions.

**Figure 5:** Open hatch shows access to the urine pipe and urine storage tank of the UDD squatting toilet (source: Plan China)

- For toilets constructed outside the house, again there can be a number of different ways to place the opening for taking out the dehydrated faeces. It can be placed on the rear wall, on any side walls or even in the front. The most optimal setting of an outside toilet is to provide openings in the rear wall and stairs in the front (middle of the vault). The other option is to provide openings in the sides and stairs in front of one vault.
- The thickness of the vault partition wall should not be more than 60 mm. Since it is a non-load bearing wall and the squatting slab rests on the peripheral wall (120 mm thick) the thickness can be reduced further by using other materials like thick dark hard glass, stone slate slab and wood with aluminium wrap. If the thickness of the partition wall exceeds 100 mm there is a chance that faeces will stick to it.
- For lighting and ventilation adequate openings in the walls of an outside toilet should be provided.

## 7 Type of reuse

Since ancient times human excreta has been used in China for crop fertilization. However, the safety aspects have often been overlooked and mostly fresh excreta have been taken to the fields while neglecting the health risks.

By promotion of ecosan systems the hygienic concerns are being addressed, and excreta can be safely utilised for crop fertilization. Note that if households open the faeces vault prematurely (less than one year) and use the dried faeces for fertiliser too early, this is not a safe practice.

The dried faeces are removed from the vault once or twice a year depending upon the filling rate. They are applied to the field before plantation or sometimes in between two planting periods. However the amount produced from one household is relatively small compared to the fertilizer need of the household, as they produce crop not only for their own consumption but also for sale. The average fertilizer need for these households of five members is 150 kg per year and the use of composted faeces and urine from UDDT fulfills around 15% of total need of the family.

Urine is applied by the households once or twice a week mostly to nearby fields. Often it is applied with a dilution of 1:2 with water but sometimes also raw followed by watering.

The toilet users are generally small farmers owning on average an area of 0.2 - 0.33 ha. Most of the farmers have some land near their household used mostly for vegetable farming and some fruit orchards (apples, dates, pears, plum, apricot etc.). The land further away from the house is generally used for grain farming such as rice, wheat and maize.

## 8 Further project components

This programme aims for comprehensive development in the field of water and sanitation in the respective communities. The sanitation programme is integrated with hygiene promotion and education activities in the communities to raise the residents' awareness about the linkage between health, sanitation and livelihood. The project focuses on behaviour change through communication. The approach of this program is "software precedes hardware", "demand based, child centred development and gender awareness", and "sanitation precedes water supply and other infrastructure".

"Sanitation precedes water supply" was the main approach with full participation from community. The sanitation intervention starts from the planning phase itself and continues in post implementation as well. The water supply component was taken up only after the overall improvement in sanitation and acts as an incentive to the community. The other project components include water supply, solid waste management, greywater management, rainwater harvesting and water source protection.

Mid-term evaluation of the programme was carried out in September 2007. The evaluation showed the improved usage of toilets (data on health improvements is planned to be collected in 2009). However it has been recommended to extend post implementation support for minimum one year to ensure the sustainability of system. The project is regularly monitored at three levels - community, programme units and country office(s). The country offices are planning to conduct research on community participation, use of urine and faeces in agriculture and the programme's impacts on community and children health in coming years.

Similar programmes are being implemented outside of Shaanxi province and also in other counties in Shaanxi in association with government departments on the initiative of Plan China.

Urine separating systems have also been introduced at schools in Plan China program area of Shaanxi province (Chunhua, Puchenmg and Xixiang county) and the initial results are encouraging (the demo toilets are being used by children and teachers). In the future more schools will be covered under this programme for constructing urine diverting toilets - in consultation with school authorities and the education bureau of the province.

Plan China is lending support to other organizations such as local NGOs, Water Bureau, Poverty Alleviation Office and Health Bureau for promotion of UDD toilets in their respective areas (reuse is the old Chinese tradition so this type of toilet promotes safe use)

Specific activities for childern should be planned in the preparation phase. Women should be encouraged to participate in regular meetings of VDC (Village Development Committees) as well as in community-wide meetings. Some activities should be planned for more active women involvement to improve overall health and hygiene of a family. Consult women for site selection of household latrine and water tap connection: For long-term and consistent use of sanitation facilities by the entire household, female members of the houses should actively participate from planning to implementation and operation and maintenance.

Post implementation support is required for permanent behaviour change, consistent use of toilets and safe use of faeces as fertilizer.

## 9 Costs and economics

The standard urine diverting toilet (complete in all respects) in the project in 2007 costs 750 RMB (€ 80). However, due to the use of local materials for superstructure, such as the use of thick plastics or asbestos sheet for roofing, the cost has come down to 500 RMB (€ 54). In cases where it has been constructed inside the house, the cost of the superstructure was saved and normally it costs 300 RMB (€ 32). Table 2 shows the cost breakdown of a standard UDDT.

The rates of materials in Table 2 are for bulk procurement by the community inclusive of transportation. The rates would be higher if procurement of material would be done individually due to higher transportation and retail cost.

Plan China has a policy of individual household subsidy for the UDDTs (50% subsidy per toilet in 2006, down to 44% in 2008). However gradually this subsidy is being reduced and will be phased out in the next 2-3 years. In the future the focus will shift more towards intensive software with complete discontinuation of hardware subsidy.

**Table 2**: Cost breakdown of a standard UDDT (outside, with superstructure including labour) in Plan China project area in 2007 (1 RMB = 0.107 € in Aug. 2008). For comparison: Double urn toilet costs 1000 RMB and the cost of biogas toilet was 2500 RMB.

| Item | Quantity | Costs in RMB | Costs in EUR |
|---|---|---|---|
| Urine diverting squatting plastic pan (produced by Jiu San Society) | 1 unit | 61 | 6.5 |
| Concrete squatting slab | 1 unit | 29 | 3.1 |
| 110 mm PVC ventilation pipe | 6 m | 24 | 2.6 |
| PVC bend 110 mm plus adhesive | 1 unit | 3 | 0.3 |
| Cement | 3 bags | 33 | 3.5 |
| Sand | 1 $m^3$ | 35 | 3.7 |
| Glazed tiles (20 x 0.3 x 0.3 =1.8 $m^2$) | 1.8 $m^2$ | 36 | 3.9 |
| 40 mm plastic urine pipe | 1.2 m | 3 | 0.3 |
| Urine container | 2 unit | 5 | 0.5 |
| Ash Container | 1 unit | 4 | 0.4 |
| Toilet paper basket | 1 unit | 2 | 0.2 |
| Spade for ash | 1 unit | 5 | 0.5 |
| Mason (1 for 3 days) | 3 | 120 | 12.8 |
| Labour (2 x 3 days) | 6 | 168 | 18.0 |
| Bricks | 700 pieces | 112 | 12.0 |
| Galvanized corrugated iron (GCI) sheet for roof | 3 pieces | 24 | 2.6 |
| Wooden beam to support roof | 1 unit | 6 | 0.6 |
| Door | 1 unit | 60 | 6.4 |
| Ventilation | 1 unit | 20 | 2.1 |
| **Total** | | **750** | **80** |

## 10 Operation and maintenance

The operation and maintenance of urine diverting dehydration toilets (UDDTs) is very simple. The most important do's for UDDTs are:

- Before the first use, cover the vault floor with a 3 cm thick layer of dry powdered earth to absorb moisture from the faeces and to prevent faeces from sticking to the floor.
- Always keep two containers on the latrine platform, one full with ash and a shovel or a small bowl, and the other for storing used toilet paper after anal cleaning with a small stick to compress it in the container (toilet paper may retard the drying process of the faeces by covering them).
- After each use (for defecation), sprinkle two bowls or shovels of ash over the faeces and return the cover attached to the pan. The ash absorbs moisture, controls bad smell, prevents fly breeding and makes faeces less unsightly to the next user.
- Paper used for anal cleaning stored in a container should be burnt regularly outside the house.
- Keep a brush or small piece of cloth for cleaning the pan at regular intervals.
- Wash hands with soap after defecation, handling urine container and cleaning the squatting pan. Always wear gloves during emptying the faeces vault and wash hands with soap afterwards.
- Always keep two small urine containers and two big urine containers. The big urine containers with tight lids should be placed in the courtyard in a shed for storing the urine from the small container. Two small containers (with a small inlet for inserting urine pipe) should be used alternatively to collect urine by placing it next to the latrine. Urine containers should be closed at all the time to prevent odour and losses of ammonia into the air. - For households who have their field away from their houses, it is not practical to take urine frequently, but for those households who have their kitchen garden and nearby fields, they can use small urine containers alternatively.

- When the first big urine container is full then seal it properly for use as a liquid fertilizer (undiluted) after 30 days and use the second container.
- In kitchen gardens, urine may be applied directly but the time gap between urine applications and harvesting should be at least one month. Urine contains salt so plain watering would be beneficial after urine application for better plant growth.
- Apply undiluted urine to open soil. For growing plants urine can be used diluted or undiluted. If urine is diluted then use one part urine with three parts of water. It may be applied in one large dose or several small doses. Apply urine in smaller doses for crops with smaller roots. For fertilizing 1 mu (0.067 ha) land, approximately 850 litres of urine would be required i.e. approx. the total urine discharge of two adults in a year.
- The first vault can be used for about 6-7 months by a household of 5 persons. Additives are also added after defecation and soil is placed on the bottom and also on top for sealing when the vault is full. Therefore the effective depth would be 0.6 m - 0.03 m (soil on floor) - 0.05 m (top soil for sealing) - 0.20 m (free space) = 0.32 m. When the vault is full up to 35 cm, level the content by a stick and then fill the vault to the brim with dried powdered earth and seal it for processing for six months. The second vault now comes into use. When the second vault is nearly full, empty the first vault.
- The timing for using compost should be planned in advance (400 - 500 kg humus per family per year can be formed).
- Wash the urine pipe at regular intervals by passing small quantities of water through it from the squatting pan, where it is attached.

## 11 Practical experiences and lessons learnt

A community, if properly mobilized and trained, is capable of identifying sanitary problems and their solutions, and is also ready to plan, design and execute the system which is useful for them. Children and women have eagerness to learn, analyze and solve their problems and manage their time in a most useful manner. One should design hygiene promotion messages with women and children in mind. Hygiene activities should suit to the women in the family and their domestic responsibility. The focus in this case study is on ecosan but this project is part of the comprehensive WES program of Plan China.

Demonstration and cross visits are important tools for community capacity building. Urine diverting toilets proved to be a community-friendly technology in rural China. Promotion of new technologies should always be supported by demonstration and cross visits. The community is able to accept the new technology for betterment of their lives and changing their unhygienic behaviours by health and hygiene information conveyed by the ecosan promotion programme. Simple, low cost technology allows independent local level construction.

More community mobilization activities should be planned. Community mobilization and gender awareness is a continuous process and cannot be achieved by a single training period.

## 12 Sustainability assessment and long-term impacts

A basic assessment (Table 3) 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 components. 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)

<table>
<tr><td></td><td colspan="3">Collection and transport</td><td colspan="3">Treatment</td><td colspan="3">Transport and reuse</td></tr>
<tr><td>Sustainability criteria (aspects)</td><td>+</td><td>o</td><td>-</td><td>+</td><td>o</td><td>-</td><td>+</td><td>o</td><td>-</td></tr>
<tr><td>• Health and hygiene</td><td>X</td><td></td><td></td><td colspan="3" rowspan="5">Not appropriate as there is no external treatment (other than the storage of urine)</td><td colspan="3" rowspan="5">Not appropriate as reuse is by the toilet users themselves</td></tr>
<tr><td>• Environmental and natural resources</td><td>X</td><td></td><td></td></tr>
<tr><td>• Technology and operation</td><td>X</td><td></td><td></td></tr>
<tr><td>• Finance and economics</td><td></td><td>X</td><td></td></tr>
<tr><td>• Sociocultural and institutional</td><td></td><td>X</td><td></td></tr>
</table>

With regards to long-term impacts of the project, the main expected impact of the project is improved public health (e.g. reduced rate of diarrhoea incidences in children). It is planned to assess this at the end of the project in late 2009.

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**Case study of SuSanA projects**

**Community-led Water and Ecosan Programme, Shaanxi Province, China**

**SuSanA 2008**

Author: Prakash Kumar

Editing and reviewing: Jürgen Eichholz, Patrick Bracken, Elisabeth v. Münch (GTZ Ecosan Program)

# Urine diversion sanitation in Olympic Forest Park Beijing, China

**Fig. 1:** Project location

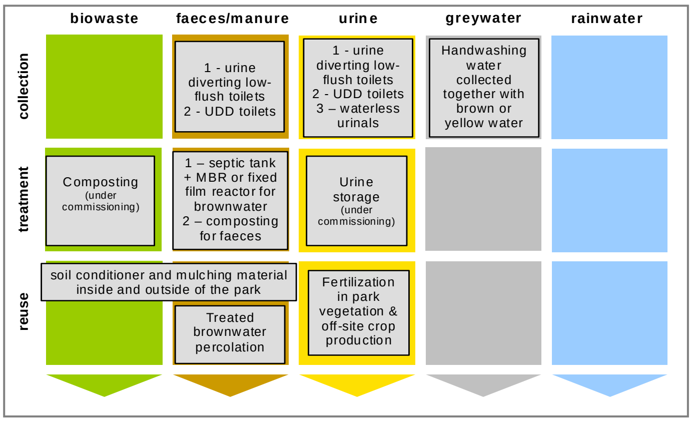


**Fig. 2:** Applied sanitation components in this project (numbers refer to different flow streams)

## 1 General data

**Type of project:**
Urine diversion and nutrient cycling in a large public urban park (demo project)

**Project period:**
Start of planning: August 2007
Start of construction: December 2007
Start of operation: August 2008
Commissioning of treatment processes: still ongoing in April 2009

**Project scale:**
Total area of 704 ha, planted area of 434 ha
5.3 million expected visitors/year
4,280 staff
38 urine-diversion public toilet blocks, 1 staff restroom
(capital costs not disclosed)

**Address of project location:**
Olympic Forest Park, Kehui Street, Chaoyang District, Beijing

**Planning institution:**
Dept. of Landscape Planning & Design (LPD), Planning & Design Institute, Tsinghua University, Beijing;
Dept. of Environmental Science and Engineering (DESE), Tsinghua University, Beijing;
Beijing Zhongyuan Engineering Design & Consulting Co. (ZEDC), Beijing

**Executing institution:**
EnviroSystems Engineering & Technology Co. Ltd., Beijing

**Supporting agency:**
None

*Note: at the time of last update of this document, we were still trying to obtain some missing information from colleagues in China. As soon as these details are available, an update to this case study will be prepared.*

## 2 Objective and motivation of the project

The main project objective was to supply the Olympic Forest Park with sanitary installations for visitors and staff. By governmental directive all works related to the Olympic summer games in Beijing in August 2008 were required to observe three principles: 'Green Olympics, High-tech Olympics and People's Olympics'. Besides the 'Green Olympics' motto, cost savings (figures not disclosed) were an additional incentive for the establishment of an alternative closed-loop sanitation system due to the park's special topography.

The aim of the system is to interlink the sanitation material flows as a water and nutrient source with the green areas of the park as a water and nutrient sink. Reduced water and energy demand as well as the substitution of fertilizer by urine and faeces-derived manure are expected advantages. A further aim is to convey the idea of alternative sustainable sanitation solutions to decision makers and the wider public.

## 3 Location and conditions

The Olympic Forest Park lies at the northern end of the historic north-south axis of Beijing. It covers a total area of 704 ha and is one of the world's biggest inner city parks.

**Fig. 3**: Public toilet block in the Olympic Forest Park[a]

[a] All pictures without further reference are by Jörn Germer.

The park's topography is characterised by a man-made mountain in the south and an extensive network of waterways, lakes and wetlands expanding over 70 ha. More than 60% of the park is covered by vegetation. An average irrigation water demand of 350 mm is estimated for these areas, which is entirely provided by reclaimed wastewater.

The park area lies inside a planar depression. This does not allow gravity drainage and was the starting point for the planning team at the Department of Environmental Science and Engineering, Tsinghua University (DESE), in charge of sanitation system planning, to consider alternative sanitation solutions.

**Fig. 4**: Elevation map of the Olympic Forest Park (source: Planning & Design Institute, Tsinghua University)

## 4 Project history

Starting in 2003 the construction of the Olympic Forest Park lasted five years and was officially completed on 3rd July 2008.

Detailed planning of the sanitation installations and the associated treatment systems began in August 2007. DESE in cooperation with the Beijing Zhongyuan Engineering Design & Consulting Company (ZEDC) developed a decentralised treatment system, integrated urine separation and suggested reuse of the sanitation-derived nutrient resources in the park.

The great amounts of nutrients involved required a careful nutrient mass balance for the park to avoid any adverse impact such as over-fertilization of the green areas or eutrophication of the waterbodies. In December 2007 in cooperation with the German Technical Cooperation (GTZ) ecosan team, material use strategies were identified and a model was developed that allows identification of nutrient flows in the park (see Section 6).

It is anticipated that the fertilization with treated urine and compost will start in the second quarter of 2010.

## 5 Technologies applied

A total of 38 public toilet blocks plus one staff restroom in a service building are located in the park. Each block contains on average five toilets in the female section and four toilets plus three urinals in the male section.

The restrooms initially planned for the park were supposed to be equipped with conventional flush toilets and urinals. Wastewater disposal to the public sewer system was planned. Due to the size and topography of the park, this would have required a very complex and costly network of pipes and pump stations. In order to reduce the length of the network, decentralised treatment was considered. Membrane as well as granular biological reactors were chosen for on-site wastewater treatment.

Further, the flush toilets in some public toilet blocks were substituted by waterless toilets. The parallel implementation of these three systems was selected to enable comparisons at a later stage. Urine separation was integrated due to the advantage of a lower nitrogen content in the wastewater for the treatment reactors and high dry matter content in the collection chambers of the dry toilet system.

The anticipated quantities of urine led to the question if nutrient cycling in the park was possible. To enable urine sanitisation by extended storage, a large-scale urine treatment unit was added to the design. Additionally, the composting unit for the treatment of gardening debris was redesigned to allow co-composting of faecal matter from UDD (urine diversion dehydration) toilets and sludge from septic tanks.

Extensive man-made wetlands covering over 6 ha (Fig. 5) are integrated into the park for the purpose of beautification and to control the nutrient status of the open water-bodies. The lake water is continuously reticulated through these wetlands. It is expected that the vegetation will take up significant amounts of nutrients, thus avoiding eutrophication of the open water-bodies.

**Fig. 5:** Vertical flow constructed wetland in the Olympic Forest Park

## 6 Design information

Low flush, urine diversion, sitting or squatting toilets are used in **33 public toilet blocks** (Fig. 6B/C) and in one staff office building. The average flush volume for faeces is approximately 6 litres and for urine 0.1-0.3 litres. The brownwater (mixture of faeces plus flush and hand wash water) is flushed by gravity into a two chamber septic tank system.

Each of the flush toilet blocks has an individual tank system with an average volume of 75 $m^3$ (50-100 $m^3$). The brownwater undergoes a liquid/solid separation in the tanks and afterwards passes through a biological reactor. The reactor effluent flows through open drains towards the wetlands and water-bodies. It is anticipated that a large part of the effluent infiltrates and evaporates on the way. Scum and sludge that floats and settles in the septic tanks is removed via a vacuum truck.


**Fig. 6**: Different toilet models and a waterless urinal used in the public toilet blocks. A Urine-diverting dehydration toilet (UDDT), B Urine-diverting, low flush sitting toilet, C Urine-diverting, low flush squatting pan and D Waterless urinal. (Source: B - EnviroSystems Engineering & Technology Co. Ltd., China)

**Five public toilet** blocks are equipped with UDDT also called no-flush (waterless), separating, sitting and squatting toilets (Fig. 6A)[b]. The faecal matter is collected in containers below the toilet. Mechanical addition of sawdust and automatic stirring of the faeces vaults controls odours and contributes to hygienisation of faeces. Every 6 months, the accumulated faecal matter mixture is conveyed to the composting plant for secondary treatment.

In all blocks, only waterless urinals without any flushing water are installed. The urine from these and yellow water (mixture of urine plus water) from the separating toilets is collected in underground tanks of an average volume of 15 $m^2$ (5-30 $m^3$) at each block. At the blocks equipped with UDDTs, the water from the hand wash basins is collected together with the yellow water.

Additionally, there are four blocks equipped with conventional flush toilets. These blocks are connected to the public sewer system.

The treatment process for the materials (excreta) collected with sustainable sanitation technology comprises three functional units which are either in operation or currently being commissioned. These are:

1. A urine storage tank complex that sanitises urine by storage. With a total capacity of **2,000 $m^3$**, the potential storage time is over 180 days (tank not yet full – awaiting further feedback from China).
2. A solid-liquid separation that receives the scum and sludge from the septic tanks. The liquid fraction is treated in an MBR and the solid fraction composted (not yet in operation).
3. A composting plant with an annual treatment capacity of about 2,000 t of fresh organic matter. The plant treats gardening debris, including grass clippings, leaves and other biomass. Faecal matter from the dry toilets as well as solid material from the solid-liquid separation plant is co-composted together with the gardening debris[c].


**Fig. 7:** Type of vacuum trucks to be used for the transport of scum and sludge from the septic tanks at the public toilet blocks with low flush, urine diverting toilets in the Olympic Forest Park. This picture was taken at an MBR wastewater treatment in metropolitan Beijing.

The sanitation system design and the number of park visitors plus staff determine the nutrient influx via urine and faeces as well as the production of yellow water, brown water and faecal matter. Currently, 5.3 million visitors are estimated per year and assumed to urinate once during their visit. Nutrient and mass flows are calculated on basis of the following assumptions:

- On average, each visitor urinates once during their park visit (18% of daily total excretion) and 15 % of visitors defecate during their visit to the park
- Excretion of 1.6 L urine and 150 g faeces per 24 hours and person (fresh weight)
- Nutrient content of 6.5 g nitrogen (N), 0.7 g phosphorus (P) and 2.0 g potassium (K) per litre of urine
- Moisture content of approximately 75% and dry matter nutrient content of 18 g N, 4 g P, 3.6 g K per kg of faeces

Accordingly, a production of 2,500 $m^3$ urine, resulting in **4,000 $m^3$ yellow water, is expected per year**. The annually harnessed yellow water contains 6.4 t N, 0.8 t P and 2.2 t K. Further, the developed flow model indicates a yearly (waterless) collection of 15 t of faecal matter containing 71 kg N, 19 kg P and 17 kg K.

At the same time, the flush toilet facilities are expected to produce about 20,000 $m^3$ brown water. It is expected that from the septic tanks, 225 $m^3$ of scum and sludge, containing

[b] In Beijing sitting toilets are more common in public toilets, while squatting toilets are usually used in homes and restaurants.

[c] We have requested more information and are awaiting a response.

0.4 t N, 0.1 t P and 0.1 t K per year, will be conveyed to the treatment site.

Co-composting of faecal matter and dehydrated scum and sludge, together with 2,000 m³ of gardening debris, produces 1,400 m³ of compost, providing 7 t N, 1 t P and 4 t K annually.

While yellow water (urine plus some flush water) and compost alone supply a great load of nutrients, additionally significant amounts of nutrients are added to the park's ecosystem through irrigation with reclaimed wastewater (see Section 8). The nutrient flow model highlights that on the 'sources side', only the use of fertilizers can be reduced, which is already minimal. On the 'sink side', organic matter (e.g. plant cuttings, grass clippings, leaves), compost and urine can be exported to maintain the nutrient balance.

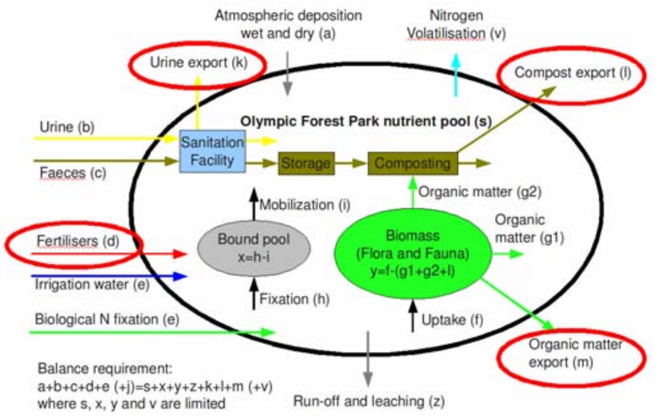


**Fig. 8:** Simplified nutrient flow model (mass balance) for a sustainable sanitation nutrient cycling in the Olympic Forest Park (source: Germer, 2008)

## 7 Type and level of reuse

So far no urine has been reused, as the urine treatment system is still being commissioned (the tank is being used, but it is not yet full – awaiting further details from China).

Application of treated yellow water will be based on current irrigation practises. Yellow water will be applied for fertigation (fertilization plus irrigation) with trucks or mobile application units (Fig. 9A). This reuse scheme allows a high degree of flexibility throughout the park until robust monitoring data is available. The estimated dilution ratio of the stored urine with water is 1:1. Whether and for what plants a further dilution is necessary is to be assessed. The co-compost will be used in the same manner as plain plant material compost or other commonly used mulch material (Fig. 9D).

As soon as the actual mass and nutrient flows are known, suitable, permanently installed fertigation systems will be implemented. Underground pipes with several outlets/taps for the attachment of hoses are a convenient option. This dispersion system is already widely used for irrigation in Beijing's parks (Fig. 9B/C).

Another possibility system is subsurface drip irrigation. This system is highly water efficient, but may require adjustment and development to avoid blockage if it is to be used for fertigation with yellow water. Subsurface drip irrigation would significantly reduce handling, limit nitrogen volatilisation and inhibit odour development, and the covering soil layer would act as a physical barrier between the yellow water and park visitors. Both of the permanent systems require either several smaller storage tanks or an extensive pipe distribution system.

The potential nutrient reuse in the Olympic Forest Park is 'sink limited' (the amount of ecosan products that can be used in the park is limited by the area available). To enable environmentally sound and sustainable use of the resources, a comprehensive monitoring program for hygienic safety and nutrient flow should be carried out. Nutrient flow monitoring is essential for the determination of whether, when and to what magnitude nutrient export will become necessary.


**Fig. 9:** Suggested application systems for the fertigation with yellow water (A via truck, B, C Pipe and hose system) and compost use (D Mulching) [A,B,C Beijing Botanical Garden, D Chaoyang Park, Beijing]

## 8 Further project components

The nearby Qinghe Wastewater Treatment Plant uses 1,000 ultrafiltration membranes for the tertiary treatment (filtration and phosphorus removal) of secondary effluent, to reclaim the wastewater. Per day 60,000 m³ of reclaimed wastewater are pumped into the park to ensure a sufficiently high water level in the Olympic Forest Park lake and to be used for irrigation and maintenance work. This contributes to the sustainability of Beijing's water supply as it reduces potable water demand.

**Fig. 10:** Nearby Qinghe Wastewater Treatment Plant supplying irrigation water and feeding the Olympic Forest Park's waterbodies

In order to raise awareness in the wider public of sustainable sanitation solutions, an ecosan education area is under discussion, enabling the visitor to follow the nutrient flow as it passes from the toilet to the collection and treatment system, and ultimately to its reuse for crop production.

## 9 Costs and economics

A comprehensive cost analysis of establishing and running the Olympic Forest Park sanitation system is not yet available.

The theoretical nutrient value of the reused excreta can be expressed as urea (for N), monoammonium phosphate (for P) and muriate (for K) of potash fertilizer equivalents. By recycling urine and faeces, € 12,650 per year (or 0.23 cent per visitor per year) worth of these fertilizers are substituted (based on currently subsidised fertilizer prices in China).

Apart from the nutrients, the economic value of running the sustainable sanitation system includes the opportunity cost of using less water and reducing the load to wastewater treatment plants.

## 10 Operation and maintenance

Chaoyang's district government was put in charge of the entire construction phase of the park by the government of Beijing. The Olympic Forest Park Management Co. Ltd., has been set up for the supervision of operation and maintenance works during the park's establishment. Final task allocation is expected when all operational units are fully functional.

## 11 Practical experience and lessons learnt

The public toilet blocks were built and equipped by different contractors, using materials of numerous suppliers. The overall acceptance of all toilet blocks by the public is good. Some of the toilets were, however, not installed as designed and the urine treatment centre is not yet finished (April 2009). Since the Beijing Olympic Games took place in Aug. 2008, the park has so far predominantly been operated under winter conditions and the system is not yet fully operational. Therefore, not enough data is available to formulate robust statements from practical experience.

A comparative assessment of the different sanitation installations will be conducted by ZEDC (Beijing Zhongyuan Engineering Design & Consulting Co.) as soon as the necessary data are available. - Operational results are not yet available.

A preliminary assessment shows that the urine tanks are currently *about* half full[d]. This means that approx. 1000 m³ of yellow water (urine plus some flush water) has been collected in the period Sept. 2008 to April 2009. This is significantly less than the amount predicted from the model for an 8-month period (see Section 6 - 4,000 m³ yellow water was expected per year, or 2670 m³ for an 8-month period). Reasons for the lower collected amount could be that the park did not receive as many visitors as assumed in the calculations because of restrictive access, the delayed opening of one of the wings of the park and the harsh winter.

## 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).

Regarding long-term impacts, it can be concluded that:

1. The Olympic Forest Park sanitation solution is contributing to the sustainability of fresh water and nutrient resource use by reducing water consumption, substituting artificial fertilizers and lowering the volume as well as the nutrient content of wastewater treatment effluent into natural water bodies.
2. This project demonstrates the feasibility of urine and brownwater separation in an urban context to visitors from China and all over the world. In this way it contributes to awareness raising for a promising approach for the future. Other cities in China may be inspired to set up a similar closed-loop sanitation system.

These impacts remain to be confirmed when the system is in full operation.

**Table 1:** Qualitative indication of sustainability of the 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, 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.

[d] Exact level in urine storage tanks has been requested; awaiting information.

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

## 13 Available documents and references

Germer, J. (2008) Ecological sanitation nutrient cycling in the Olympic Forest Park: From nutrient flow planning to cycle implementation. Consultancy report for GTZ Eschborn, Germany. Available at: http://www2.gtz.de/dokumente/oe44/ecosan/en-ecological-sanitation-nutrient-cycling-2008.pdf.

Kangning Xu, Chengwen Wang (2008) Sustainable treatment of green waste and wastewater based on urine-diverting: a case study of Beijing Olympic Forest Park in China. Proceeding of the 15th seminar of JSPS-MOE core university program on urban environment, Sept. 2-3, 2008, Toyohashi, Japan.

An Excel spreadsheet program for this case as a nutrient flow decision management tool is available either from j.germer@sanergy–net.de or ecosan@gtz.de.

## 14 Institutions, organisations and contact persons

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*Note: we are currently still waiting for information about the Chinese suppliers of the urine diversion toilets and waterless urinals.*

**Case study of SuSanA projects**

***Urine diversion sanitation in Olympic Forest Park, Beijing, China***

**SuSanA 2009**

**Authors: Jörn Germer (Sanergy), Kangning Xu (Tsinghua University)**

**Editing and reviewing: Carola Israel, Steffen Blume, Elisabeth v. Münch - ecosan@gtz.de**

sustainable sanitation alliance

Case study of sustainable sanitation projects

# Urine-diverting vacuum sanitation system

# Beijing, China

**Fig. 1:** Project location

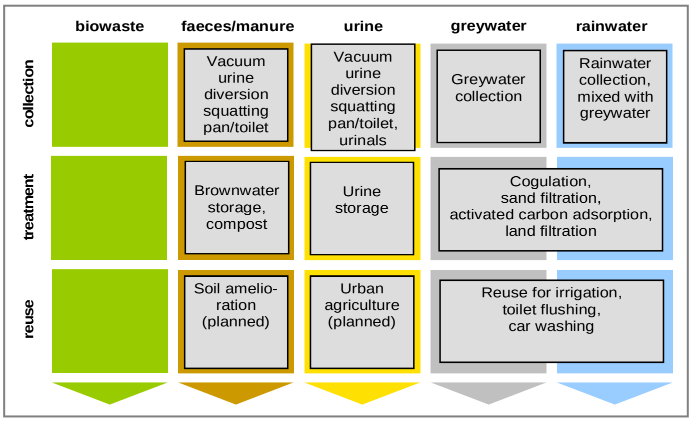


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

Vacuum urine-diverting sewerage system at a university building

**Project period:**

Planning: Jannuary 2003 – November 2004
Construction: December 2004 – May 2006
Start of operation: February 2007

**Project scale:**

9 storey building with total area of 20,000 m², capacity of 50 persons per floor
26 squatting and 2 sitting toilets, 14 urinals
total project budget € 20 million, € 27,000 for the vacuum sanitation system

**Address of project location:**

Sino-Italian Environment & Energy Building (SIEEB), Tsinghua University, Beijing 100084, P. R. China

**Planning institution:**

China Construction Research & Design Institute, P. R. China

**Executing institution:**

EnviroSystems Engineering & Technology, P. R. China

**Supporting agency:**

None

## 2 Objectives and motivation of the project

The main objective of the project is to demonstrate and evaluate the functionality of an alternative sanitation system for urban buildings. The vacuum urine-diverting sewerage system is used to reduce potable water consumption and to reduce wastewater production.

## 3 Location and conditions

The Sino-Italian Environment & Energy Building (SIEEB) is located on the campus of Tsinghua University in north-western Beijing and is financed by the Italian Ministry for the Enviromental and Territory and the Tsinghua University, in the framework of the Sino Italian Cooperation Programme for Enviromental Protection. Its design integrates ecological and energy-efficient technologies and shows the reduction potential of $CO_2$-emissions in China's building sector. On nine stories, plus the ground floor and two stories below ground SIEEB provides a total floor space of 20,000 m². The west wing of the symmetrical building is equipped with conventional water flush toilets, while the east wing is equipped with a vacuum urine diverting sanitation.

Fig. 3: Sino-Italian Environment & Energy Building at Tsinghua University, Beijing (source: EnviroSystems)

## 4 Project history

Reclamation of greywater for the flushing of conventional toilets was originally planned in 2003/2004. In the course of the detailed design phase, vacuum toilets were adopted as a very water efficient flush system. Urine diversion was integrated; further reducing water and electricity demand. The implementation of the source separation of urine and faeces provides an additional option to reduce the environmental footprint of SIEEB due the reuse of urine and faeces as a fertiliser for landscaping and agriculture. Currently, suitable pathways for urban-rural nutrient cycling are being investigated. The system has been in operation since Feb. 2007.

## 5 Technologies applied

Urine collected in the source-separation sitting and squatting toilets as well as the waterless urinals[1] is drained by gravity. Faeces are withdrawn by vacuum suction. Both evacuation systems are made of PVC pipes. Transport of both fractions is carried out with minimal volumes of flush water. Greywater from the hand washing basins is also collected separately and transferred to a compact water treatment facility, where it undergoes coagulation, sand filtration and activated carbon adsorption processes.

**Fig. 4:** Urine-diversion vacuum squatting toilet in the Sino-Italian Environment & Energy Building (source: EnviroSystems)

## 6 Design information

From the 2nd to the 7th floor, two vacuum urine diverting squatting pans are installed in men's and women's restrooms, while on the 1st floor, one vacuum urine diverting squatting pan and one vacuum toilet are used in both restrooms. On all floors, the men's restrooms are equipped with two waterless urinals.

[1] We have requested more information on the type of the waterless urinal and are awaiting a response.

The collection and storage station in the basement consists of a urine storage tank, a brownwater (faeces + water) storage tank and a buffer tank for pressure compensation of the vacuum system. All three tanks have a diameter of 0.6 m and a height 2.0 m (volume 565 L). Two pumps with an installed power of 1.1 kW each generate a vacuum force of 0.4 to 0.6 bar. The vacuum in the air tight system is consistently maintained.

**Fig. 5:** Collection and storage station for the urine and brownwater (source: EnviroSystems)

The pipes in the system have a relatively small diameter (i.e. 40/50 mm for faeces and 50 mm for urine, compared to 100 mm for conventional toilets).

The flush system of the toilets is operated with two buttons. Flushing urine requires only about 0.1 L of water. The button for faeces simultaneously opens two electronic valves and 0.8-1.5 L of water flushes the faeces area while 0.1 L rinses the urine area. There is no separate collection of toilet paper and used paper is evacuated together with the faeces.

The calculation of the average flowrates for designing the system were based on the following figures:

- Number of persons using the system per floors: 25
- Number of floors: 7
- Number of flushes per day per capita for faeces: 1
- Number of flushes per day per capita for urine: 5
- Water volume per flush for faeces: 0.8 – 1.5 L
- Water volume per flush for urine: 0.1 L
- Water demand for faeces flushing per day: 140 – 263 L/d
- Water demand for urine flushing per day: 87.5 L/d

## 7 Type of reuse

Rainwater, mixed with reclaimed greywater is used for toilet flushing, car washing and landscaping. Especially the internal garden, consisting of water falls and pools with a capacity of more than 150 m³, requires much water. The landscaping water is treated by land filtration integrated in a lawn nearby and recycled.

There is currently no reuse of urine and brownwater, but they flow to the sewer.

## 8 Further project components

- Rainwater is drained from the terraces of each floor and collected together with the greywater.
- A small lab next to the collection and storage station is used for water quality monitoring and analysing.
- The difference between the conventional water flush system in the west side of the building and the vacuum urine diverting system in the east side of the building are being studied.
- The SIEEB building is equipped with a variety of additional ecological and environmentally sound technologies that focus primarily on the energy efficiency of the building.

## 9 Costs and economics

The construction cost of the vacuum urine diverting system (pipe, pump and storage installations) was about € 27,000. A detailed cost break-down is not available. O&M (Operation and maintenance) costs are also not available.

## 10 Operation and maintenance

The collection and storage station in the basement is automatically controlled. No dedicated staff is required for the routine operation except periodical maintenance, carried out by a contracted service company. The service staff was trained by the system supplier for several months.

Until now, no chemical or mechanical cleaning of the pipe systems has been necessary as there have been no blackages, neither due to precipitation of urine salts nor due to toilet paper. The collected urine and brownwater (faeces plus flush water) is used for research purposes, before disposal in the public sewer system. No routine reuse has been established.

## 11 Practical experience and lessons learnt

The vacuum urine diverting sanitation system has been newly developed for SIEEB and is the first of its kind in China. Its successful use in a modern multi-storey building demonstrates that the system is a potential alternative to more water-demanding gravitation flush systems in urban areas.

Based on the knowledge gathered during planning and in later phases, it was found that the system represents a technologically feasible and economically reasonable system. Accumulated data on the design, construction and operation are expected to provide important information for optimisation of the technology and its dissemination.

Low dilution with flush water yields concentrated yellow- and brownwater. Due to the concentration, the volume to be treated and transported is quite low per nutrient unit. This is a valuable advantage if these materials are to be used as plant fertilisers. The mass flows as well as their chemical and hygienic properties are being currently monitored to study such reuse options. Thus, vacuum urine diverting systems contribute to limiting the water requirements of modern cities and may help to close the nutrient loop between rural and urban areas. [2]

## 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 emphasized (weaknesses).
The vacuum urine diverting system in combination with greywater reclamation reduces greatly the fresh water demand. Accordingly, the system lowers significantly the amount of wastewater discharged to the municipal wastewater treatment plant. Further, the on-site treatment of greywater lessens the absolute load of organic and mineral compounds in the wastewater stream.

**Table 1:** Relative sustainability of system components
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 | | | Treat-ment* | | | 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 | |
| • sociocultural and institutional | X | | | | X | | | X | |

*Currently applies to greywater reclamation only

**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, e.g. 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 the SuSanA Vision document "Towards more sustainable solutions" (www.susana.org).

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[2] We have requested more information on the experiences and are awaiting a response.

## 13 Available documents and references

Wang, C. and Bao, W. (2007) Case Study of Vacuum Urine-Diverting Sewerage System of SIEEB Tsinghua University, Gewässerschutz, Wasser, Abwasser, 206, 22/1-22/6. Editor: Institut für Siedlungswasserwirtschaft, University RWTH Aachen, Germany (http://www.isa.rwth-aachen.de/). Also available: http://www2.gtz.de/Dokumente/oe44/ecosan/en-case-study-of-vacuum-urine-diverting-sewerage-system-2007.pdf

Zhang, J. (2008) Application of vacuum toilets and collection systems for water saving and source separation, China Water & Wastewater Engineering, 34(2), 96-99 (in Chinese, available on request by J. Zhang)

## 14 Institutions, organisations and contact persons

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Xu Kangning (PhD student with Prof. Wang)
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I: http://www.env.tsinghua.edu.cn/Eng
Or: http://www.tsinghua.edu.cn

EnviroSystems Engineering & Technology Co., Ltd., Beijing, 100088, P.R. China (supplier of the UD toilets and the waterless urinals)
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China Construction Research & Design Institute (planning institution)
http://www.cadreg.com.cn

*Note: we are currently still waiting on information about the Chinese suppliers of the urine diversion toilets and waterless urinals and the experiences of the owners.*

**Case study of SuSanA projects**
***Urine-diverting vacuum sanitation system, Beijing, China***
**SuSanA 2009**
**Authors: Jörn Germer – j.germer@sanergy-net.de (Sanergy)**
**Editing and reviewing: Elisabeth v. Münch, Steffen Blume and Carola Israel – ecosan@gtz.de**

sustainable sanitation alliance

Case study of sustainable sanitation projects

# Decentralized Wastewater Mgmt at Adarsh College Badlapur, Maharashtra, India - Draft

**Fig. 1:** Project location

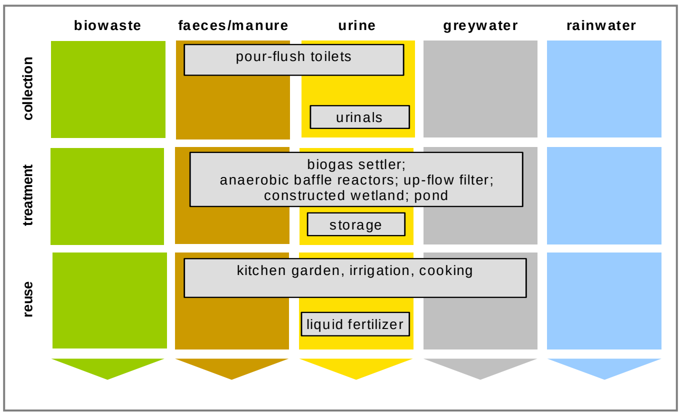


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

Decentralized Reuse-oriented Wastewater Management at Adarsh Vidyaprasarak Sanstha's College of Arts & Commerce

**Project period:**

Start of construction: Apr. 2006

End of construction: Sep. 2008

Start of operation: Sep. 2008

**Project scale:**

Approx. 2,600 students attending Senior and Junior College and up to 800 people attending special programmes (such as wedding ceremonies) on about 20 occasions per year

**Address of project location:**

Adarsh Vidya Mandir, Kulgaon Badlapur Municipal Corporation - East, Maharastra State, India, 421503

**Planning institution:**

Ecosan Services Foundation (ESF), Seecon gmbh, Paradigm Environmental Strategies Ltd.

**Executing institution:**

Kulgaon Badlapur Muncipal Council

**Supporting agency:**
EU-funded AsiaProEco II - project
GTZ-ecosan project

## 2 Objective and motivation of the project

Badlapur Municipal Council and the Board of "Adarsh Vidya Mandir School" decided to incorporate an ecologically sound sanitation concept (Fig. 2) at the "Adarsh Vidyaprasarak Sanstha's College of Arts & Commerce". This concept does not only meet the sanitation needs of the students and the people attending special programmes such as wedding ceremonies at the school premises, but also protects the environment and raises awareness amongst the students, about the importance of water and sanitation in promoting health and hygiene.

## 3 Location and conditions

"Adarsh Vidya Mandir School" is located in Badlapur town, in Maharashtra's Thane district, about 68 kms. from Mumbai, 34 kms. from Thane and 10 kms. from Ulhasnagar.
The school accommodates about 11,000 students attending Primary School, Secondary School, Junior College or the "Adarsh Vidyaprasarak Sanstha's College of Arts & Commerce".
The college building is located at the southern fringe of the school premises and doubles-up as Senior College in the morning and as a Junior College in the afternoon. The number of students attending Senior and Junior College is about 1,400 and 1,200 per day, respectively.

## 4 Project history

This school project is a pilot project demonstrating alternative decentralized sanitation solutions to the Badlapur Municipality Council. The council plans to replicate the concept in other areas after evaluating the findings of decentralized reuse-oriented school sanitation project.

## 5 Technologies applied

A single-storied sanitation block having two independent enclosures for ladies and gents has been constructed next to the school building.
Each enclosure is equipped with 4 bucket-flush squatting-type toilets and 1 western-style cistern-flush pedestal (for the physically challenged). Waterless urinals are provided in the gents' toilet block; while the ladies' toilet block has an

increased number of toilets. Sufficient numbers of washbasins (i.e. 3 numbers) are provided in each toilet block.
A flow chart of the implemented wastewater management scheme is depicted in Fig 3.

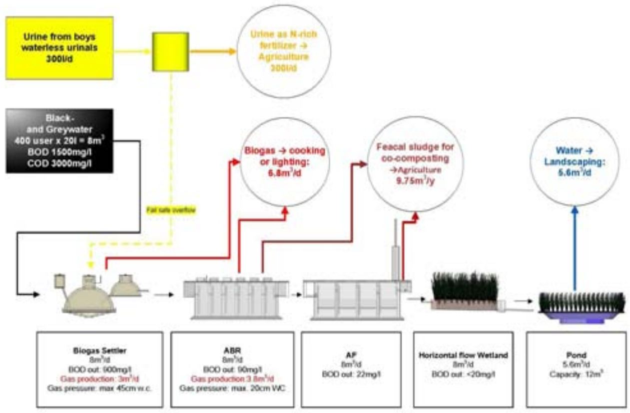


Fig 3: Flow chart of wastewater management scheme (source: N. Zimmermann)

Blackwater along with greywater from the washbasins is discharged to a “biogas settler” (Fig. 4) where solids are retained and subjected to anaerobic decomposition.

Fig 4: Biogas settler (under construction) (left) and (right) (photo: N. Zimmermann)

The biogas settler effluent is drained by gravity flow to an Anaerobic Baffled Reactor (ABR) and Up-flow Filter (UF) (Fig. 5) for further anaerobic treatment.

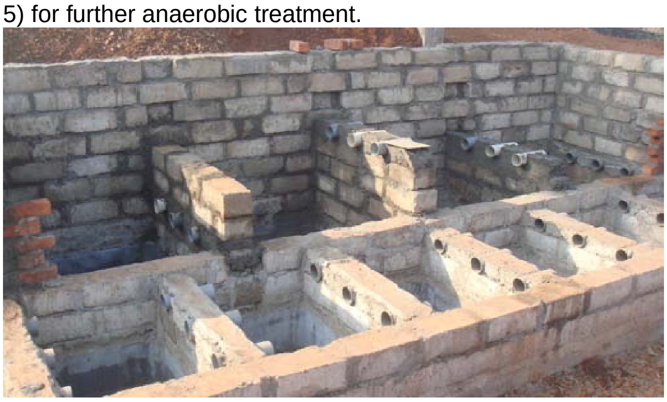

Fig 5: Construction of ABR and UF (photo: N. Zimmermann)

Post treatment of the UF effluent happens in a small-scale horizontal flow constructed wetland (HFCW). The final stage of the treatment concept is a pond (Fig. 6) that doubles-up as storage tank.
Waterless urinals (Fig. 7) are provided in the gents' compartment for the source-separate collection of urine, which is drained into a collection tank outside the toilet block. The tank is provided with a fail-safe overflow emptying to the anaerobic treatment plant.

Fig 6: Construction of polishing cum storage pond (photo: N. Zimmermann)

Treated water and urine will be used in a yet to be established kitchen garden. Sludge drying beds will be constructed for dewatering the sludge from the biogas settler, baffled reactor and up-flow filter.

## 6 Design information

In order to keep water consumption low, specially designed squatting pans (so called “rural” or “pour-flush” pans) made of ceramic that require a little amount of water for flushing the excreta have been installed and no water taps are provided inside the cubicles. The toilet users have to fetch water for cleansing and flushing with a bucket (approx. 5 litres) from a central tank that is located inside the enclosure. Daily total wastewater production (blackwater plus greyater) is estimated to be about 8.0 m³ (i.e. 8,000 litres).
The hemispherical shaped biogas settler provides a volume of approx. 21 m³ at an inner diameter of 1.25 m.
The anaerobic baffled reactor volume is approx. 12.0 m³. The reactor comprises 6 compartments of 2.0 m3 each and provides for 1.5 days hydraulic retention time at a wastewater production of 8 m³/d).

Table 1: Treatment system characteristics

| Component | Approx. Volume [m3] |
|---|---|
| Biogas settler | 21.0 |
| Baffled reactor | 12.0 |
| Up-flow filter | 14.6 |
| Constructed wetland | 12.6 |
| Pond | 12.0 |

The anaerobic up-flow filter volume is approx. 14.6 m³. The up-flow filter comprises of 4 compartments of approx. 3.6 m³ each. The height of the filter media (gravel of 40 mm diameter) is 0.75 m.
Length and width of the horizontal flow constructed wetland is 6.00 m by 3.00 m. Main filter media is fine gravel with a grain size of 4 – 8 mm. Height of filter media (at inlet) is approx. 0.70 m. Saturated water depth is approx. 0.60 m. The pond has an effective volume of 12 m³ at a maximum depth of about 1.20 m.
The gents' urinals are equipped with membrane stench traps that are especially adopted to fit Indian urinals.

## 7 Type and level of reuse

Although the toilet block and treatment system is in operation since end of November 2008, the reuse part is not yet fully

Fig 7: Waterless urinals for boys (photo: N. Zimmermann)

established. For the time being only the final effluent, which is collected and stored in the polishing pond, is reused for irrigation purposes.
Within the next weeks/months the remaining activities will be finished to allow also for the reuse of biogas and hygienized urine.

- The produced biogas (from biogas settler and the anaerobic baffled reactor) will be used either for cooking or lighting purpose.
- The collected urine will be stored and used for agriculture/gardening purpose within the school campus (especially on the yet to be established kitchen garden).
- The dried sludge from the biogas settler, baffled reactor and up-flow filter will be applied as soil amendment within the school premises for agricultural/gardening purposes.

## 8 Further project components

Students attending environmental classes will be involved in the monitoring of the treatment system and practise the reuse of recyclates in the kitchen garden.
Next to the decentralized treatment system an exhibition hall has been constructed, which will host permanent poster exhibitions, models, etc. on ecologically sound sanitation concepts. There will also be the provision for preparation of tea on a biogas-fuelled cooker.

## 9 Costs and economics

The costs for establishing the above mentioned treatment scheme are summarized in Table .

Table 2: Costs of treatment system

| **Component** | **Costs [INR]** |
|---|---|
| Biogas settler | 120,000 |
| Baffled Reactor | 120,000 |
| Up-flow filter | 120,000 |
| Constructed wetland | 50,000 |
| Pond | 40,000 |
| **Total** | **450,000** |

## 10 Operation and maintenance

For O&M of the toilet block and reuse of the recyclates caretakers cum resource managers (1 female and 1 male person) are hired.

Students will support the resource managers in their daily work (e.g. application of nutrients, gardening activities, etc.).

## 11 Practical experience and lessons learnt

As implementation of the treatment and reuse facilities is just finished, practical experiences, lessons learned and comments will be provided at a later stage.

## 12 Sustainability assessment and long-term impacts

With regards to long-term impacts of the project, the main expected impact of the project is improved sanitation, demonstration of substitution of LPG by biogas, and the safe reuse of the treated water for irrigation purposes.

Table 3 depicts a preliminary assessment of the five sustainability criteria for sanitation (according to the SuSanA Vision Document 1) of this project.

**Table 3:** Qualitative indication of sustainability of system

| | 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 | |

## 13 Available documents and references

No documents are available at the moment.

## 14 Institutions, organisations and contact persons

**Project owner:**
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**Case study of SuSanA projects**

**Decentralized Wastewater Mgmt at Adarsh College Badalapur, Maharashtra, India**

**SuSanA 2008**

**Authors: Nanchoz Zimmermann, Martin Wafler**

**Editing and reviewing: Nanchoz Zimmermann, Martin Wafler**

Case study of sustainable sanitation projects

# Pour-flush toilets with biogas plant at DSK Training Institute Gujarat, India - Draft

**Fig. 1:** Project location

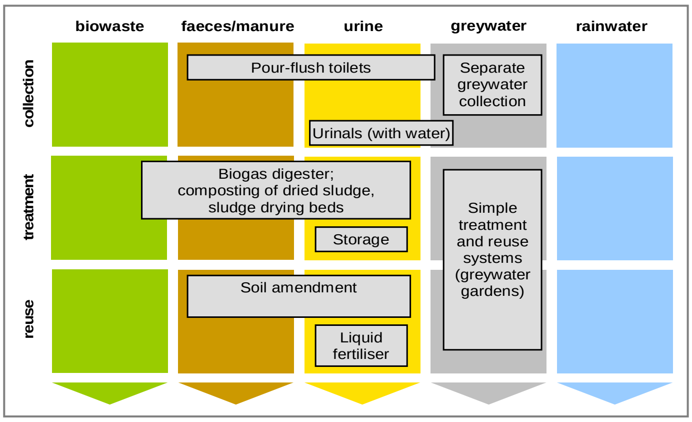


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

Upgrading of sanitation system at a rural training institute

**Project period:**

Start of planning: July 2004

Start of construction: February 2005

Start of operation: August 2006

**Project scale:**

Vocational training institute with 300 students and a variable number of guests attending workshops; 22 pour-flush toilets and biogas digester

Capital cost?

**Address of project location:**

Nani Devti village (close to Ahmedabad), Gujarat State, India

**Planning institution:**

seecon GmbH (Swiss consulting firm) and
Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, ecosan program

**Executing institution:**

Navsarjan Trust (an India NGO)

**Supporting agency:**

Swiss Agency for Development and Co-operation (SDC)

This is a draft version. Text in yellow is currently still being investigated with the responsible project staff.

## 2 Objectives and motivation of the project

The objectives of this project were:

- to find technical solutions that can help in the elimination of manual scavenging practices, which is a caste-based occupation in India and a source of discrimination
- to improve the sanitation situation at this rural training institute
- to provide Navsarjan Trust first-hand experiences on ecologically sound sanitation concepts and with the knowledge for further dissemination of ecosan in the state of Gujarat.

Navsarjan Trust aims to implement, evaluate and disseminate socially and culturally acceptable, sustainable and hygienically safe sanitation, treatment and reuse concepts for human excreta (urine and faeces) and greywater.

## 3 Location and conditions

The DSK institute was built on an area of 3.2 ha in Nani Devti village near Sanand, about 30 km southwest of Ahmedabad City (a city of 3.7 million inhabitants (in 2004) in Gujarat State in the west of India at the border to Pakistan). The institute has buildings for administration, kitchen and a workshop, one hostel for males, one hostel for females and a building for computer classes. The institute is used by 220 students and approx. 20 staff members (the staff members do not live on site). Thus the number of people permanently staying on the campus is approx. 240. At times, this number can increase to 400 when participants of meetings and workshops are also at the campus (do these participants also stay overnight?).
Numbers of students and staff are a bit confusing.

**Fig. 3:** Navsarjan Vocational Training Institute (DSK) in Nani Devti village (source: seecon GmbH, which year?)

Before this project was implemented, the wastewater from the campus (with flush toilets? How many?) was collected and infiltrated into the ground by two soak-pits located close to the hostel building. The following reasons have led to a malfunction of this system:

- Due to the lack of maintenance (sludge removal of the soak-pits), sludge accumulated at the bottom and walls of the soak-pits leading to an insufficient infiltration of the wastewater into the ground.
- In addition, wastewater was not discharged into the soak-pits at ground level but at a depth of 3 m below ground. This caused a permanently flooded sewer and soak-pits, resulting in significant odour as well as unhygienic conditions (flies breeding contributing to the transmission of diseases).
- The groundwater level varies between 5 m (during dry season) and only 1.5 m below ground (during rainy season). It can therefore be assumed that wastewater also mixed with the groundwater, which was a severe health risk as groundwater is used for drinking water.

For these reasons, and to meet the needs of an expansion of the institute (expansion from what size to what size?), a new sanitation concept was developed.

In India, the under-five mortality rate[1] is currently 72 children per 1000 (http://www.childinfo.org/mortality.html).

## 4 Project history

Navsarjan Trust, an NGO based in the city of Ahmedabad, was established in 1989 to help eliminate discrimination based on the caste system (including gender), to assure equality of status and opportunities and to ensure the rule of law. The NGO works with Dalits[2], but also with tribes and other resource-poor groups all over Gujarat. Navsarjan Trust has come to realise that education coupled with skilled training could help in the economic empowerment of the Dalit community.

Thus a suitable training centre had to be established. With financial support from the Swiss Agency for Development and Co-operation (SDC), a vocational training institute called "Dalit Shakti Kendra" (DSK) was established in 1999 to provide technical training in various fields to Dalit youth and to link them up with institutions for financial assistance for self-employment.

The planning process started in July 2004 and the construction started in February 2005. The new sanitation system was inaugurated in August 2006.
How did Navsrajan Trust get together with seecon GmbH and GTZ?

## 5 Technologies applied

The new sanitation concept includes the following components:

Water supply

The entire water used at the campus is groundwater which is pumped into a storage tank. From there the fraction for cooking and drinking is pumped into a reverse osmosis plant (due to its salt content) while the predominant (how much?) fraction is used directly. The byproduct of the generation of 1,000 litres of drinking water is 3,000 litres of low quality water which is used as flushing water for the pour-flush toilets (is the 3000 litres = the brine? Or what is meant by byproduct?).

How much water is used at the campus?
Who built the RO plant? Running costs?
What happens to the brine? Is this what is used for toilet flushing?

Biogas plant

A new common sanitation complex was built consisting of 22 toilet cabins (11 for females and 11 for males) arranged in a circular shape around a biogas plant located in the center. In these toilet cabins, pour-flush squatting pans (so-called "rural" or "pour-flush" pans) made of ceramics were installed which are equipped with a water seal (Fig. 4) and are supplied by the Indian company Shital Ceramics. Compared to conventional flush toilets, these toilets reduce water consumption and keep the blackwater relatively concentrated. Low quality water (brine?) from the reverse osmosis plant is used to flush the toilets.

All students have to use the sanitary block connected to the biogas plant – all the other toilets (except two which are not accessible to the students) have been removed from the campus.

What is the distance from hostel to toilets? What is the design number of people using this sanitation complex?

**Fig. 4:** Pour-flush squatting pan ("rural pan") and water seal ("P-trap") (supplier: Shital Ceramics, India).

The decision for a biogas plant was made in order to treat the blackwater (blackwater is a mixture of urine, faeces and flushing water) and to recover energy in form of biogas. The biogas plant has a "floating drum" cover which simultaneously stores and provides the produced gas at a constant pressure. The slurry (biogas plant effluent) is led to a sludge drying bed.

[1] The under-five mortality rate is the probability (expressed as a rate per 1,000 live births) of a child born in a specified year dying before reaching the age of five if subject to current age-specific mortality rates.
[2] "Dalits" is a term for people historically stigmatised as so-called "untouchables", representing approx. 16% of the Indian population. They work in leather industries, as a shoemaker, unskilled worker in agriculture or scavenger. The last-mentioned group is responsible e.g. for the excavation of graves, the removal of animal carcasses and of human excreta (modified from Wikipedia.org).

**Fig. 5:** New sanitation complex with 22 pour-flush toilets and biogas plant (source: seecon GmbH, which year?)

Urinal centre
The former common toilet centre has been converted into a urinal centre. Two independent enclosures provide urinals (How many?) for ladies and gents. The urine is collected in a tank and pumped to storage/hygienisation tanks when full. The urinals were originally designed as waterless urinals but are now used with flushing water, see Section 11 for explanation. Supplier for waterless urinals?

**Fig. 6:** View of ladies squatting urinals, which are now water flushed (source: seecon GmbH, which year?)

UDDTs for night-time use
Near the gents hostel two "Urine-Diversion Dehydration Toilets" (UDDTs) have been constructed by the MIT (how did MIT get involved?) to serve students and staff members as "emergency toilets" during the night (Fig. 10). The design, with the anal cleansing part behind the faecal hole at the back, resulted however in spilling of the anal washwater into the faeces hole. Therefore both of these UDDTs are not in use anymore. There is a plan to place the anal cleansing part on the side.

For the ladies hostel (the former Community Training Centre) an additional single-vault UDDT has been built for “emergency use” during the night. Why can’t they use the other toilets at night? What is the distance from bedrooms to toilets? What does the squatting pan look like here?

Greywater treatment
A new stand for dishwashing was built (Fig. 7) where the water is supplied by a solar panel operated pump (Fig. 8). It was planned to lead the dishwashing stand effluent via an organic filter (container filled with straw) to a storage tank. However, this filter had been designed with a hydraulic gradient that could not be built due to the high groundwater level in this area. This resulted in the straw being permanently flooded and consequently losing its filtration effect. Therefore a new filter has been installed (when?) whose effluent is fed into a storage tank before it is reused for gardening purposes.

**Fig. 7:** View of new stand for washing dishes (source: seecon GmbH, which year?)

**Fig. 8:** Solar panel and water pump (source seecon GmbH, which year?)

New bathrooms (comprising shower facilities (how many?), washbasins and laundry facilities) have been constructed (where exactly?) to serve students. The greywater is discharged to elevated greywater gardens for pretreatment. Any surplus of water that does not infiltrate into the soil is collected in a tank (size?) and is reused for irrigation purposes during dry periods. Are there drain pipes in the base?

**Fig. 9:** Elevated (why "elevated"?) gardens for the treatment/reuse of greywater (source: seecon GmbH, which year?)

Kitchen water will be treated (when?) in a similar treatment/reuse unit as the greywater collected from the new shower facilities.

Greywater from the ladies hostel (showers?) (the former Community Training Centre) is led to a settling tank and is further reused for subsurface irrigation of the surrounding lawn. A greywater garden for a further treatment is planned. When?

The sludge (digestate) from the biogas plant is led to a drying bed, composted and then stored for a further reuse as soil amendment.

Organic solid waste management

Kitchen waste is disposed of in a landfill and grass clippings are used to cover the sludge drying beds. These materials could however be fed to the biogas plant provided they are chopped before. But due to lack of time and staff this is presently not done.

## 6 Design information

A summary is given here for the design information. Futher details is available in Wafler and Heeb (2006), see Section 13.

Water supply

Assuming an average of 240 people permanently on the campus, an amount of approx. 11 $m^3$/d of water is consumed equaling a water demand of approx. 46 L/(cap x d).

Biogas plant

For flushing of the squatting pans, a volume of 4-5 litres of water is needed. Assuming a water flushing volume of 4 L/(cap x d), on average 1.5 uses/(cap x d) and between 240 and 400 people onsite, this results in a daily amount of blackwater of 1.4 to 2.4 $m^3$/d. With the given volume of the biogas digester of 27.3 $m^3$, this results in a hydraulic retention time (HRT) of 11 to 20 days. With a HRT of 11 days at mesophilic temperatures, anaerobic decomposition and hygienisation (if at all) will however be very low (see also Section 11).

UDDT for night-time use

Prefabricated urine diversion squatting pans made of fiber-reinforced plastic have been installed serving as “emergency toilets” at night (as UDDTs).

Supplier?

**Fig. 10:** Urine-diversion squatting pan that allows separate collection of urine, faeces and anal washwater (source: seecon GmbH, which year? Supplier?). The anal washwater section on the left of the pan was found to be too small.

Photo of UDDT installed? Is it being used?

## 7 Type of reuse

The following products are being reused:

- The **biogas** is used as a substitute to Liquefied Petroleum Gas (LPG) and firewood for cooking. The amount of biogas produced is not measured but the amount of saved LPG is known: From an original consumption of 25 cylinders of LPG per month, the use of biogas saves on average 2-3 cylinders (of 16 kg LPG each) per month (what does this equate to in cost savings?).
- The **digested slurry** from the biogas plant is used as a soil conditioner, e.g. for growing seedlings.
- **Urine**, which is collected (with water) from the urinal centre and the urine-diversion dehydration toilets, is applied after storage as a nitrogen-rich liquid organic fertilizer in the kitchen garden (to grow what?) and the campus lawn in general. Urine onto lawn? Dilution? Fertilising results?
- **Greywater** from dishwashing is treated by organic (straw) filter, stored and used to irrigate nearby plantations. Which crop?
- Pre-treated greywater (after greywater garden) from the new bathrooms is reused for irrigation purposes in dry season.

**Fig. 11:** Kitchen garden near the hostel for male students. (source: seecon GmbH, which year?) What is grown? Get better photo?

**Fig. 12:** Organic straw filter at the dishwashing stand (source: seecon GmbH, which year?)

## 8 Further project components

For the ladies hostel it is planned (when?) to install an additional emergency night toilet (What type? Why at top of the building?) at the top of the building and to build a second greywater treatment garden.

## 9 Costs and economics

Information on investment costs and operation & maintenance costs is yet to be provided.
Who paid for what?

Due to the excavation required, the cost for the biogas plant was much higher than expected: on the height of 2.5 m, the groundwater flooded the pit and the further excavation (up to 6 m) had become much more demanding than expected.

## 10 Operation and maintenance

To disseminate knowledge on the different implemented technologies, operation and maintenance is done by trained institute staff and students.

Two gardeners and one “ecosan person” are responsible for the maintenance of the grounds. The students have to help them with the work and are responsible for the maintenance of the grounds in general and especially for the toilets. A group of approx. 10 students shares one toilet and the responsibility for its maintenance.

What are the actual tasks which are carried out, how often and by whom exactly?

## 11 Practical experience and lessons learnt

Three years after its implementation, the sanitation system on the DSK campus is working satisfactorily even though the operation team aims at further improvements.

Urinal centre:
The waterless urinals do not have any siphons, therefore odour control devices become necessary. Odour control devices from Shital had been installed but most probably due to incorrect installation, odours came out of the drains anyhow and hence flushing became necessary. A Swiss odour trap (which brand? With sealant liquid?) has also been tried but since the urinals were flushed twice a day for cleaning purposes, the flushing water stream exceeded the flow capacity of those odour traps which led to flooding of the urinals.

The odour traps have therefore been removed and today the urinal is flushed 8 times a day (at peak times) with ground water (water consumption of 250-300 L/d). With this high amount of flushing water, compliance with the requirements of the WHO guidelines for safe reuse may be compromised[3].

New waterless urinals are now on the market, also in India, and may be trialed in the future[4].

How long is urine stored for?

Biogas plant and sludge drying beds:
With the actual number of 240 to 400 people permanently present on the campus, the volume of 27.3 m³ of the biogas plant has become insufficient. This leads to a hydraulic retention time of 11 to 20 days being much lower than the 45 days initially designed for.

**Fig. 13:** The biogas plant inside the sanitation complex (source: Annik Staub, Sept. 2008).

If the slurry was homogeneous, this would result in a very low hygienisation effect (pathogen die-off). But it was found that the slurry is inhomogeneous (liquids pass the digester faster than faecal matter). This would mean that the sludge remains longer in the digester than estimated in the design, possibly allowing for a better hygienisation. In order to check the hygienisation effect, pathogen tests are planned for a further decision on how to proceed (When? Results?). If not complying with the requirements, one option could consist in adding an anaerobic baffled reactor (ABR) to the system.

In order to increase the gas production organic material is sometimes added: from the neighbouring farmer’s cow manure is added to the plant (rarely) or else chopped kitchen waste (sometimes). But if the kitchen waste is not chopped properly, the outlet of the biogas tank will be clogged: the staff has to free the jammed part with a stick. Since the chopping of the raw kitchen waste (e.g. banana peel) is time consuming and needs

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3 Relevant WHO Reuse Guidelines from 2006: http://www.who.int/water_sanitationhealth/wastewater/gsuww/en/index.html

4 See also this list of suppliers for waterless urinals: http://www.gtz.de/en/dokumente/en-urine-diversion-appendix-suppliers-lists-2009-14-May.pdf.

to be done properly (the material should be mushy), it is often neglected by the kitchen staff.

However, it should be taken into account that also the secondary treatment on the sludge drying beds contributes to a further pathogen die-off. The problem is that during monsoon, the sludge drying bed is exposed to heavy rain and as a consequence is flooded in this period. In order to reduce the moistening of the compost, an elevation of the sludge drying beds has been discussed.

Are there other lessons learnt (how was involvement of the students and school staff?). User acceptance?

## 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 this project has its strengths and weaknesses.

**Table 1:** Qualitive indication of sustainability of system. A cross in the respective column shows where the system component is considered to have a strong (+), average (o) or weak (-) sustainability.

| | 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 | |
| • sociocultural 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, 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 regard to long-term impacts of the project, the main impacts of the project are

1. Improved environmental conditions (e.g. reduced odour and groundwater contamination) – observed?
2. Reduced disease incidences from poor sanitation (observed?)
3. The learning effect for students to see wastewater as a resource
4. Experience for Navasarian Trust with ecosan systems

It must be noted that the main driver for this project was the desire to improve the existing wastewater management system. The reuse of products is an "add-on", but optimisation of this aspect (also with regards to biogas production) is not a focus point for the staff.

## 13 Available documents and references

- This project is shown briefly in a 1-minute promotional video clip on ecosan (from 2007), posted on Youtube: http://www.youtube.com/watch?v=2ZQdGvpok3Y
- Wafler, M. and Heeb, J. (2006) Report on Case Studies of ecosan Pilot Projects in India, report for GTZ-ecosan. http://www2.gtz.de/Dokumente/oe44/ecosan/en-ecosan-case-studies-draft-report-iesni-2006.pdf
- Find out from seecon if there is a more recent report?

## 14 Institutions, organisations and contact persons

Project owner and operator:

Navsarjan Trust
Contact: Sanjiv XXX (sanjiv272005@gmail.com)
2, Ruchit Apartments, Behind Dharnid-har Derasar, Vasna, Ahmedabad - 380007, Gujarat, India
E: navsarjan@icenet.net
I: http://www.navsarjan.org/

Technical consultancy:

seecon GmbH (Martin Wafler, Johannes Heeb)
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E: johannes.heeb@seecon.ch
E: martin.wafler@seecon.ch
I: http://www.seecon.ch/

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
Ecosan program
P.O. Box 5180
65726 Eschborn, Germany
E: ecosan@gtz.de
I: http://www.gtz.de/ecosan

Ecosan Services Foundation
Pune, India

Technical planning/implementation

SAVE (Saline Area Vitalization Enter-prize) Ltd.
Shree Apartment, University Hostel Road, Ahmedabad - 380009, Gujarat, India
E: saveltdad1@sancharnet.in

Suppliers of pour-flush squatting pans:

Shital Ceramics Works

# 103, Suyojan, Milan Park Society, near Swastik Cross Road, Navrang-pura, Ahmedabad - 380009, Gujarat, India
E: shitalcera@rediffmail.com, shitalcera@yahoo.com
I: http://ruralsanitation.net/

ARIES (to supply what? Waterless urinals?)
# 169, New H Sector, Govindpura Industrial Estate, Bhopla, Madhya Pradesh, India
E: ariesngo@rediffmail.com

**Case study of SuSanA projects**

***Pour flush toilets with biogas plant at DSK Training Institute***

**SuSanA 2009**

**Authors: Martin Wafler, Johannes Heeb (both: seecon GmbH), Annick Staub (annick.staub@gmail.com) and Christian Olt (GTZ)**

**Editor: Carola Israel, Elisabeth von Münch (GTZ), ecosan@gtz.de**

# Madha Housing Society
# Maharashtra, India - Draft

**Fig. 1:** Project location

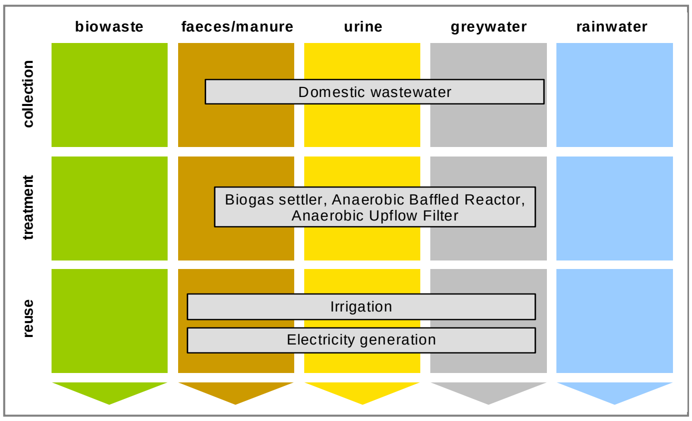


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

Decentralized wastewater management and re-use concept

**Project period:**

Start of Planning: 2008

Start of construction: 2009 onwards

Start of operation:

**Project scale:**

Decentralized wastewater treatment scheme for 300 + 240 households (stage I & II, respectively)

**Address of project location:**

Madha Housing Society, Badlapur, Dist. Thane, Maharashtra, India

**Planning institution:**

Ecosan Services Foundation (ESF)

Paradigm Environmental Strategies Ltd.

seecon gmbh

**Executing institution:**

Kulgaon Badlapur Municipal Council

**Supporting agency:**
Kulgaon Badlapur Municipal Council

## 2 Objective and motivation of the project

Inspired by the ongoing ecosan pilot project at “Adarsh Vidyaprasarak Sanstha’s College of Arts & Commerce, Kulgaon” in Badlapur town, the Badlapur Municipal Council has decided to promote decentralized sanitation concepts in Badalapur town on the large-scale. It was decided that 5 existing large-scale septic tanks at Mhada Housing Colony shall be replaced by decentralized wastewater treatment plants allowing for the reuse of the treated water.

## 3 Location and conditions

Madha Housing Colony is located in Badlapur town, in Maharashtra’s Thane district, about 68 kms from Mumbai, 34 kms from Thane and 10 kms from Ulhasnagar.
The wastewater from about 300 households (i.e. Cluster A) drains to a septic tank for treatment (see Fig. 3). But due to the desolate condition of the existing sewer system, a large amount of the wastewater does not even reach the treatment system. The septic tank itself is in bad condition as well; partially filled with solid waste dumped at the site.

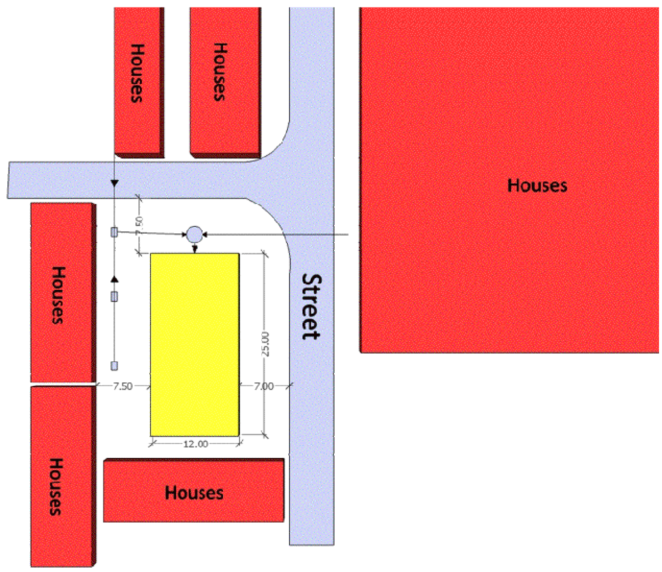


**Fig 3:** Layout map of „Cluster A“ of Madha Housing Society depicting location of houses and existing septic tank (yellow rectangle) (source: N. Zimmermann)

# Madha Housing Society
# Maharashtra, India - Draft

Therefore the existing sewer lines and septic tanks at Cluster A and B (about 240 households) shall be augmented or replaced by decentralized treatment systems comprising of a settler, an anaerobic baffled reactor and an anaerobic upflow filter respectively. Stage-I of the project foresees replacement of the septic tank at Cluster A with a decentralized treatment system; Stage-II Cluster B shall follow after successful completion of the treatment and re-use system in Cluster A.

## 4 Project history

The project is in the construction approval stage; structural drawings, layout and bill of quantities (BoQ) are prepared and submitted for sanctioning.

## 5 Technologies applied

Treatment of domestic wastewater will happen in a decentralized treatment systems comprising a (biogas) settler, an anaerobic baffled reactor and an anaerobic upflow filter (see Fig 4).

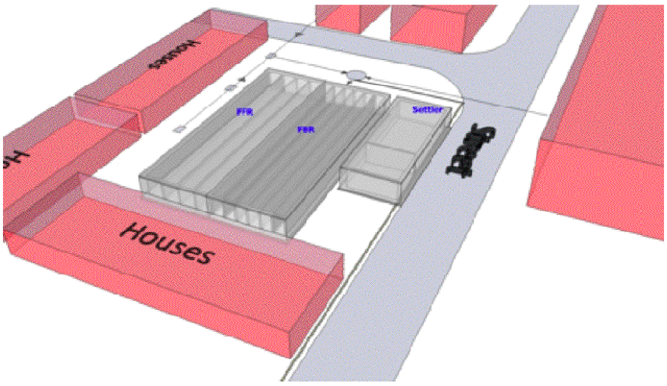


**Fig 4:** Proposed decentralized wastewater treatment scheme (source: N. Zimmermann)

## 6 Design information

Daily wastewater production is estimated to be about 200 m³ (i.e. 200,000 litres). The surface area for construction of all treatment steps is approx. 500 m2.

## 7 Type and level of reuse

The treated water shall be reused for irrigation purpose at the site. Biogas produced in the process of anaerobic wastewater treatment will be collected and shall be converted into electricity via a (bio) gas generator; the electricity can be stored in a accumulator (battery) and be used on-site to bridge power cuts.

## 8 Further project components

(This section will be updated soon)

## 9 Costs and economics

A cost estimate suggests total project implementation costs of about INR 40 lakhs (i.e. approx. € 65,000).

## 10 Operation and maintenance

Operation and maintenace of the treatment facilities will be done by the Kulgaon Badlapur Municipal Council.

## 11 Practical experience and lessons learnt

As the project is in the planning and building permission phase and implementation is expected to happen in the year 2009 only, practical experiences, lessons learned and comments will be provided at a later stage.

## 12 Sustainability assessment and long-term impacts

With regards to long-term impacts of the project, the main expected impact of the project is improved treatment of the total domestic wastewater and the safe reuse of the treated water for irrigation purposes.

Table 1 depicts a preliminary assessment of the five sustainability criteria for sanitation (according to the SuSanA Vision Document 1) of this project.

**Table 1:** Qualitative indication of the sustainability of the 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 | |

## 13 Available documents and references

No documents are available at the moment.

## 14 Institutions, organisations and contact persons

**Project owner:**
Kulgaon Badlapur Municipal Council opp. Badalapur Railway Station Badlapur(E)
Taluka-Ambernath
Dist-Thane,Maharashtra, India
phone: +91-(0)251-2690397
email: rampatkar@gmail.com
web: http://www.kbmcinfo.com

# Madha Housing Society
# Maharashtra, India - Draft

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web: http://www.seecon.ch/

**Technical planning/implementation**
Ecosan Services Foundation (ESF)
"Vishwa Chandra", 1002/42 Rajendra Nagar, Pune – 411030,
Maharashtra, India
phone: +91-(0)20-64000736
fax: +91-(0)20-24530061
email: ecosanindia@gmail.com
web: http://www.ecosanservices.org/

**Case study of SuSanA projects**

Madha Housing Society, Maharashtra, India

**SuSanA 2008**

**Authors: Nanchoz Zimmermann, Martin Wafler**

**Editing and reviewing: Nanchoz Zimmermann, Martin Wafler**

# Greywater treatment and reuse at Ashram School Maharashtra, India - Draft

**Fig. 1:** Project location

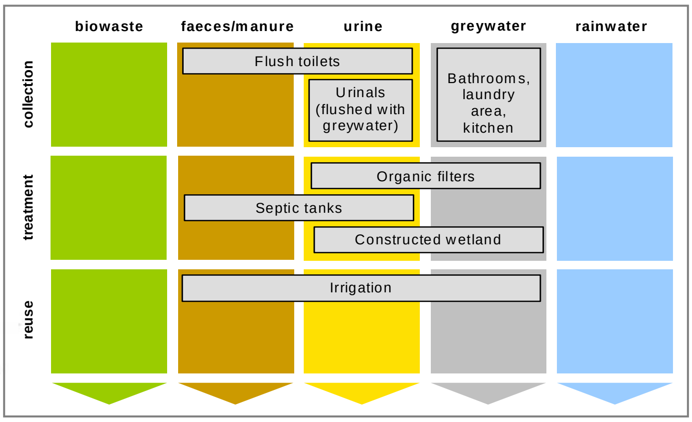


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

School Sanitation

**Project period:**

Start of Planning: 03/2008

End of construction: 05/2008

Start of operation: First quarter of 2009

**Project scale:**

Approx. 500 pupils and staff members living at Shree Baleshwar Anudanit Primary and Secondary Ashram School

**Address of project location:**

Shree Baleshwar Anudanit Primary and Secondary Ashram School

Sarole Pathar, Tal Sangamner, Dist. Ahmadnagar 422 620, Maharashtra State, India

**Planning institution:**

Ecosan Services Foundation (ESF)

seecon gmbh

**Executing institution:**

Shree Baleshwar Anudanit Primary and Secondary Ashram School, city? Country?

**Supporting agency:**

European union (under Asia ProEoll scheme) website??

## 2 Objective and motivation of the project

The objectives of this project are:

- Up-grading the existing sanitation scheme at Shree Baleshwar Anudanit Primary and Secondary Ashram School in Sarole Pathar.
- To treat a mixture of urine and greywater to such a degree that it is fit for reuse as irrigation water.
- Demonstration etc.

## 3 Location and conditions

Shree Baleshwar Anudanit Primary and Secondary Ashram School is a boarding school, which is situated off the Pune-Nashik road in India's Maharashtra State. At present it accommodates 155 female students, 162 male students, 2 female and 9 male teachers as well as 5 female and 2 male non-teaching staff members.

Currently, extension of the school to a total capacity of 500 students (300 girls and 200 boys) is ongoing.

Water supply to the boarding school is provided from a nearby water tank in the village. The school utilises about 20 $m^3$ of freshwater (having drinking water quality) per day at annual costs of INR 2,000 (approx. 30€). The water taken from the tank is just sufficient to cover basic needs, but cannot provide for any other activities such as irrigation of land or gardening.

2 sanitation blocks, one for the girl students (comprising of 6 toilets, 7 urinals and 6 bathrooms) and one for the boy students (comprising 5 toilets, 7 urinals and 6 bathrooms) are provided within the school premises. Each sanitation block has a water tank of 2 $m^3$ capacity for fetching water for washing clothes, taking a shower and flushing the toilets (see Fig 3).

# Greywater treatment and reuse at Ashram School Maharashtra, India - Draft

The toilet wastewater is discharged to septic tanks that drain to an open field.
The trench-type urinals are flushed with greywater from bathrooms and the laundry area. The urine-greywater-mixture is discharged to an open field outside the school premises.

## 4 Project history

The implementation of the above-described treatment cum reuse facilities is still ongoing. Commissioning of the reuse oriented treatment system is expected in the first quarter of 2009.

## 5 Technologies applied

Greywater and/or greywater-urine mixture will be drained to the vertical flow filters (Fig 4) filled with organic matter.(rice husk, saw dust, etc.) for rudimentary pre-treatment (i.e. removal of solids) before being discharged to a horizontal flow constructed wetland (Fig 5). The wetland effluent is collected in a storage pond from where the water will be pumped for irrigation purposes.

**Fig 4:** Organic filter for….(under construction) where? Month , year (photo: N. Zimmermann)

**Fig 5:** Horizontal Flow Constructed Wetland for…? (under construction) Where..? Month, year? (photo: N. Zimmermann)

**Fig 3:** Water tank for fetching water inside the sanitation facilities (photo: N. Zimmermann)

## 6 Design information

The wastewater production is estimated to be about 15.0 m³ (i.e. 15,000 litres/d).
The surface area and height of the organic filter media are 1 to 4m$^2$ (depending on anticipated wastewater production) and height is 0.9 m, respectively.
Length and width of the horizontal flow constructed wetland is 6 m by 20 m. The main filter media is fine gravel with a grain size of 4–8 mm. The height of filter media (at inlet) is approx. 0.80 m. while the saturated water depth is approx. 0.6 m.
The pond/tank has an effective volume of 14 m³ with a maximum depth of about 1.2 m. Type of liner?

The constructed wetland shall be operated as a “productive wetland” growing (hybrid) Napier grass (also referred to as "Elephant grass" due to its tallness and vigorous vegetative growth, "Sudan grass" or "King grass"), which is an improved fodder grass that produces a lot of high-protein forage.

## 7 Type and level of reuse

The constructed wetland effluent shall be used for irrigation purposes at the school premises.

## 8 Further project components

There are currently no further project components

## 9 Costs and economics

As the construction is not yet finished, there is no detailed information on the costs of the different components of the wastewater management scheme.

## 10 Operation and maintenance

Operation and maintenance of the treatment facilities will be done by staff members of the school.

## 11 Practical experience and lessons learnt

As implementation of the treatment and reuse facilities is not yet finished, practical experiences, lessons learned and comments will be provided at a later stage.

## 12 Sustainability assessment and long-term impacts

.

Table 1 depicts a preliminary assessment of the five sustainability criteria for sanitation (according to the SuSanA Vision Document 1) of this project.

The main expected impact of the project is improved sanitation at the Ashram School and the treatment of greywater for reuse as irrigation water

**Table 1:** Qualitative indication of the sustainability of the 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 | |

## 13 Available documents and references

No documents are available at the moment.

## 14 Institutions, organisations and contact persons

**Project owner:**
Shree Baleshwar Anudanit Primary and Secondary Ashram School, Sarole Pathar, Tal Sangamner, Dist. Ahmadnagar 422 620, Maharastra State, India

**Technical consultancy:**
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web: http://www.seecon.ch/

**Technical planning/implementation**
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**Nanchoz Zimmermann** …. email adress?
email: ecosanindia@gmail.com
web: http://www.ecosanservices.org/

**Case study of SuSanA projects**

**Shree Baleshwar Anudanit Primary and Secondary Ashram School**

**SuSanA 2009**

**Authors: Nanchoz Zimmermann(ESF), Martin Wafler(Seecon GmbH)**

**Editing and reviewing: Rahul Ingle (GTZ) ecosan@gtz.de**



**This document is available from:**
**www.susana.org**

Case study of sustainable sanitation projects

# Improved traditional composting toilets with urine diversion Leh, India - Draft

**Fig. 1:** Project location

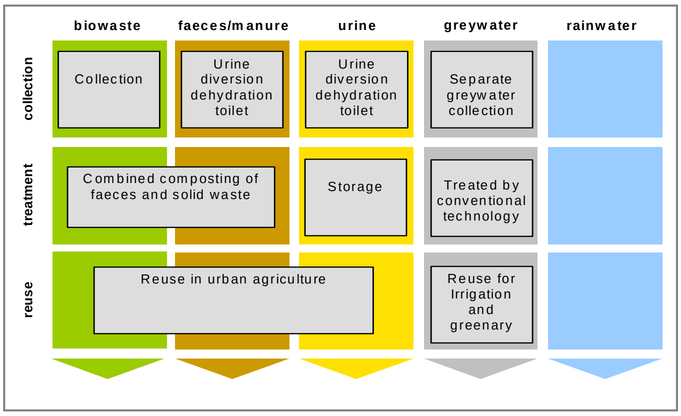


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Project Part 1**

**Type of project:**
New constructed demonstration facility in an Ecology Center guest house

**Project period:**
Start of planning: 1985
Start of operation: 1986

**Project scale:**
1 demonstration toilet (a traditional Ladakhi toilet, improved by ventilation). It is used by approx. 100 persons per day.

**Address of project location:**
Ladakh Ecological Development Group (LEDeG)
Karzoo, Leh, Ladakh 194101
Jammu & Kashmir, India

**Planning institution and executing institution:**
LEDeG

**Supporting agency:**
None

**Project Part 2**

**Type of project:**
Implementation of separation toilets.

**Project period:**
Start of planning: 2005
Start of operation: 2006

**Project scale:**
8 ecosan separation toilets (large scale promotion is planned)

**Address of project location:**
Leh, India

**Planning institution:**
LEDeG

**Executing institution:**
LEDeG
Technical support: Eco-Solutions, Kerela (India)

**Supporting agency:**
Financial assistance: BORDA, Germany

*This case study is in draft form. Further information is currently being collected by GTZ-ecosan team.*

## 2 Objective and motivation of the project

This project represents rather the revitalisation of the traditional ecological sanitation practice that is threatened to fall into oblivion than the introduction of innovative technologies. Therefore it serves educational purposes by

- presentation of the improved traditional Ladakhi sanitation and reuse concept to local, national and international visitors of the Ecology Center
- information about the advantages of the traditional system and research and development on possible improvements to optimise the utilisation and
- awareness raising that waterborne systems are no viable option for the region.

**Fig. 3:** The project region of LEDeG in Ladakh, Jammu and Kashmir, Northern India (Source : www.wikipedia.org)

## 3 Location and conditions

Ladakh ("Little Tibet") is one of the last remaining traditional cultures on earth. It is located in the north of India in the east of the federal state Jammu and Kashmir and borders on China. Ladakh has about 270,000 inhabitants. The capital is Leh with 27,000 inhabitants. The region is sparly populated (3/km²) and the average household size is 4.7 (1981) persons per household. Leh is situated in a mountainous desert 3,500 m above sea level with long cold winters and severe water scarcity with rainfall below 100 mm per year. In the seventies of the last century, tourism came to Ladakh undermining traditional agrarian lifestyle and values.

In the case of sanitation, especially in Leh people try to replace traditional sanitation systems by waterborne toilet systems. This development e.g. increases water supply problems and pollution of surface and groundwater due to leakages and disposal of untreated wastewater. The waterborne systems often simply drain into the irrigation systems of the urban and peri-urban agriculture of Leh, leading to smell and hygienic concerns. An additional problem of waterborne systems in this region is freezing of pipes during winters with temperatures reaching minus 30 °C.

In 1978, the ecological Ladakhi project was founded with participation of the International Society for Ecology and Culture ISEC (GB) in order to preserve and develop ways of living adapted to the local conditions and values.

As a continuation in the meanwhile, the influential indigenous non-governmental organisation (NGO) LEDeG has been actively promoting, among others, adapted ecological technologies for renewable energy generation and locally manufactured household and agricultural devices which can now be found all over Ladakh. LEDeG is running an Ecology Center for visitors in Leh establishing a soft tourism and facilitating close contact of tourists to the nature-based life of the Ladakhi society. In the center, a demonstration facility of the traditional Ladakhi toilet system is implemented.

**Fig. 4:** Ecological farm house in Ladakh (source: ISEC)

## 4 Project history

The start of planning was in 1985 to revitalise the traditional waterless sanitation system. In 1986, the demonstration toilet was build.

The second component of the project includes the implementation of different sanitation systems. Therefore 8 ecosan separation toilets were built in 2006.

## 5 Technologies applied

**Traditional Ladakh toilet system:**
The toilet at LEDeG is used by the workers and visitors of the LEDeG Ecology Centre in Leh. It is based on the traditional local toilet system, improved by a black-painted vent-pipe (like in VIP latrines) to ventilate the collection chamber and reduce annoyance by flies. The traditional Ladakhi toilet system is well described in the book "Ecological Sanitation" published 2004 at SEI: "Most traditional houses have an indoor toilet on the upper floor (see Fig. 6).

Due to an extremely dry climate it is possible to process human excreta indoors without prior diversion of urine, by using a combination of soil composting and dehydration. On the floor of a small room upstairs, typically in some distance to the kitchen/living room, there is a thick layer of soil from the garden. In the floor, a drop hole leads to a small ground-floor room. This room can only be reached from the outside. People excrete on the soil which is on the floor. Then they push soil and excreta together down the drop hole. Urine goes the same way. Ashes from the kitchen are added from time to time.

The household members bring loads of soil into the room when necessary. For the long winter (September–May), a supply of soil is piled into one corner of the toilet room upstairs. A spade or shovel is also kept in the room. Normally there is no anal cleaning. The decomposed excreta are removed in spring and again at the end of summer and spread on the fields.

As long as the toilet is well maintained and enough soil is pushed down the drop hole every day, there are no odours. In some cases there might be a faint smell of ammonia from urine splashed on the soil-covered floor of the toilet room. There is no fly breeding due to the dryness of the soil/excreta pile. The system has worked well in rural areas for hundreds of years, but in recent years there have been some problems in the central part of the town of Leh where households have no easy access to soil."

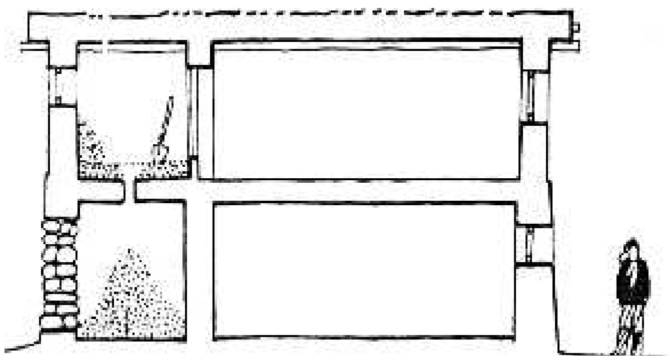

**Fig. 5:** Section of Ladakhi toilet (source: EcoSanRes)

Other problems occur e.g. in places rented out to people with different toilet behavior like utilisation of water for anal cleansing. This increases the moisture of the material to be disposed and thus odour and fly breeding. Also the removal of humid excreta mixture gets more difficult, so that people sometimes refuse to do it properly.

Open question and interest of LEDeG is to design, improve and promote the system in a way, that it can be commonly used in guesthouses etc. were currently waterborne systems are introduced and causing problems for Leh.

In the authors´ perception, the owners of the guest houses as well as the visitors simply anticipate the necessity of flushing toilets without thinking of the consequences. It is hoped that awareness raising campaigns and information material can help to understand the advantages of an improved traditional system. It shall be a visible advantage of the guesthouse to have a toilet system which is both based on traditional practice and ecologically sound.

**Two pit traditional Ladakh toilet system**
Another modification is the use of a two pit toilet, where urine and excreta are collected separately. The urine pit is connected to a diversion pipe. The excreta are collected for further treatment (like in the traditional system).

**Trombe wall solar passive toilet system**
Additionally, the LEDeG has implemented an ecological sanitation system with a Trombe wall solar passiv toilet. The Trombe wall is a sunfacing-wall with a solar collector to heat the air between the tombe-wall and the second wall of the room, where the excreta are stored. The temperature is rising inside and even in the night it keeps a higher temperature inside than outside. The higher temperature enforces the composting process.

*Further information on used technologies and number of systems in use is yet to be collected.*

## 6 Design information

The toilet is designed according to the traditional knowledge.

**Fig. 6:** Traditional toilet (source: LEDeG)

## 7 Type and level of reuse

In India, faecophobia is prevalent. Not so in the upper Himalayas, where excreta were composted and seen as important resource for nutrients traditionally since centuries.

The quantity of composted excreta material collected for reuse is about 3 m³ per year. The amount of soil added per year is about 2 m³. The excreta material (plus soil) is traditionally collected for reuse as fertiliser and soil conditioner once a year. It is taken out by laborers (or in villages by the farmers themselves) and brought to the fields. This work is not related to problems due to being related to dignity questions in this region. The material is seen as valuable, usually produced and used by the same farmers' family to grow barley or vegetables. Urban agriculture is common in Leh.

Due to the very low temperatures, the material has not always finished the composting process before collection. It is therefore taken out, brought to a nearby field (200 meters) and covered with soil to finalise the composting process. After a period of 20-30 days, it is applied to the fields.

**Fig. 7:** Agriculture in Ladakh (source: ISEC)

## 8 Further project components

As mentioned in the beginning, LEDeG, amongst other activities, also promotes:

- Wind and solar energy as well as small scale water power for diverse household purposes, crop drying, greenhouses and grain grinding
- ecological farming and food production without pesticides and artificial fertilisers
- adapted ecological building
- a women association supporting female autonomy, amongst others, by business activities like handicraft etc.
- tours serving sensitisation for the local natural, social and political conditions.

## 9 Costs and economics

The construction of the toilet was included in the ordinary construction of the Ecological Center. Total investment for the demonstration toilet was 40,000 Indian Rupies (INR) (≅ 650 EUR). The costs for each ecosan toilet in a household was 15,000 – 20,000 INR (≅ 225 – 300 EUR[1]).

Direct economic benefits of the project are not described, but the complete dependence on natural fertilisers will prevent the farmers to buy artificial fertilisers for food production recovering all the nutrient contents in human excreta.

*Further information on costs and economics is yet to be collected.*

## 10 Operation and maintenance

Operation and maintenance of the traditional and the diversion system is done as collaborative work. Most of the farmers collect and reuse the excreta by themselves, so there is not much operation and maintenance cost for the system as the work is carried out by the farmers themselves.

*Further information on costs is yet to be collected.*

## 11 Practical experience and lessons learnt

- If the demonstration toilet in the Ecology Center is properly used and maintained, it is accepted as the traditional solution.
- Ashes from the kitchen are added from time to time to reduce moisture and thus improve compost quality.
- Improving the traditional system with a ventilation increases the comfort of the system.
- If compost process is not finished, it is brought to a nearby field and covered with soil to finalise the process.
- Problems in the system occur, when people practice anal cleansing with water. It increases the moisture of the material and thus odor and fly breeding.
- Adding water or other liquids, apart from urine, makes removal of the humid excreta mix more difficult and people refuse to do it properly
- It may not be suitable for people with different toilet behavior (if the are clueless about the system)

Future:

- Information material in or near the toilet is presently discussed as it would probably raise the awareness about the advantages of the traditional toilet and explain some of the visitors (mainly tourists) how it works.

There are different problems caused by the long cold winters:

- The urine diversion does not work, because the urine is freezing in the diversion pipe.
- The urine is freezing inside the storage container. To hygienise the urine for reuse, the storage time has to be extended, because the temperature is to low during wintertime.
- The quantity of the "human fertiliser" is too high for reuse, because agricultural activities are taking place only a few months of the year.

*Further information on experiences and lessons learnt is yet to be collected.*

[1] Exchange rate April 2009: EUR 1 ≅ INR 65.5.

## 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).

With regards to long-term impacts of the project, the main expected impact of the project is that the re-introduction of traditional sanitation system combined with modern components creates a useful system to reduce water consumption and to provide the population with high quality compost.

**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.
**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).

## 13 Available documents and references

LEDeG Website:
http://www.ledeg.org/

ISEC Website
The Ladakhi project
www.isec.org.uk/pages/ladakh.html

Eco-solutions Website
http://www.eco-solutions.org/ladakh.html

## 14 Institutions, organisations and contact persons

LEDeG
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**Case study of SuSanA projects**

***Improved traditional ladakhi composting toilet***

**SuSanA 2009**

**Authors: Sonam Dawa (LEDeG) Gert Kreutzer (BORDA), Arne Panesar and the GTZ ecosan team**

**Editing and reviewing: Carola Israel , Annika Schöpe and Philipp Feiereisen (GTZ ecosan team, May 2009)**



**This document is available from:**
**www.susana.org**

# UDD toilets with reuse in allotment gardens Cagayan de Oro, Philippines

**Fig. 1:** Project location

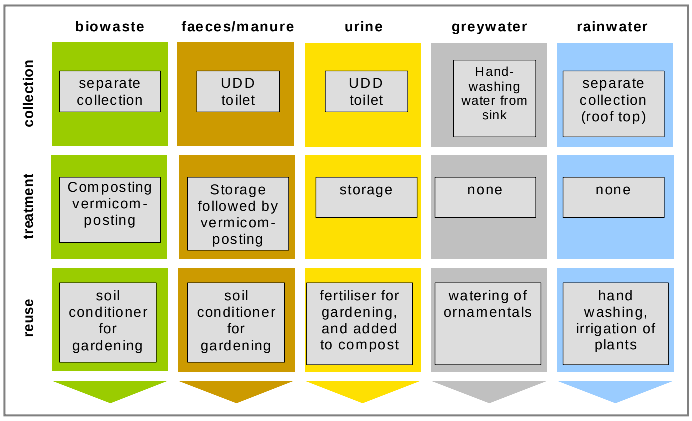


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

Urban upgrading (large pilot-scale)

**Project period:**

Start of planning: May 2005
Start of construction: October 2005
Start of operation: November 2005
Ongoing monitoring: planned until 2009

**Project scale:**

100 urban poor families in 10 self-sustaining allotment gardens (3 within premises of public elementary schools) in 8 city districts (barangays). Nine allotment garden have one UDD toilet each.

**Address of project location:**

Barangays Balubal, Balulang, Carmen, FS Catanico, Gusa, Kauswagan, Lapasan and Macasandig
9000 Cagayan de Oro City
Philippines

**Planning institution:**

Periurban Vegetable Project (PUVeP)
Xavier University – Research & Social Outreach (RSO)
Manresa Farm
9000 Cagayan de Oro City
Philippines

**Executing institution:**

Same as planning institution

**Supporting agency:**

Local government units of Balubal, Balulang, Carmen, FS Catanico, Gusa, Kauswagan, Lapasan and Macasandig
Kauswagan, Carmen and Gusa (all Cagayan de Oro)

City Government of Cagayan de Oro (Philippines)
German Embassy, Manila, Philippines
Center for International Migration (CIM), Frankfurt/M., Germany

## 2 Objectives and motivation of the project

The overall objective of the project is to improve the living conditions for urban poor families of Cagayan de Oro City through the introduction of the ecological sanitation concept in several allotment gardens of the city.

The specific objectives are in line with PUVeP's mandate as a research and social outreach unit of Xavier University, namely:

- developing economically viable, environmental benign and socially accepted community-based vegetable production systems to ensure the supply of affordable, healthy vegetables, particularly to the urban poor;
- promoting ecological sanitation systems to close the loop in the nutrient cycle which cities have broken;
- integration of urban and periurban food production and ecological sanitation systems into city planning by using participatory, asset-based approaches;
- integration of urban and periurban agriculture and ecological sanitation in relevant academic curricula, research and social outreach programs of Xavier University.

## 3 Location and conditions

Cagayan de Oro City is located in the province of Misamis Oriental on the Northern coast of Mindanao, the most Southern island of the Philippine archipelago. It is a rapidly growing urban centre with more than 600,000 inhabitants.

**Fig. 3:** Demonstration allotment garden with UDD toilet at Manresa Farm, Cagayan de Oro City (source: PUVeP 2008).

The city is subdivided into 80 city districts (*barangays*). The allotment gardens have been set up in the barangays of Balubal, Balulang, Carmen, FS Catanico, Gusa, Kauswagan, Lapasan and Macasandig. In addition, one allotment garden demonstration and training area with UDD toilets, vermicomposting and biogas facilities was established in Manresa Farm, which forms part of the Xavier University campus. It serves as training venue for students, farmers, staff of government and non-government agencies, as well as a showcase for the general public. The size of the gardens varies depending on the number of participating families (between 7 and 23 families) with an average area of 300 $m^2$ per family, plus the necessary space for commonly used areas such as composting, nursery, UDDT, tool shed and the like.

**Fig. 4:** Double vault UDDT in barangay FS Catanico (source: PUVeP 2008).

The project was implemented to address some socio-economic and environmental challenges caused by the rapid growth of Cagayan de Oro which is representative for the Philippines being classified among the world's fastest urbanizing countries. Among the major challenges that urban areas in the country are facing are:

- Availability, accessibility and affordability to safe and nutritious food for its residents, otherwise known as food security. The poorest sector of the Philippines, which comprises almost 40% of all households, spends about 60% of its income on food.
- 20% of Filipinos are regularly suffering from hunger and about one third of all children are underweight with iron deficiency anaemia and low vitamin A levels.
- Average per capita vegetable consumption is very low with 36 kg per year.
- Further, two thirds of all children suffer from intestinal worms due to lack of water and appropriate sanitation facilities at home and in schools.
- More than 90% of the wastewater is untreated and pollutes the water bodies.

## 4 Project history

The Periurban Vegetable Project (PUVeP) is a research and social outreach unit of Xavier University, located in Cagayan de Oro City, Philippines. It started its operation in October 1997 under the College of Agriculture and transferred to the newly established Research and Social Outreach Cluster (RSO) on July 1, 2008.

In 2003, the first allotment garden was established as part of a European Union funded project following a period of agronomic and socioeconomic researches in cooperation with German, Belgian and Philippine universities, local government units and non-governmental organizations. As of 2008, this number has grown to ten self-sustaining gardens located in different urban and periruban areas of the city, three of them within the premises of public elementary schools enabling more than 100 urban poor families the legal access to land for food production. Aside from different vegetables, some gardeners grow also herbs and fruits. In some gardens, small animals are kept to provide an additional income source. Each allotment garden has a compost heap where biodegradable wastes from the garden as well as from the neighboring households are converted into organic fertilizer, thus contributing to the integrated solid waste management program of the city.

Shortly after the first community-based allotment gardens were established, one of the constraints observed was the lack of sanitary toilet facilities inside the gardens. A sustainable solution to address this sanitation problem had to be found.

Several stakeholder meetings with community members and local government officials took place. The model of a urine-diversion dehydration (UDD) toilet, similar to those used in Danish allotment gardens (Bregnhoj, 2003), was introduced and discussed as one of the possible alternatives. This idea was introduced to Cagayan de Oro after one of the PUVeP technicians attended a training course on ecological sanitation at the Stockholm Environment Institute (SEI) in 2004. Research conducted by PUVeP as part of the SEI course requirements showed that the application of urine increased the marketable yield of sweet corn by an average of 14%.

Similar experiments were also carried out for non-food crops in cooperation with commercial growers in different areas of Cagayan de Oro. The urine application resulted in earlier and increased flowering of different ornamental plants with subsequent better marketability, as confirmed by the growers. Greenerleaves and healthier crop stand in general were reported for certain palms and mango seedlings, which are traits appreciated by both growers and customers.

Socioeconomic studies were also conducted to investigate urban growers' and customers' acceptance of crops fertilised with treated urine and faeces. Initial studies showed that acceptance among allotment gardeners was high, with an approval rate of more than 90%, since for them treated urine and faeces were not much different from the animal manure commonly used. However, only about 60% of the potential customers said that they were willing to buy vegetables fertilised with human urine and faeces, indicating the need for a strong information and education campaign to increase acceptance of vegetables produced in such a way.

**Further developments based on the allotment garden UDDT experiences:**

As a result of different capacity building activities of PUVeP, more than 30 UDDTs were established by several non-government agencies in other areas of the province of Misamis Oriental (see separate SuSanA case study), as well as in the provinces of Lanao del Norte and Zamboanga. Most of them are located in public schools which do not have proper sanitation due to lack of water. When toilets are dirty and non-functional, open defecation is the only option left leading to serious hygienic concerns. Provision of hand washing facilities and tooth-brushing troughs by another project further complements the basic hygiene concept of these pilot schools.

Additonal 15 UDDT were established by PUVeP in rural communities of Northern Bukidnon, particularly in the municipality of Manolo Fortich and in the neighboring barangay of Balubal, Cagayan de Oro City. Primary and high schools as well as a chapel are among the beneficiaries.

## 5 Technologies applied

Double-vault urine-diversion dehydration toilets (UDDTs) are used for the collection of faeces and urine. Once the first vault is full (after approximately one year), the second vault is used by transfering the UDD bowl. A 1:1 mix of sawdust and lime is used as covering material for the faeces. Sawdust is easily available in Cagayan de Oro and free of charge. However, it has to be filled into bags and hauled at own cost. Lime is available at 12 to 15 PhP per 50 kg-bag (€ 0.24 – 0.3) and is used to raise the pH of the faeces to increase pathogen destruction. In case lime and/or sawdust are not available, ash, rice hulls and dried soil are recommended to be used as substitutes since those are usually available free of charge.

**Fig. 5:** The cemeted hole on the floor (left) is for anal washing, the blue container in the back (left) contains a mix of sawdust and lime (1:1) used as cover material for the faeces; the green container is for the collection of used toilet paper (source: Wafler, 2008).

The **waterless urinal** for men is a modified plastic container used normally for drinking water since those are very cheap compared to ceramic urinals. One side of the container is cut in a “U” shape and it is connected with a pipe at the bottom. A rubber balloon which is placed at the end of the pipe at the opening of the storage container (see Fig. 9) expands when it is filled with urine and allows urine to flow into the container. Once emptied, the rubber balloon contracts and, thus, seals the container and prevents odor emission.

Rainwater is collected from the roof top of a neighbouring building and stored in a cistern. A piping systems leads to the allotment garden and UDDT, and is used for handwashing and irrigation. Greywater from the handwashing is reused for irrigation of ornamentals.

**Fig. 6:** Ceramic urine-diversion toilet pedestal, inside of the toilet house shown in previous photo (source: DILG-GTZ Program; see also supplier’s website: www.ecosan.ph).

**Fig. 7:** The recycled water container serves as waterless urinal for men while the sink next to it is for hand-washing. Below the sink is a bucket that contains collected rainwater for handwashing with soap (Source: PUVeP, 2008).

**Fig. 8:** Sawdust-lime mixture as covering material (source: Wafler, 2008).

**Fig. 9:** A rubber balloon which seals once the urine enters the container, prevents odour emission through the pipe (source: PUVeP, 2008).

**Fig. 10:** Collected urine is stored in a plastic jerrican. The filled container is then sealed and placed in full sunlight for a period of one month for further pathogen destruction (source: PUVeP, 2008).

**Fig. 11:** The dried faeces is stored in one of the storage vaults for a period of one year after the last defecation has occurred (source: Wafler, 2008).

**Fig. 12:** Robert Holmer on the right with handful of dried faeces: **"***To believe is: …not to smell*" (source: PUVeP, 2008).

**Fig. 13:** Dried faeces after several months of storage (source: PUVeP, 2009).

## 6 Design information

The design of the double-vault UDD toilets of Cagayan de Oro was adapted from an ecosan project of Barangay Tingnan, Panglao Island, Bohol, Philippines of the DILG-GTZ Water and Sanitation Program (see Fig. 14). See also the separate SuSanA case study on this project.

# UDD toilets with reuse in allotment gardens Cagayan de Oro, Philippines

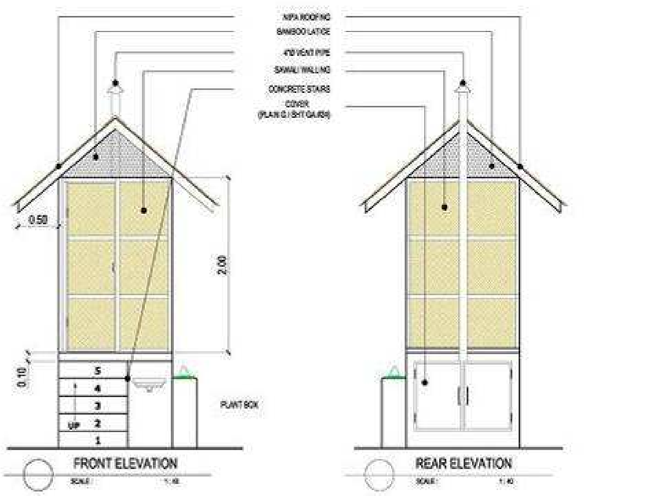


**Fig. 14-a:** Design drawings for double-vault UDD toilets (source: DILG-GTZ Water & Sanitation Program Philippines, 2005).

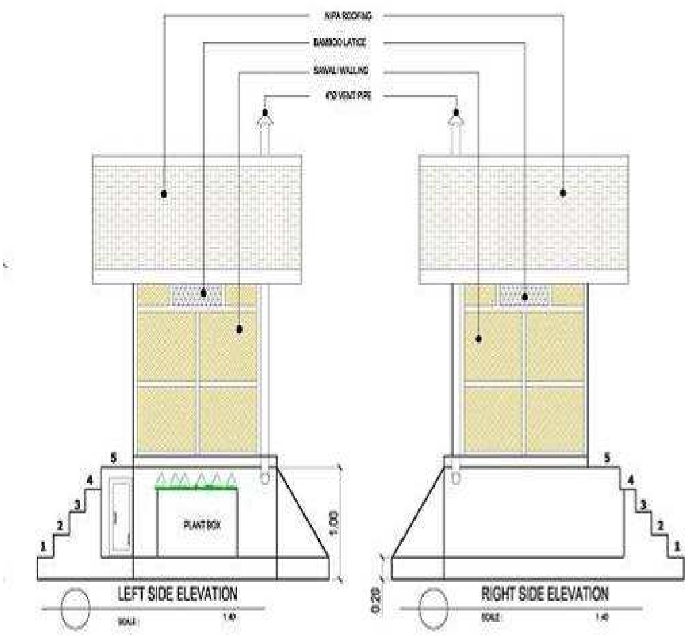


**Fig. 14-b:** Design drawings for double-vault UDD toilets (source: DILG-GTZ Water & Sanitation Program Philippines, 2005).

Design data:

- Floor area: 2 m x 1.5 m
- Floor Elevation: 0.9 m
- Ventilation pipe: diameter 2 inch, PVC
- Ceramic UD waterless bowl for urine and faeces separation
- 20 l plastic container for collection and storage of urine
- Nipa (coarse weaved palm leaves) for the roofing
- Plain G.I. Ridge roll
- For the faeces vault door plain G.I. is used painted black to increase the absorption of heat from the sunlight.
- 4x4 coconut wood for the posts in 4 corners of the toilets.
- For the urinal pipe 1" diameter also for the urinal drain difference.


**Fig. 15-a:** User guidelines "Do's" for UDD toilets (source: DILG-GTZ Water & Sanitation Program Philippines, 2006).


**Fig. 15-b:** User guidelines "Don'ts" for UDD toilets (source: DILG-GTZ Water & Sanitation Program Philippines, 2006).

## 7 Type of reuse

Urine is mainly used as a side-dress fertilizer after diluting it with water before application to plants (1 part urine to 3-5 parts of water depending on age of plant). Plants at seedling stage are more sensitive, hence a higher dilution (e.g. 1:5) is recommended compared to more mature plants. The following guidelines are given for the reuse of the treated urine:

- After the last urination, remove container from UDD toilet and store urine undiluted and in a closed container for 1 month to eliminate all pathogens.
- Storage in a sealed container prevents contact with humans or animals and hinders evaporation of ammonia
- During storage, the urine should not be diluted to provide a harsher environment for micro-organisms.
- Prior to application to crops dilute at a rate of 1 part urine with 3-5 parts of water.
- Urine can be considered as a liquid fertilizer since nutrients in urine are mostly water soluble, hence, are directly available for plant uptake.
- Urine should not be sprayed on plants but incorporated into the soil 10 cm away from the plant. This will reduce odor, foliar burns and the loss of nitrogen.

- Urine may also be applied through drip irrigation systems. However, clogging of emitters by salt precipitation may occur.
- Observe a waiting period of one month from last urine application to harvest of crops.
- Urine should not be applied to crops that are consumed raw (cucumber, lettuce, etc.) to ensure acceptance by costumers.

**Fig. 16:** Stored urine is harvested from jerrican (source: Wafler, 2008)

**Fig. 17:** Diluted urine ready for application (source: Wafler, 2008)

**Fig. 18:** Urine is applied about 5 to 10 cm from plant base (source: Wafler, 2008)

**Fig. 19**: After application, urine is covered with topsoil (source: Wafler, 2008)

**Fig. 20:** Urine is also used as a compost accelator. It is added to a compost pile when a lot of carbon-rich materials are used to reduce the C:N ratio (source: PUVeP, 2008).

Research studies conducted by Xavier University indicate that six months of storage may not fully eradicate the presence of helminth ova. Hence, for safe reuse of faeces, secondary treatment after storage is a must to prevent spreading of pathogens. The following procedures are recommended:

- Faeces should be kept in the storage vault of the UDD toilet for 6-12 months after the last defecation. Thereafter it should be subjected to a secondary treatment:
    - 60 days of vermicomposting

- aerobic composting where a temperature of > 50℃ should be obtained during at least one week in the compost heap.

- After secondary treatment, the dried and composted faeces can be used like any other organic fertilizer where nutrients are slowly released as faeces-compost is degraded in the soil by soil organisms.
- To ensure acceptance of the produced vegetables by customers and to minimize health risks, it is recommended to use treated faeces not for vegetables but for fruit trees (banana, papaya, etc) or other tree species, where the harvested plant part is at a certain distance from the soil.

The amount of treated urine and processed faeces applied depends on the specific crop and soil status. Some guidelines on the production of different vegetable crops as well as estimated fertilizer requirements are given in the Philippine Allotment Garden Manual which can be downloaded from PUVeP's website (http://www.puvep.com).

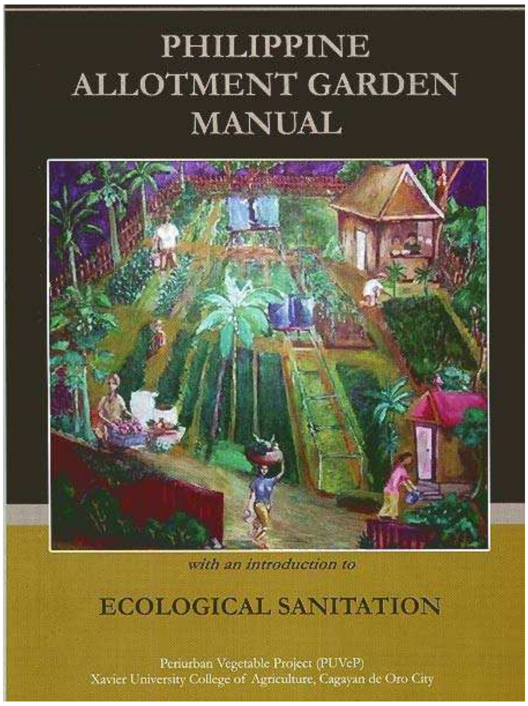


**Fig. 21:** Philippine Allotment Garden Manual with an Introduction to Ecological Sanitation (2008).

**Fig. 22:** Vermicast: Stored faeces after being vermicomposted with other crop residues (source: PUVeP, 2008).

**Fig. 23:** Treated faeces/compost is stored in bags prior to application (source: Wafler, 2008).

**Fig. 24:** The recommended amount of treated faeces/compost (usually 100 g/per hill) is placed in the planting hole and covered with soil (source: Wafler, 2008).

**Fig. 25:** An eggplant seedling is placed in the planting hole on top of the organic fertilizer (source: Wafler, 2008).

## 8 Further project components

Further project components are:

- Research on agricultural reuse, health and socioeconomic aspects of ecological sanitation
- Capacity building on ecological sanitation for the government, non-government and private sector.

- Integration of ecological sanitation in relevant academic curricula of Xavier University's School of Medicine as well as the Colleges of Agriculture and Engineering.
- Policy advocacy to decision makers such as assistance in drafting an executive order for the establishment of a technical working group on sustainable sanitiation for the city government of Cagayan de Oro, and consultancy for the Philippine House of Representatives in drafting a so-called "Ecosan Act" (June 2008).
- Showcasing of different ecosan technologies (UDDT, composting, vermicomposting, biogas and rainwater harvesting) at Manresa Farm to more than 1500 visitors from different parts of the Philippines as well as other countries. A highlight was the visit of Ms. Chin-Chin Gutierrez in July 2007, a multi-awarded Filipino actress and a Time Magazine Asian Heroine for the Environment.


**Fig. 26:** Ms. Chin-Chin Gutierrez at the UDDT in Manresa Farm (source PUVeP 2007).

## 9 Costs and economics

The material costs for establishing a UDD toilet may range from 25000 PhP (€ 410) for a double-vault UDDT to 12000 PhP (€ 197) for a single-vault UDDT, depending on the materials used. Labour costs for the construction are not included in this cost estimate because the work force was provided by the gardeners. However, it is estimated to be in the range of 5000 to 7000 PhP (€ 82-115) per toilet .

The UDDTs used in this project were purposely designed in a "luxurious", and therefore expensive, manner (e.g. use of tiles) since they were the first of their kind in Mindanao and served also as a showcase for decision makers. The costs presented also include "extras" such as information posters, floor mop, toilet paper as well as plaque of recognition for the donor.

**Table 1:** List of materials and costs (in currency PhP) for one double-vault UDDT (Source: Philippine Allotment Garden Manual - PUVeP 2008). 1 PhP = 0.02 €. Total sum: € 494.

| Qty | Unit | Item | Total |
|---|---|---|---|
| 1 | unit | Ecosan bowl (incl. freight costs) | 1,500.00 |
| 1 | pc | Urinal (reused empty water gallon) | 150.00 |
| 1 | load | Sand (1 $m^3$) | 770.00 |
| 1 | load | Gravel ( ¾ ordinary) | 1,100.00 |
| 20 | bags | Portland Cement | 3,564.00 |
| | | Coco lumber (assorted) | 3142.70 |
| 160 | pcs | Concrete Hallow Blocks – 4"x8"x16" | 880.00 |
| 5 | Length | Deformed bars – 8 mm Ø x 6m | 176.00 |
| 16 | Length | Deformed bars – 10 mm Ø x 6m | 1,953.60 |
| 2 | kg | G.I. tie wire - #16 | 105.60 |
| 3 | pcs. | ¼" x 4' x 8' – Marine plywood | 950.40 |
| 3 | pcs. | 3/16" x 4' x 8' – Hardiflex board | 1,056.00 |
| 2 | pcs | Plain G.I. Sheet – gauge #26 (3' x 8') | 473.00 |
| 8 | pcs | 2" x 3" – Hinge | 80.00 |
| 2 | pcs | 3" x 3" – Hinge | 50.00 |
| 7 | pcs | Door pull - #5 | 126.00 |
| 1 | kg | #1 – Common wire nails | 50.60 |
| 1 | kg | #1-1/2 – Common wire nails | 48.40 |
| 0.5 | kg | #2-1/2 – Common wire nails | 23.10 |
| 3 | kg | #3 – Common wire nails | 132.00 |
| 1 | kg | #4 - Common Wire Nails | 34.00 |
| 0.5 | kg | Flathead nails | 30.00 |
| 3 | pcs | 1"Ø x 10' – PVC pipe blue | 455.40 |
| 10 | pcs | 1"Ø – PVC blue – elbow 90° | 209.00 |
| 2 | pcs | 1"Ø – PVC pipe – tee | 83.60 |
| 1 | pc | 4"Ø x 10' – PVC pipe (orange) | 297.00 |
| 1 | pc | 4"Ø – PVC pipe – Tee (orange) | 74.80 |
| 120 | pcs | Nipa shingles | 420.00 |
| 0.5 | bundle | Rattan Strip | 24.75 |
| 4 | sheets | Bamboo Mat (*Amakan*) | 484.00 |
| 100 | pcs | Tiles (8 x 8) | 1,210.00 |
| 1 | Can | Solvent cement – 400 grams | 66.00 |
| 1 | pc | Kitchen Sink – small | 649.00 |
| 2 | pcs | Water jug - 20 (transparent) for urine | 440.00 |
| 1 | pc | Soap case | 22.00 |
| 1 | pc | Plastic waste can (oval-small) | 55.00 |
| 2 | pc | Container (for sawdust and tissue) | 220.00 |
| 1 | pc | Container (for water) | 110.00 |
| 1 | pc | Water ladle | 16.50 |
| 1 | pc | Cup (for ash) | 22.00 |
| 1 | quart | Black paint | 104.50 |
| 1 | quart | Red lead paint | 121.00 |
| 1 | bottle | Paint thinner | 27.50 |
| 1 | pc | Safety hasp - #4 | 13.20 |
| 1 | pc | Padlock – medium | 62.70 |
| 1 | pc | Barrel Bolt #3 | 13.20 |
| 1 | gallon | Clear gloss varnish | 418.00 |
| 1 | bottle | Lacquer thinner | 343.20 |
| 2 | pcs | Paint brush – 2" | 44.00 |
| 2 | bundles | Bamboo | 132.00 |
| 1 | pack | Gloves | 120.00 |
| 1 | pack | Facial mask | 110.00 |
| 1 | pc | Shovel | 220.00 |
| 0.5 | kg | White cement | 16.50 |
| 1 | pc | Floor mop | 275.00 |
| 1 | pc | Toilet seat | 260.00 |
| 1 | pc | Plaque | 500.00 |
| 1 | pc | Info poster (Do's and Don'ts) | 450.00 |
| 1 | pack | Toilet paper | 200.00 |
| | | **Subtotal** | **24,685.25** |

## 10 Operation and maintenance

The gardeners assign on a rotational basis a person in-charge for maintenance of the toilets. The work is equally shared between men and women. The following guidelines are provided to the gardeners:

- Well-constructed and well-maintained UDD toilets do not develop bad odors, nor attract flies.
- Ensure that the urine is directly diverted and does not touch the faeces.
- The faeces are directed into a vault or container and are covered with appropriate dehydration materials (lime/sawdust mixture or dried soil, ash, or rice hulls).
- An ample supply of covering material must always be available.
- The faeces vault must always be kept completely dry. Avoid water from entering when cleaning the floor. Do not pour water on the floor since it may enter the storage vault.
- Always close the toilet bowl lid to prevent flies from entering.
- For people who are "wipers": throw toilet paper in separate trash bin; since the toilet is dry, paper will not decompose and it is not nice to look at later on.
- For people who are "washers": use the separate anal washing area next to the toilet bowl.
- Make sure that water is always available for anal and hand washing.
- Clean the UDD bowl with a rag. A stick with a damp cloth can also be used to clean the bowl.
- Brief "first time users" on the appropriate use and/or place "user's guidelines" inside the toilet for those persons who are not familiar with how to use a UDD toilet.

## 11 Practical experience and lessons learnt

Most of the gardeners are of the opinion that the toilet is very useful not only for them but also for their children, visitors, and customers of their produce. Some of the gardeners regard the toilet as something to be proud of since it adds beauty to the garden.

All of them consider the use of the UDDT as far better than open urination and defecation. Besides the missing privacy and washing facilities there is a high risk of being bitten by snakes and harmful insects. As the toilet uses no water for flushing, a septic tank for blackwater is not needed. Furthermore, natural fertilizer is produced for free.

Some gardeners, however, are not using the toilets because they prefer to go to their own toilets in their houses if they are located nearby. Other gardeners feel not yet comfortable using the UDD toilets because they are too shy – the UDD toilets are more "beautiful" than the toilets they have at home!

There was a need to improve the design of the urinal for men because sometimes urine remained in the urinal and produced odour problems. This was done by changing the original urinal (plastic waste bin) to a recycled water container (see Section 5).

Odour problems also occurred from the faeces vault when the faeces was not well-covered after defecation. Also, so-called "rollers" caused odour problems. "Rollers" occur when the faeces in the vault is not flattened and becomes the shape of a steep hill. Faeces deposited on the top of the steep hill roll down the slope and tend not to be covered. The problem was solved by flattening the faeces pile regularly. Dung beetles and mango flower beetles, who naturally entered some of the faeces vaults as their habitat and feeding ground of their larvae faciliate the automatic flattening of the faeces, hence no human intervention is needed in those vaults.

Most of the users found that the anal washing area was inconvenient to use since there is too little space available, it is very shallow and it is located too close to the wall. Changes in the design have now been discussed.

Most of the gardeners find the toilet bowl not suitable for children's use. Some gardeners allow their children to squat on top of the toilet bowl which makes the seats dirty. The cleaning of the toilet bowl is also a concern especially when there are many users who do not know how to use it properly e.g. when some of the faeces remain on the sides of the bowl after defecation. Better systems on cleaning and maintenance of the toilet are now being discussed.

A UDD squatting pan from India will be tested later in 2009, especially for children's use in selected schools.

The difficulty of separating urine from faeces is sometimes a problem: For women it is a more difficult task than for men to keep the urine and faeces separated during defecation, but can easily be managed with some practice.

## 12 Sustainability assessment and long-term impacts

A basic assessment 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 emphasized (weaknesses).

**Table 2:** Qualitative indication of sustainability of system components. 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 | | |
| • sociocultural and institutional | X | | | X | | | X | | |

Regarding the long-term impacts of this project, it can be said that the establishment of these gardens has significantly contributed to the improvement of food security of the participating families as well as of the neighbouring families who can buy fresh, affordable and safe vegetables. Another advantage besides gardening is the fact that the gardeners collect the biodegradable wastes from the neighbouring households for composting.

This project has also served as a research and teaching facilitiy and the concept is being copied by others (see for example SuSanA case study on ecosan projects in Misamis Oriental implemented by WAND Foundation in the Philippines, www.susana.org).

## 13 Available documents and references

The website: http://puvep.xu.edu.ph/publications.htm contains numerous references for download, including those mentioned below.

Nuesca, M. Z., Lee, S. O., Trappe, L., Holmer, R. J. (2007) Effect of vermicomposting on the presence of helminth ova (*Necator americanus, Trichuris trichiura, Ascaris lumbricoides*) in human faeces. In: Proceedings of the "International Conference on Sustainable Sanitation: Eco-Cities and Villages", August 26-31, 2007, Dongsheng, China. http://www.susana.org/index.php/lang-en/cap-dev/conferences/icss-dongsheng-07, number 58.

Holmer, R., Itchon, G. (2008) Reuse of Ecological Sanitation Products in Urban Agriculture: Experiences from the Philippines. Urban Agriculture Magazine, 20, 44-46, RUAF, Leusden, Netherlands.

PUVeP (2008). Philippine allotment garden manual with an introduction to ecological sanitation. Periurban Vegetable Project (PUVeP), Xavier University College of Agriculture, Cagayan de Oro City, Philippines.

Itchon, G., Holmer, R., Tan, L. B. (2008) An Observational Study to Determine the Length of Time Necessary to Eradicate Parasitic Ova and Pathogenic Bacteria in Human Excreta Kept in the Storage Vaults of Urine-Diverting Dehydration Toilets in Cagayan de Oro City 2007-2008: A Preliminary Report. Faculty Working Series No. 11, March 2008, Kinaadman Research Center, Xavier University, Cagayan de Oro City Philippines, 6p. Also on: http://www.gtz.de/en/themen/umwelt-infrastruktur/wasser/9835.htm

## 14 Institutions, organisations and contact persons

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Robert Gensch
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Xavier University School of Medicine
Cagayan de Oro City, Philippines
Email: robert.gensch@web.de

Source for ceramic UDD bowls:
Center for Advanced Philippines Studies, Inc.
120A K-8th Street, East Kamias
Quezon City 1102 Philippines
Email: danlapid@caps.ph / dglapid@gmail.com
Web: www.caps.ph; www.ecosan.ph

Source for cement UDD bowls:
WAND Foundation, Inc. (Elmer Sayre)
Lubluban
9021 Libertad, Misamis Orienta
Philippines
E-mail: empower_8@yahoo.com
Web: http://www.wandphils.org/

**Case study of SuSanA projects**

**UDD toilets with reuse in allotment gardens, Cagayan de Oro. Philippines**

**SuSanA 2009**

**Authors: Robert J. Holmer (rjholmer@yahoo.de), Horacio S. Factura III, Analiza U. Miso, Glenda Y. Sol, Clarito A. Santos Jr., Elmer G. Elorde, Stephen O. Lee, Angelito A. Montes**

**Editors: Robert Gensch (Integrated Expert for Sustainable Sanitation at Xavier University) and Carola Israel, Elisabeth v. Münch (GTZ ecosan program: ecosan@gtz.de)**

# Bayawan City, Philippines

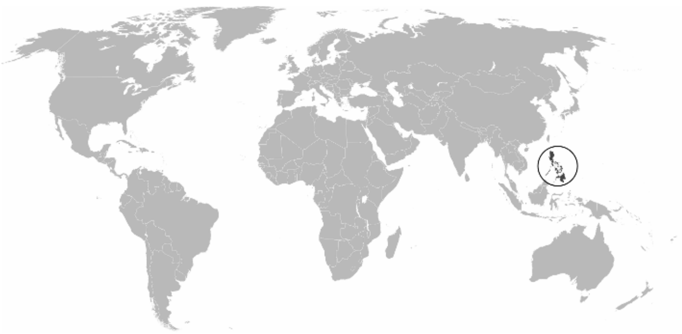

**Fig. 1:** Project location

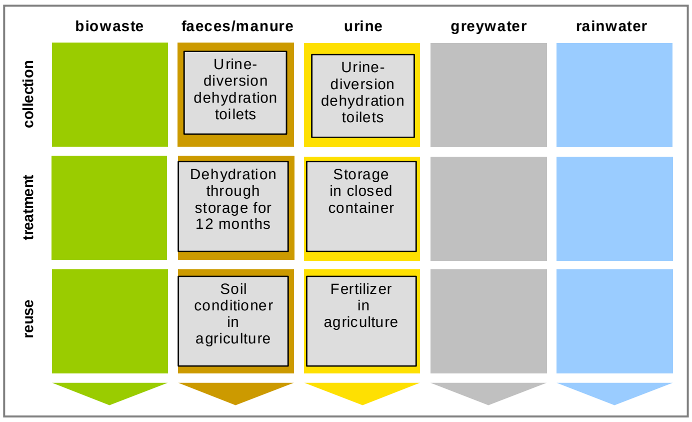


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**
Rural upgrading (pilot project)

**Project period:**
Start of planning: June 2005
Start of construction: Nov 2005
Start of operation: Jan. 2006
Phase 1 started June 2005 and is still on-going
Phase 2 started in April 2008 and is on-going

**Project scale:**
Phase 1: 40 UDD toilets planned in 28 barangays/ villages (approx. 220 people or 5.5 people per toilet)
End of 2008: UDD toilets at 22 households (household size: 5-6), 1 rural health centre, 6 barangay agricultural development centres in operation
Phase 2: UDD toilets for schools (planned number not yet known);
End of 2008: 8 UDD toilets completed
Project budget (provided by Bayawan City):
Phase 1: € 10,000
Phase 2: € 25,000

**Address of project location:**
Private households and public institutions in the rural areas (brangays) of Bayawan City

**Planning institution:**
City of Bayawan, Philippines

**Executing institution:**
Same as planning institution

**Supporting agency:**
DILG-GTZ Water & Sanitation Program (technical assistance only)
(DILG is Department of the Interior and Local Government, Philippines, GTZ is German Development Cooperation)

## 2 Objectives and motivation of the project

The objectives of the pilot project were:

- Provide improved sanitation facilities for households and public institutions in rural areas, in order to improve public health, in particular reduce intestinal worm infestation of children.
- Provide fertilizer for vegetable growers and small-scale farmers.

Note: The focus of this document is on Phase 1 of the project (Phase 2 is only mentioned for completeness).

**Fig. 3** House of a family with a UDD toilet, barangay Villareal, Bayawan City, 2006 (source: DILG-GTZ Program)

## 3 Location and conditions

Bayawan City is located in the south-western area of Negros Island in the Central Visayas region, about 700 km southeast of Manila. It has a population of about 105,000. The city has 7 barangays[1] that are classified as urban and sub-urban areas, and 21 barangays that are classified as rural. 80% of the

[1] Barangay is the smallest administrative division in the Philippines.

population of Bayawan lives in these rural areas which cover 83% of the land area.

The project is located in these rural areas (barangays) of Bayawan City. The people there are engaged in self-employment activities such as farming, fishing or trading activities. In the rural areas the vast majority of the households live of farming, either as tenants of big landowners or on their own small farms. The residents in this region are predominantly Christians.

In the project area only 10% of the population are served with safe drinking water. The majority relies on dug wells and springs. Only 1 % of the rural population has a household water connection (piped water). 63% of the households have a toilet. These are mainly pour-flush toilets with a pit or pit or VIP latrines. However, many of these facilities are in poor condition and are considered unsanitary. A common problem is the lack of water for the pour-flush toilets. In most schools the service level standard of 40 students per toilet is not met. In Bayawan City only 26 % of the students are adequately served with school toilets.

Due to these conditions, water and food borne diseases, i.e. diarrhoeal diseases, are among the leading causes of morbidity. In addition more than 50 % of school children are affected by intestinal worm infections.

## 4 Project history

The concept of ecological sanitation was introduced to the Visayas and Mindanao regions of the Philippines through the “1st International Symposium on Low Cost Technology Options for Water Supply and Sanitation” in September 2004 in Bohol. This conference was organized by the DILG-GTZ Water & Sanitation Program and the WSP (Water & Sanitation Program) of the World Bank. DILG is the Department of the Interior and Local Government in the Philippines.

The City of Bayawan attended this symposium and a group of German and Philippino experts visited Bayawan City after the conference to conduct an assessment. Two wastewater management and sanitation options were identified: a constructed wetland for domestic wastewater of a peri-urban resettlement area (see separate SuSanA case study description) and a dry sanitation concept for the sparsely populated rural areas (described in this document).

In June 2005, Bayawan City and the DILG-GTZ Water & Sanitation Program signed a Memorandum of Agreement for the planning and implementation of the ecological sanitation pilot project. An ecosan technical working group (ecosan TWG) was set up by Executive Order of the City Mayor. The ecosan TWG is a multi sectoral group chaired by the City Health Officer and composed of 10 employees from the engineering, environmental, health and agricultural offices of Bayawan City.

In September 2005, members of the ecosan TWG attended the “First ecosan Training for Rural Areas in the Philippines”, organized by the DILG-GTZ Water & Sanitation Program. After the training, the ecosan TWG began with the planning process. The project started with two pilot toilet facilities, namely one single-vault UDDT[2] with movable container and one double-vault UDDT in two different coastal barangays.

Assisted by the Community Organizer and the Technical Adviser of the GTZ Program, the TWG developed a work plan, conducted a series of stakeholder workshops and identified the two target households. Construction started in November 2005 and the facilities were turned over to the users in January and February 2006.

After a short trial period, the actual Phase 1 of the project began. It was decided to set up 1 to 2 pilot facilities in each of the **28 barangays** of Bayawan City, resulting in a total of **40 UDD toilets**. The target households and public institutions were selected through baseline surveys, interviews with selected families and in consultation with the barangay officials.

In April 2008, the City of Bayawan has started a second phase with a budget of € 25,000. Based on the experience from the previous phase, the second phase focuses mainly on schools and on selected households that can afford to cover the cost for construction material.

The implementation of Phase 1 and Phase 2 is in progress and by the end of 2008, 37 facilities had been completed: 22 in private households, 1 unit in a barangay health centre, 6 units in barangay agricultural development centres (BADC) and 8 units in 4 schools.

The DILG-GTZ Water and Sanitation Program and the GTZ-Philippines did not directly contribute cash to this project, but provided the two ceramic urine-diversion pedestals for the first two toilets and in-kind support such as posters about “Do’s and Don’ts”. Technical support comprised of several trainings and stakeholder workshops, joint monitoring and general support via staff time.

## 5 Technologies applied

The ecosan technical working group of Bayawan City decided to use UDDTs because of their comparably easy maintenance and the quick benefit that is generated through the direct use of urine as a fertilizer. Furthermore a dry system is preferred because the majority of households has no piped water supply but has to get water from communal wells or standpipes.

Sanitation technologies applied are single- and double-vault urine diversion dehydration toilets (UDDT) which have a ceramic urine diversion toilet pedestal (see Fig. 4). The urine is drained through a plastic pipe and stored in 20-liter plastic containers. Most toilets have a separate waterless urinal for men made of old 4-liter plastic bottles.

The collection vault for the faeces is made of concrete hollow blocks with concrete floors and slabs. The single-vault toilets have mobile collection containers. The toilet rooms (super-structure) are made of different materials, ranging from bamboo mats to split bamboo and ply wood.

[2] UDDT = urine-diversion dehydration toilet (some people call this also “ecosan toilet).

**Fig. 4** Ceramic urine-diversion toilet pedestal, inside of the toilet house shown in next figure (source: DILG-GTZ Program; see also supplier's website: www.ecosan.ph)

**Fig. 5** Single vault UDDT, barangay Villareal, Bayawan City, 2006 (source: DILG-GTZ Program)

The vast majority of rural households uses firewood for cooking, which means they have ash available. After defecation the faeces are covered with the ash to enhance the drying process and for optical reasons. In cases were no ash or not sufficient ash is available, carbonized rice hull[3] is used.

About 90 % of the users practice dry cleaning with toilet paper, old paper or other material. For those users which practise anal cleansing with water, all toilets have an anal cleansing area next to the toilet pedestal.

The anal cleansing water is drained into a plant box filled with gravel and soil, which is made of concrete and is attached to the collection vault. The plant box functions as a planted soil filter. Since there are no household water connections, the water sued for anal washing is provided in a plastic container.

All toilets have a handwashing basin either inside or outside the building. The used water is drained into the plant box as well.

## 6 Design information

The double-vault UDDTs were designed for households with 5 to 6 members and a 12-month storage time for the faeces. The required faeces storage vault volume per person was estimated at 110 liters. Based on these design parameters, each faeces collection vault has a storage capacity of 0.7 $m^3$.

The single-vault toilets with mobile collection containers have a faeces vault volume of about 1 $m^3$. The collection containers consist of used plastic or steel drums equipped with bin liners. When the bags are full they are stored in the vault next to the container or in another safe place if the vault is full.

The size of the urine container is limited by the space that is available below the toilet stairs (see Fig. 9). The urine containers vary in size: Most UDDTs have a 20-liter container which was shown to last a family of 5 for about one week. If the urine of 2 adults and 3 children was collected for one week at 1.25 L per adult per day, and half the amount for a child, this would result in 30 L of urine per week. But in farmer families people are often out in the fields, and urinate in the open and hence, less urine is collected. Moving the 20-L container is not too difficult, especially not for people who are used to physical work such as farmers.

The UDDTs are all built entirely above ground to facilitate high temperatures in the vaults and thus accelerating the drying process. Therefore the buildings have a small staircase. The number of steps varies, depending on the individual design. The standard design has 4-5 steps of 20 and 25 cm width and height, respectively.

**Fig. 6** Single-vault UDDT, technical drawings (source: Provincial Engineering Office, Negros Oriental, 2007)

[3] Carbonized rice hull is made by partly burning rice hulls so that the hulls keep their texture and do not turn into ash.

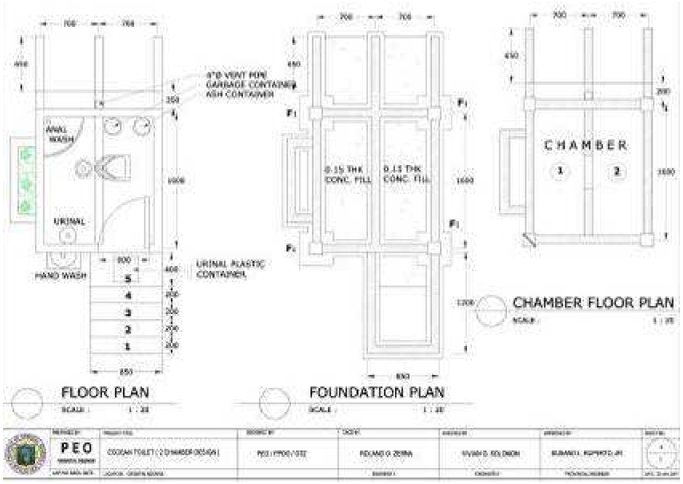


**Fig. 7** Floor plan double-vault UDDT (source: Provincial Engineering Office, Negros Oriental, 2007)

Both UDDT types have access hatches for the faeces vaults which are at an angle and made of black metal to attract heat. The big doors make it easy to spread the faeces and empty the collection vaults. Ventilation is provided through ventilation pipes at the back of the building. The pipe is usually made of PE and 20 cm in diameter. It starts in the vault and reaches up to 0.3 m above the roof. The openings are covered with fly screens to prevent insect infestation.

The faeces collection vaults of both toilet types are made of concrete hollow blocks with concrete floors and slabs. The storage space for the urine storage containers is under the stairs and easily accessible through a separate door.

The toilet pedestals are made of sanitary ceramic which is easier to maintain than concrete pedestals. The pedestals were purchased through a manufacturer in Luzon (Centre for Advanced Philippine Studies, CAPS – www.ecosan.ph), who is the only producer of ceramic UDDT pedestals in the Philippines so far.

The toilets are also equipped with waterless urinals for the men because they prefer the urinals instead of the UDDT pedestal for urinating. The urinals are made of old plastic bottles. The drainage pipes for the urine have a sufficient slope to drain completely. Thus urine odour can be kept at a minimum.

The toilet super-structure ("house") is made of different materials. The material is chosen by the household and depends on availability and affordability. Thus the material ranges from split bamboo to plywood for the walls and GI galvanized steel sheets to palm leaves for the roof.

All UDDTs were built as outdoor toilets. The main reason for this was that the users felt at the beginning more comfortable with this conventional setting. Many users were concerned about insects and bad odours as it is known from simple pit latrines. Future UDDTs could also be built indoors.

**Fig. 8** Inside a UDDT, barangay San Miguel, 2008 (source: DILG-GTZ Program). Note waterless urinal on the left. Area for anal washing in the far left corner.

**Fig. 9** Urine container, UDDT in barangay Villareal, 2007 (source: DILG-GTZ Water and Sanitation Program)

## 7 Type of reuse

The use of human faeces as a fertilizer has no tradition in Bayawan. However, many households have practiced the use of urine as a fertilizer for a long time. It is usually collected in vault pots. In the morning the urine is dilluted with water and directly applied as fertilizer.

At the beginning of the project the ecosan technical working group informed the households about the benefits of using urine and dried faeces for crop production.

The information campaigns during project implementation included training sessions on the safe use of dried faeces and urine. Households with a double-vault UDDT store the faeces in the vaults for 12 months and use it directly as soil conditioner around fruit trees as well as for corn and rice fields. The faeces of the single-vault UDDTs are either stored for 12 months as well or are composted after 6 months in the composting facilities of the city (barangay agricultural development centres) before it is used[4].

The urine from the UDDTs is usually directly used (without any storage period). The farmers dilute one part of urine with 3 to 5 parts of water and use it as fertilizer for rice, certain vegetables and ornamental plants as needed.

The farmers reported that plants grow better than before. Since the majority of farmers have no money to buy commercial fertilizers, the fertiliser from the ecosan UDD toilets is perceived as a big advantage.

The Periurban Vegetable Project of Xavier University in Cagayan de Oro, Mindanao, which is a partner of the DILG-GTZ Program, has carried out various research projects on treatment and reuse of faeces and urine (see http://puvep.xu.edu.ph/ and also the separate SuSanA case study description).

## 8 Further project components

The project put a strong focus on active household participation during the planning and implementation stages. It started with information campaigns on health, hygiene and sanitation, which included discussions of the existing situation.

The planning phase included baseline surveys of the project area, a series of stakeholder workshops and household interviews to generate interest, confirm the commitment of the selected households and to agree on design parameters.

The households were involved in the construction process by providing building material and assisting the construction workers in the construction of the toilets. Thus local people were trained in UDDT construction.

Training sessions in maintaining the UDDTs and in practices of safe reuse constituted further important aspects of the implementation phase. Once the toilets were completed, the project team conducted household visits to monitor the use of the toilet and the reuse practices.

Monitoring activities throughout the entire project phase are an integral part of the project cycle. They made it possible to improve the design, mitigate construction errors and to ensure that the households maintain their new toilet facilities properly and are encouraged to apply safe reuse practices.

A short monitoring visit to observe of the proper use and operation of UDDTs is usually conducted a couple of weeks after the users begin to use the facility. A more comprehensive monitoring is conducted after several months of operation. This includes technical aspects (maintenance, functionality) as well as the general perception of the users, their satisfaction with the ecosan system and reuse practices.

Until the end of 2008, monitoring was conducted by members of the ecosan technical working group (TWG) with support of GTZ-Philippines personnel. From January 2009 onwards, monitoring of new facilities will be done by the ecosan TWG only.

**Fig. 10** Construction of a double-vault UDDT, barangay Narra, 2007 (source: DILG-GTZ Program)

## 9 Costs and economics

The capital costs for the two types of UDD toilets are shown in Table 1 below. Attempts were made to reduce the costs through a modified design. However, especially for the single-vault UDDT, the cost could only be reduced by about 16% by choosing cheaper materials for the super-structure.

**Table 1:** Budget with cost breakdown of UDDT units in this project (including material and labour cost)

| Item | Cost (€) | |
|---|---|---|
| | Single-Vault | Double-Vault |
| Material super-structure | 60 – 85 | 60 – 85 |
| Material sub-structure (including piping) | 120 – 170 | 180 – 200 |
| UDDT ceramic pedestal | 15 | 15 |
| Labour cost[a] | 70 – 90 | 90 |
| Total | **285 – 340** | **345 - 390** |

[a] Actual labour cost might have been lower

The costs are so high that most low-income households cannot build UDDTs without external funding. Currently the City of Bayawan funds the substructure (collection vault), the pipes and the toilet pedestal. The households contribute around 30 % of the construction costs through material for the super-structure and unskilled labour.

Bayawan City allocated approximately € 10,000 for the first phase of the ecosan project. The budget included costs for the planning process, i.e. social preparation and construction costs for the substructures. The planning process (social preparation) consumed about 40% of this budget.

This means that the 22 UDD toilets were built with approx. € 6000 equating to approx. € 272 per toilet. Bayawan City used a lot of surplus material from other construction projects for the UDDTs and the real labour costs might have been lower than in the cost calculation shown in Table 1.

[4] Unfortunately, Bayawan city does not monitor the amount of compost produced from this facility.

For Phase 2 Bayawan City allocated € 25,000 for school toilets. So far 8 units in 2 schools have been completed. The target number of schools and toilets has not yet been published. If the costs per toilet were the same as in Phase 1, and 60% was again used for hardware, then about 55 UDD toilets could be built in Phase 2.

The costs for operation and maintenance have not been monitored. However, the time spent for providing ash, carbonised rise hull and water for handwashing as well as the cleaning of the toilet (emptying the urine container and the faeces vault) was conservatively estimated as € 5 per year. This figure includes € 1 contingency in case people have to pay for the carbonized rice hull. At the moment it is still for free.

## 10 Operation and maintenance

Operation and maintenance include keeping the toilets clean, covering the faeces after defecation with carbonised rice hull or ash, and monitoring the urine and faeces levels in the collection containers and vaults. The faeces are spread in the vault from time to time to enhance the drying process. All these tasks are done by the households themselves. In the barangay agricultural development centres and the health centre the facilities are maintained by the staff.

The results of the comprehensive monitoring showed that the vast majority of users is motivated and able to operate and maintain their UDDTs properly. However, in some cases additional instructions were necessary. This was mainly the case with families who had undergone the training several weeks before the facilities were completed and the first monitoring visit had been delayed.

A number of completed facilities were only monitored for a few months after completion. Some of these UDDTs had not been used at all because the households didn't feel confident to use the new facilities. Refresher trainings resolved the problem and the vast majority of facilities are used and well maintained at the time when this document was last updated.

## 11 Practical experience and lessons learnt

Intensive social preparation through stakeholder workshops and recurring household visits ensured that the future users participated right from the beginning in the planning and implementation processes.

Training sessions on operation and maintenance as well as on safe reuse practices were part of the implementation process and prepared the households for the new concept.

All UDDTs have a poster with Do's and Don'ts in picture format. However, households needed refresher training in operation, maintenance and reuse when the time between training and completion of their facility was too long.

The planning and implementation process took much longer than originally planned because the project area covered all rural barangays of Bayawan City. Each pilot site covered only one to two families. This made especially the planning process with its numerous social preparation activities very time consuming and expensive for the city administration.

Monitoring visits by the ecosan technical working group (TWG) ensure that the users can discuss issues and ideas with the members of the ecosan TWG. The ecosan TWG uses the information for the ongoing ecosan activities.

The comprehensive monitoring of the GTZ program showed that most users and the city government prefer *single vault* UDDTs with mobile container (rather than double-vault UDDTs). The users state that is more pleasant to use and maintain. For the city government the lower cost are an important advantage. For the schools, the single-vault with mobile container is the better option because the storage volume for faeces is more flexible with this system.

## 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).

The technology was assessed as easy to use during the monitoring in late 2008 and early 2009, and especially the easy reuse of urine was considered a strong point.

With regards to long-term impacts of the project, the main expected impact of the project is lower disease and parasite infestation (intestinal worms).

Water pollution is not an issue here because of the hydrological conditions in the project area.

At least the 220 people who will have UDD toilets at the end of Phase 1 will be positively affected by the project. But, more importantly, it is the expectation that this concept and technology will be copied by others who see the UDD toilets and understand their benefits. This should particularly occur with the UDD toilets located at the rural health centres and the barangay agricultural development centres.

**Table 2:** Qualitative indication of sustainability of system components. 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 | | |
| • sociocultural and institutional | X | | | X | | | X | | |

## 13 Available documents and references

Some of the documents listed below are available on http://www.watsansolid.org.ph/. Those which are not on this website can be obtained via the PEN (Philippine Ecosan Network) Yahoo Group. Robert Gensch from CIM at Xavier University has taken over the administration of this group in Feb. 2009 (robert.gensch@web.de).


- DILG-GTZ Water & Sanitation Program (2004) 1st International Symposium on low cost technology options for water supply and sanitation, September 2004
- DILG-GTZ Water & Sanitation Program (2005) Ecosan potential for Bayawan, Anne Kleyboecker, January 2005
- City of Bayawan, Office of the City Mayor (2005) Executive Order No 2005-20, Creating the ecological sanitation technical working group for the implementation of the ecosan project of Bayawan in cooperation with the German Technical Cooperation Agency, June 2005
- DILG-GTZ Water & Sanitation Program (2005) 1st ecosan training for rural areas in the Philippines, September 2005
- Provincial Engineering Office Negros Oriental (2006) Technical Drawings for double and single vault UDDT, February 2006
- Bayawan City (2007) Bayawan City adopts ecosan as a tool for health and environmental management, Mayor Herman P. Sarana, presented at International Conference on Sustainable Sanitation, Dongsheng, China, 28 August 2007, http://www.ecosanres.org/icss/proceedings-presentations.htm (under: 28 August 16:00-17:30, Room #2)
- DILG-GTZ Water & Sanitation Program (2008) Project Report on Monitoring of ECOSAN Urine Diversion - Dehydration Toilets (UDDT) in Southern Philippines, Philippines, Imelda Balbuena and Ulrik Lipkow, February 2009[5]
- DILG-GTZ Water & Sanitation Program (2006 and 2008) Guideline for planning and implementing ecosan projects in rural and peri-urban areas of the Philippines, Bianca Gallinat and Ulrike Lipkow, December 2008


## 14 Institutions, organisations and contact persons

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Quezon City, Metro Manila
Philippines
Email: gtzwater@info.com.ph
Web: www.watsansolid.com.ph
*Note: this project will finish in July 2010.*

**Supplier of ceramic UD toilet pedestals:**
Ecosan Philippines
c/o Centre for Advanced Philippine Studies
www.ecosan.ph

**Case study of SuSanA projects**

**Urine-diversion dehydration toilets in rural areas, Bayawan City, Philippines**

**SuSanA 2009**

**Author: Ulrike Lipkow (was GTZ Philippines until March 2009); ulrike.lipkow@gmail.com**

**Editor: Carola Israel, Elisabeth v. Münch (GTZ ecosan program: ecosan@gtz.de)**



[5] The final report is not yet complete. However, most of the information for this case study is based on data from the last monitoring trips and the draft report. The report will be available in March 2009 either through PEN or the DILG-GTZ program website.

Case study of sustainable sanitation projects

# Rural community and school UDD toilets in Misamis Oriental
# Libertad, Initao and Manticao, Philippines

**Fig. 1:** Project location

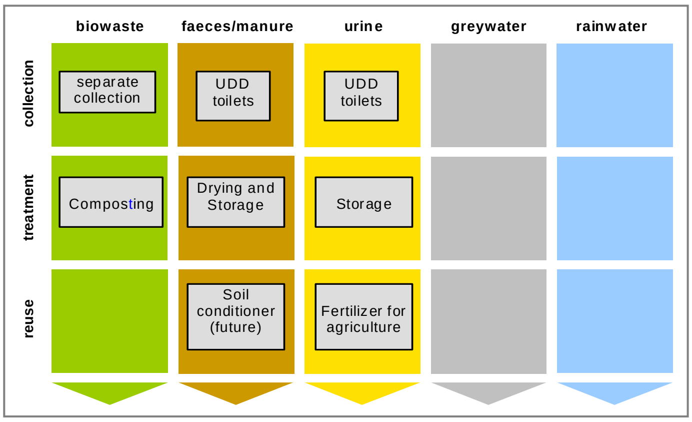


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

Rural community and school toilets (pilot scale)

**Project period:**

Start of planning: February 2006
Start of construction: March 2007
Start of operation: August 2007
Monitoring and support period: March 2007 to present (and ongoing)

**Project scale:**

23 community ecosan UDD toilets at “barrio centres” and at primary schools (at 14 different locations), frequented by an estimated total of 1,000 people

**Address of project location:**

Municipalities of Libertad, Initao and Manticao in the province Misamis Oriental, Philippines

**Planning institution:**

Water, Agroforestry, Nutrition and Development Foundation, Inc. (WAND)

**Executing institution:**

Same as planning institution

**Supporting agency:**

German Federal Ministry of Economic Cooperation and Development (BMZ) through the German Doctors for Developing Countries

## 2 Objectives and motivation of the project

The main objective of the project is to improve the lives of low-income, marginalized farmers through the improvement of sanitation, promotion of sustainable farm-based livelihoods, and mobilization of the communities so that they live dignified lives with full participation in the democratic society.

These improvements will come about by – amongst other initiatives - installing community toilets[1] where local people can get organic fertilizer for their seedling nurseries and plants (a community toilet is a toilet building where local people share its use and upkeep). Furthermore, toilets were also built at local primary schools.

**Fig. 3** Ecosan UDD toilet (painted concrete pedestal) at Libertad Municipality (photo: E. Sayre, March 2008)

## 3 Location and conditions

Misamis Oriental is a province in the Philippines located in a region called Northern Mindanao, about 1 hour and 20 minutes flight from Manila[2]. Its capital and provincial center is Cagayan

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[1] In this document, „community toilets“ are understood to be the same as „public toilets“.

[2] The Philippines is divided into three island groups: Luzon, Visayas, and Mindanao. These are divided into 17 regions, 81 provinces, 136 cities, 1,494 municipalities, and 41,995 barangays or barrios (www.wikipedia.org).

de Oro City. Misamis Oriental is composed of 24 municipalities, most of which are located along the coastline. The province has different types of industries such as agriculture, forestry, food processing, metal, mineral, and chemical industries.

The ecosan projects are established in the municipalities of Libertad, Initao and Manticao which are located 40 kilometers west of Cagayan de Oro. In these municipalities, 95% of the population consists of farmers. The average household size is quite large (7 members).

Most families are small-scale farmers with an average of less than 1.5 hectares per family. About 12% of the rural population consists of land owners. The main staple crop is corn and the perennial crop is coconut. Other crops grown are banana, tobacco and vegetables. The average income per family is € 60 per month.

Most families have poor sanitary conditions and lack proper toilet facilities. 42% of the residents have no toilets but defecate in open fields or in creeks and rivers (the other 58% of the population use either open pit latrines or flush toilets).

This results in a high prevalence of parasites, worms, and transmission of communicable diseases within the local residents. It is estimated that up to 60% of the children are infected by intestinal parasites.

In rural areas of the Philippines, the under-five mortality rate[3] is currently approx. 35 children per 1000 (http://www.childinfo.org/mortality.html).

**Fig. 4** Two double-vault ecosan UDD toilets in Sinalac Elementary School in Initao Municipality – one for boys, one for girls. The school has 230 pupils; it also has 2 conventional toilets, being pour-flush with pit (photo: E. Sayre, Feb. 2008).

## 4 Project history

The Water, Agroforestry, Nutrition and Development Foundation (WAND) is a local NGO with its main office in Lubluban, Libertad, Misamis Oriental. WAND started as a localised initiative implemented in 2003 in 2 barrios in Mindanao. The German NGO "German Doctors for Developing Countries" is WAND's long-term partner supporting its agro-forestry and small scale agriculture initiatives since 2004. The introduction of ecosan is an offshoot in WAND's search for cheap and readily available fertilizer for local farmers.

The German Doctors for Developing Countries received funding from the German Federal Ministry of Economic Cooperation and Development (BMZ) via Referat 112 (chapter 2302, title 687 06) – this is a pot of money for private implementing organisations („private Träger"). The reference number for the entire project is 112 – T 7360 – PHL 43. The total budget for this project, which is carried out by two implementing organisations is € 584,480; the BMZ part is € 438,360. The project period is from 2006 to 2009. See also www.bengo.de for further information on the application procedure.

Technical knowledge about ecosan was acquired from the Periurban Vegetable Project of Xavier University College of Agriculture (see Section 6). Participation in ecosan training sessions enhanced further the knowledge of the users, i.e. the members of the local communities, on the ecosan concept.

The construction of the **23 UDD toilets** began in March 2007 and was completed by August 2007 (for details see Table 1 and 2). The toilets have now been used for 1.5 years. These 23 toilets, built at 14 different locations, of which 7 are schools, are frequented by approx. **1,000 people** overall (about 60 people per toilet for the school toilets and 22 people per toilet for the community toilets).

WAND's present practice is to promote ecosan UDD toilets at the community level (community toilets at barrio centres[4] or at primary schools) since the cost of building these toilets is too high for the low-income households in these areas.

## 5 Technologies applied

Double-vault urine diverting dehydration toilets (UDDTs) are used: Urine and faeces are collected separately, and without water, in these toilets. People who use water for anal cleaning ensure that this water is collected in a separate container (this water is directly used for plants and gardens). Very few people in this area practise anal cleansing with water (about 5% of the population is Muslim, the rest Christians).

The sites where the ecosan UDD toilets are built are selected during a 2-stage process whereby local officials or school officials submit a letter of interest to the WAND Foundation, and then WAND's field staff conducts a local assessment.

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[3] The under-five mortality rate is the probability (expressed as a rate per 1,000 live births) of a child born in a specified year dying before reaching the age of five if subject to current age-specific mortality rates.

[4] A barrio centre is a place where the barrio office, a meeting hall and the health centre are located. A barrio is much smaller than a town. A town consists of 15 to 30 barrios.

**Table 1**. Eight Locations of 10 community ecosan UDD toilets implemented by WAND foundation in province Misamis Oriental, (all are now in operation and are being monitored) – about 22 people use each community toilet, located near barrio centres.

| Municipality | Location | Number |
|---|---|---|
| Initao | Apas | 1 |
| Libertad | Gimaylan | 1 |
| Initao | Initao Poblacion (1 in Purok 3, 1 in Purok 5) | 2 |
| Libertad | Lubluban (WAND Office and Demo Farm) | 1 |
| Initao | Tagpaco | 2 |
| Initao | Tubigan: Tubigan Barrio Center | 1 |
| Initao | Sinalac: Sinalac Barrio Center | 1 |
| Manticao | Mahayahay | 1 |

**Table 2**. Seven locations of 13 school UDD toilets implemented by WAND foundation in province Misamis Oriental (all are now in operation and are being monitored) – frequented by approx. 60 people per school toilet)[5].

| Municipality | Location | Number |
|---|---|---|
| Initao | Casilihon Elementary School | 1 |
| Initao | Initao Central Elementary School | 2 |
| Libertad | Lubluban Elementary School | 2 |
| Initao | Sinalac Elementary School | 2 |
| Initao | Calacapan Elementary School | 2 |
| Initao | Oguis Elementary School | 2 |
| Manticao | Digkilaan Elementary School | 2 |

## 6 Design information

The double-vault UDDT design was adopted from ecosan projects of the allotment gardens in Cagayan de Oro City (see separate case study for further details and/or the website of the "Peri-urban vegetable project" at Xavier University: http://puvep.xu.edu.ph). One toilet is to be shared by 10 to 200 people depending on the location (e.g. the estimate used in Section 4 is that 22 people share a community toilet and 60 people share a school toilet).

The concrete urine-diversion pedestals were manufactured by the WAND Foundation. WAND copied the mould from a commercial unit bought from a supplier in Manila c/o the Center for Advanced Philippine Studies (CAPS: www.ecosan.ph). The pedestal (or bowl) is made of cement, iron wires for strength and special paint. At present WAND has manufactured a total of 120 UD pedestals and will use the remaining 97 pedestals for the expansion of WAND's ecosan activities.

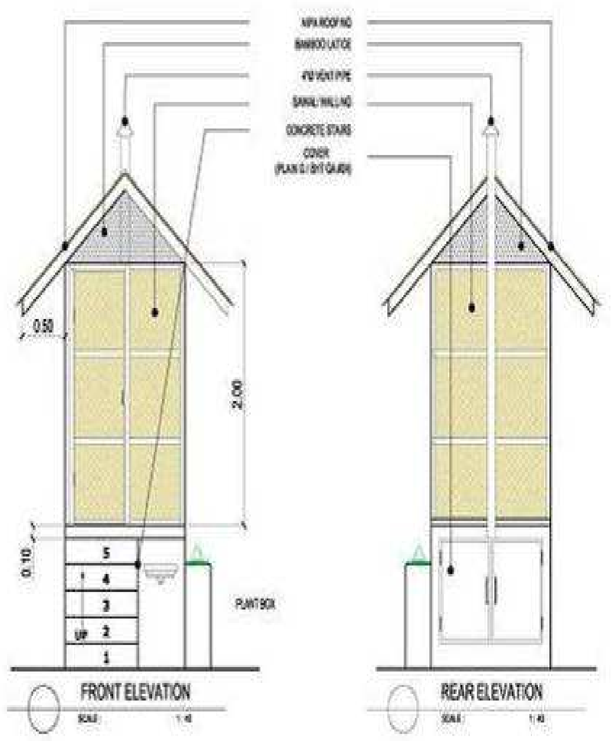


**Fig. 5** Design drawings for double-vault UDD toilets – Part 1 of 2 (design drawings provided by Dr. Holmer from PuVep, see http://puvep.xu.edu.ph)

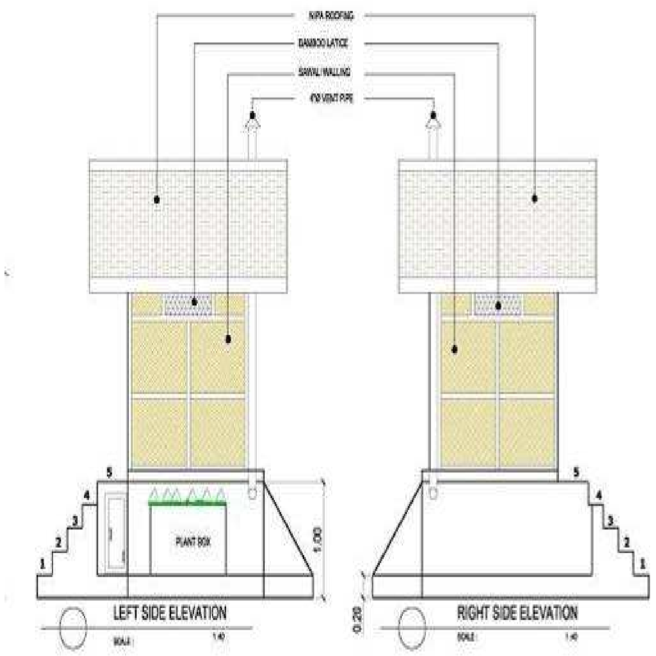


**Fig. 6** Design drawings for double-vault UDD toilets – Part 2 of 2 (design drawings provided by Dr. Holmer from PuVep, see http://puvep.xu.edu.ph)

5 Most of the schools currently have 2 conventional toilets, 1 for male, 1 for female. The toilets are pour flush with a septic tank or pit.

**Fig. 7** Elmer Sayre with 2 visitors inspecting construction of a UDD toilet and a garden for product reuse at Libertad Municipality (photo: WAND, Feb 2007)

Technical details for the UDD toilets:

- Floor area: 2.00 m x 1.50 m
- Floor Elevation: 0.9 m
- Ventilation pipe: diameter 2 inch, PVC
- Urinal pipe: diameter 1 inch
- 16 L plastic container and 200 L plastic drums for collection and storage of urine
- Roof: thatched roof (made of nipa leaves) or corrugated sheet roof
- For the faeces vault door, galvanized steel is used painted in black to increase the absorption of heat from the sunlight. The faeces vault is about 1 m x 1.5 m in floor area and 1 m high (1.5 $m^3$ volume[6]).
- Four 4-inch coconut wood for the posts in the 4 corners of the toilets.
- Faeces covering material is either ash or, if that is not available, soft limestone which is available throughout the region.

## 7 Type of reuse

Urine is diluted with water (1:15 dilution) and is used as fertilizer in household vegetable gardens, fruit orchards, and seedling nurseries where the seedlings are raised. The seedlings are Gmelina arborea, mahogany, ipil-ipil, mango, lanzones and other fruit trees. Urine is stored for 2-3 days, then diluted with water (1:10) before being directly worked in the soil to fertilize the plants (in the case of fruit and timber tree seedlings, the farmers use the urine immediately; in the case of vegetables, they store the urine in 200-liter plastic drums for at least one month).

When both faeces vaults are full (approx 1 year for each vault, so 2 years in total), the faeces will be further decomposed in a vermi-composting process before being used as soil conditioner. The vermi-composting units are simple boxes made of bamboo and sticks and filled with the dried faeces, animal manure and other organic waste. This is simple to operate and local community members know how to operate this already.

Users of some UDD toilets have already switched from vault 1 to vault 2, others are still using vault 1 only. It is expected that in Feb. 2009, the first vault needs to be emptied for some toilets – after 1.5 years of UDD toilet operation.

**Fig. 8** Use of diluted urine in a seedling nursery at Initao Municipality (photo: E. Sayre, May 2006)

**Fig. 9** Peter Wychodil of the "German Doctors for Developing Countries" inspecting a vermi-composting unit at Dipolog City (photo: E. Sayre, November 2008)

## 8 Further project components

This project is part of WAND's water, agroforestry and nutrition initiative funded by the Federal Ministry of Economic Cooperation and Development (BMZ) via the German Doctors for Developing Countries, who engaged WAND for this project (as explained in Section 4).

Further project components include:

- Promotion of small, sustainable farming systems including local livelihood projects, helping farmers to have an increased income.
- Reforestation of at least 300 hectares watershed areas.

[6] This is quite a large volume compared to other UDD toilets (adding to cost of construction).

- Planting of fruits such as lanzones, durian, noni, rambutan and pomelo.
- Training and developing the capabilities of local people in terms of organizational development and technical skills like agro-forestry and animal breeding.
- A part of the WAND project is a package of assistance to small-scale farmers consisting of support to their water demand, soil conservation and vegetable gardening. Vegetable seeds are provided to small-scale farmers on a credit basis.

## 9 Costs and economics

The total cost of building the 23 double-vault UDD toilets was pesos 600,000 or roughly € 9,000 Euro, which includes costs for monitoring, training and general management (equivalent to € 390 per UDD toilet, including "software").

The "hardware" costs of establishing one outdoor double-vault UDDT is **€ 300**. The cost is relatively high, and one option for cost reduction would be to use bamboo for the wall and roofing materials. Another option is to use single-vault UDD toilets with movable containers instead of double-vault toilets (see also case study description about UDD toilets in Bayawan, Philippines).

The total cost of € 300 consists of:

- concrete hollow blocks: € 30
- cement: € 46
- steel bars: € 42
- painted concrete UD pedestal: € 25
- wood, wall and roofing materials: € 66
- sand and gravel: € 24
- nails, reducer and tiles for flooring: € 43
- galvanized iron: € 24

Labor such as constructing the vaults, plumbing, building the walls and roof is provided at no cost by the local counterpart.

In the Philippines, user fees at public toilets are fairly common. An "ecosan user fee" could be implemented in order to recover costs for construction, operation and maintenance of the community UDD toilets. This idea has been tried already with an NGO in the nearby province of Zamboanga del Norte where users are asked to pay per use of the ecosan UDD toilet constructed near a market place.

Some of the urine fertilizer and compost could also be sold to seedling nurseries and gardeners.

## 10 Operation and maintenance

The community members are in charge of operation and maintenance of the UDDTs since these are community toilets. A local committee is in charge of the maintenance and mainly the women do the cleaning. In the case of UDD toilets in schools (see Table 2), the school headmaster takes over responsibility of the operation and maintenance of the system.

The reported experience so far is that all toilet users are using the toilets without problems, and the separation of urine and faeces works well. One factor which may have contributed to this success is WAND's close monitoring and the involvement of the school headmasters and local barrio (or barangay) officials at the start of the project.

**Fig. 10** Inside view of a faeces vault (with faeces and ash) of a double-vault UDD toilet at Initao Municipality. Note how dry the vault content looks – excellent operational result (photo: E. Sayre, Feb. 2008)

## 11 Practical experience and lessons learnt

A guideline produced by the GTZ-Philippines detailed the steps on how to start an ecosan initiative (see Section 13). These steps were helpful even though it turned out that the steps, consisting of awareness raising, launching, baseline study, social preparation, decision making and implementation, do not take place in a chronological order but as an iterative process.

Promotion and implementation of ecosan UDD toilets have met the following difficulties from which lessons could be learned:

- Some people did not participate, distrusted or even opposed the ecosan project because it aimed at changing existing sanitation norms and practices such as open defecation.
- It became clear that social acceptance cannot be reached by a one-time activity, since it may be very difficult to change long-held religious beliefs and cultural practices. One belief is that faeces are associated with dirt and are "yucky" therefore it is not appropriate to use them as fertilizer. It is important to involve the community from the planning phase to the implementation and to provide a proactive, consistent, clear and reliable communication with all concerned stakeholders in order to gain trust.
- The lack of political will among the local government units for providing improved sanitation constituted a major obstacle.

Some of the factors the project succeeded in are described below:

- Identification and mobilization of local promoters: An evaluation carried out by the municipality found that approx. 70% of the people were neutral to the ecosan approach. Another 15% of early adopters actively supported the idea while the remaining 15% vehemently opposed it. For an effective promotion, the 15% of early adopters were encouraged with the aim to have them persuade the 70% of neutralists. This was done by concentrating on innovative local farmers who had leadership capacity and stamina to promote ecosan to their neighbours.

- Implementation of incentives: As an incentive, farmer participants were provided with vegetable seeds on a credit basis.
- Use of multiple teaching and learning techniques: Some of the early ecosan initiatives lacked continuous training (one example is the experiment done in Bohol Province by a group based in Thailand). In the present case, multiple teaching methods were used like lectures, posters and simple illustrated manuals in the local dialect as well as on-site demonstrations. The GTZ Philippines office supported WAND by training 3 of their community trainers on ecosan in Dumaguete City in 2007. This has ensured that the ecosan concept slowly became part of the people's routine actions.
- In order to be credible, own practice should precede any promotion. In this spirit, an ecosan UDD toilet was built in the WAND main office in Libertad which is used by WAND staff and by farmers coming to the office to attend training sessions.

## 12 Sustainability assessment and long-term impact

A basic assessment (Table 3) 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 components. 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[a] | | | transport and reuse[b] | | |
|---|---|---|---|---|---|---|---|---|---|
| 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 | |
| • sociocultural and institutional | X | | | X | | | X | | |

[a] Storage and drying of faeces and in future vermi-composting
[b] Reuse only for urine so far, not for faeces

With regards to long-term impacts of the project, the main expected impact of the project is improved health of villagers (e.g. less intestinal worms) and lower pollution of water bodies. A full assessment of the long-term impact of the ecosan project will be carried out in 2009.

It will be difficult to prove the health benefits from this project as there are many pathways for disease transmission. From this point of view, it would be better to equip an entire school with UDD toilets instead of many schools with just one. Then the pupils' health status could be compared from one school with UDD toilets to another school without. As the UDD toilets also produce valuable fertiliser, the pupils' nutritional status may also be increased if the fertiliser applications result in higher yields at the school gardens.

## 13 Available documents and references

Sayre, E. V. (2007) Muslim-Christian Ecological Sanitation Project. Award-winning project submitted to the 2007 Philippine Development Marketplace.

Sayre, E. V. and Sayre, C. (2007) Promoting the Rehovot Approach in Advancing Integrated Rural Development and Peace in Conflict Areas in Mindanao, the Philippines. First prize winner, Weitz Center Israel international competition on integrated rural development, 2007.

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DILG-GTZ Water & Sanitation Program (2008) Guideline for planning and implementing ecosan projects in rural and peri-urban areas of the Philippines, Bianca Gallinat and Ulrike Lipkow, updated December 2008

## 14 Institutions, organisations and contact persons

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www.aerzte3welt.de
E-mail: PWychodil@aerzte3welt.de

**Case study of SuSanA projects**
**Rural community and school UDD toilets in Misamis Oriental – Libertad, Initao and Manticao, Philippines**
**SuSanA 2009**
**Authors: Elmer V. Sayre (WAND), Elisabeth v. Münch (GTZ)**
**Editor: Carola Israel (GTZ ecosan program) – ecosan@gtz.de**

# Constructed wetland for a peri-urban housing area Bayawan City, Philippines - Draft

**Fig. 1:** Project location

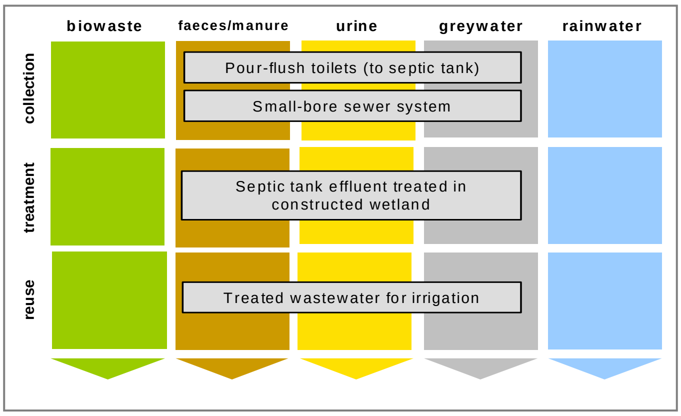


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

Peri-urban upgrading of a settlement; domestic wastewater treatment with constructed wetland (or reed bed)

**Project period:**
Start of planning: Feb 2005
Start of construction: June 2005
Start of operation: Sept 2006 (and ongoing)

**Project scale:**
Relocation housing area for ultimately 676 households (average household size of 5 people); currently 2,775 people have moved in.
Total construction cost for the constructed wetland was about EUR 160,000 including consultancy and labour.

**Address of project location:**

Fishermen's Gawad Kalinga Village, Barangay Villareal, Bayawan City, Philippines

**Planning institution:**
City of Bayawan, Philippines
Oekotec GmbH, Belzig, Germany
Gerry F. Parco & Marc Mulingbayan, Philippines

**Executing institution:**
City of Bayawan, City Engineering Office

**Supporting agency:**
Department of the Interior and Local Government (DILG)-GTZ Water & Sanitation Program (but only for consultancy fees and various technical assistance - not for construction itself which was financed by Bayawan City)

*Draft version: We are still in the process of obtaining some missing data (marked in yellow).*

## 2 Objective and motivation of the project

The objectives of the project were:

- To protect coastal waters from pollution with domestic wastewater.
- To protect the health of the local residents through improved housing with safe sanitation and wastewater treatment facilities.
- To demonstrate constructed wetland technology. Bayawan was the first city in the Philippines that built a constructed wetland for domestic wastewater treatment. Therefore, one of the objectives was to use it as a pilot and demonstration project for other communities.

## 3 Location and conditions

Bayawan City is located in the south-west of Negros Island, covering a total land area of about 70,000 hectares and with a population of about 105,000. The project is located in a peri-urban area of Bayawan, which has been used to resettle families that lived along the coast in informal settlements and had no access to safe water supply and sanitation facilities. Records from the City Health Office showed a high incidence of morbidity and mortality arising from water-borne diseases in these informal settlements.

**Fig. 3:** Relocation housing area, Barangay[1] Villareal, Bayawan City, June 2006 (source: Bayawan City).

The families have been resettled to a 7.4 hectares social housing site which consists of 676 terraced houses, a day-

[1] A barangay is the smallest administrative division in the Philippines.

care centre, a health centre, a multi-purpose hall and a community centre. By December 2008, 555 of the houses were occupied. The majority of the households that moved into the relocation area make their living from fishing. The average household size is 5 people.

One of the projects recently introduced in the Fishermen's Gawad Kalinga Village to diversify their livelihoods, is vegetable and cut flower production using organic farming methods.

The under-five child mortality rate[2] in the Philippines is currently approx. 28 children per 1000 which is relatively low for a developing country (http://www.childinfo.org/mortality.html).

## 4 Project history

The concept of ecological sanitation was first introduced to the Visayas and Mindanao Regions of the Philippines during the "1st International Symposium on Low Cost Technology Options for Water Supply and Sanitation" in September 2004 in Bohol (speakers and guests came from Philippines, Indonesia and Germany). The conference was organised by the DILG[3]-GTZ Water & Sanitation Program and the WSP (Water & Sanitation Program) of the World Bank.

Representatives from the City of Bayawan attended the symposium and a group of German and Filipino experts subsequently visited Bayawan City to conduct a rapid assessment of the sanitary situation in specific areas. Two wastewater management and sanitation options were identified: a constructed wetland for domestic wastewater of a peri-urban resettlement area (described in this case study) and a dry sanitation concept (urine diversion dehydration toilets) for the sparsely populated rural areas (as described in a separate SuSanA case study).

The first visit of the German and Filipino consultants was in March 2005. The experts assessed the location and design parameters and discussed different technical options with the engineers and officials of the local government of Bayawan City. The detailed design was prepared by Filipino consultants and the construction process was carried out by the City Engineers Office of Bayawan. The Filipino consultants were also responsible for construction supervision.

In April 2005, the partnership between the City Government of Bayawan and the GTZ was formally sealed with a Memorandum of Agreement providing technical assistance in the construction of the constructed wetland treatment facility.

The users were not consulted in the design of the system, only the city government with its various offices, i.e. health, engineering and environment. But the users were involved in the general decision to treat the wastewater in a decentralised facility and not only in septic tanks.

A German consultant (Dr. Joachim Niklas, Oekotec GmbH) visited Bayawan twice during the construction phase, in November 2005 and June 2006. The first visit included the selection of a filter material for the soil filters. A manual for operation and maintenance was developed together with local consultants and the City Engineering Office. The second visit took place when the distribution pipe system was installed in the vertical soil filter.

The construction was carried out by the City Engineering office from May 2005 to August 2006. The constructed wetland was inaugurated in September 2006 and has been in operation ever since. The GTZ sanitation program in the Philippines came to an end in March 2009, and the constructed wetland now continues to be operated by Bayawan City Council.

The implementation phase included social preparation activities for the future inhabitants of the relocation area. As part of the relocation project the City of Bayawan set up a village association to organise the affairs of the relocation area.

The planning process was a joint undertaking of one German and two Filipino Consultants, supporting knowledge exchange and the introduction of a technology which was relatively unknown in the Philippines: the constructed wetland (also called: vegetated vertical soil filter or reed bed).

## 5 Technologies applied

The houses in the resettled fishermen's village have pour-flush toilets. The wastewater from the toilets, bathrooms and kitchen sinks is partially treated in septic tanks where solids are settled and the organic load is reduced[4]. There are a total of 67 septic tanks, each receiving the wastewater from 6 to 10 houses. The liquid portion of the wastewater (overflow from septic tanks) is transported through a small-bore sewer system with a 250 mm diameter pipe sloped at 0.2% towards the main sump for storage and additional solids removal.

From the main sump, the wastewater (septic tank effluent) is pumped into four header tanks and then flows by gravity into the first cell of the constructed wetland, which is a vertical soil filter. From here, the wastewater flows by gravity into the second cell. This cell is a horizontal soil filter. The effluent from the second cell is collected in the effluent sump.

The faecal sludge from the septic tanks will be treated in drying beds that are located at the sanitary landfill. Emptying of the septic tanks has not yet been necessary, but is expected to be carried out in 2009. The drying beds will be ready for operation by March 2009 (are they used now?).

The treated wastewater is pumped from the effluent sump into an elevated storage tank and is used for irrigation mainly in the cut flower and vegetable farming project of the GK Fishermen's Village.

The combination of septic tanks, small-bore sewers and constructed wetland was built because the construction of the houses in the relocation area was already in progress

[2] The under-five mortality rate is the probability (expressed as a rate per 1,000 live births) of a child born in a specified year dying before reaching the age of five if subject to current age-specific mortality rates.

[3] DILG is Department of the Interior and Local Government.

[4] Bayawan City had started with the construction of the septic tanks before the idea of the wetland was conceived. They are designed as 3-chamber tanks.

when the City of Bayawan decided to upgrade the treatment process. The city looked for an affordable and reliable treatment technology that could easily be implemented, operated and maintained. Also the treated wastewater should be clean enough for different reuse options, for example as water for construction or irrigation.

A combination of a vertical and a horizontal vegetated soil filter was recommended to ensure suitable treatment efficiency, and taking into account the available space.

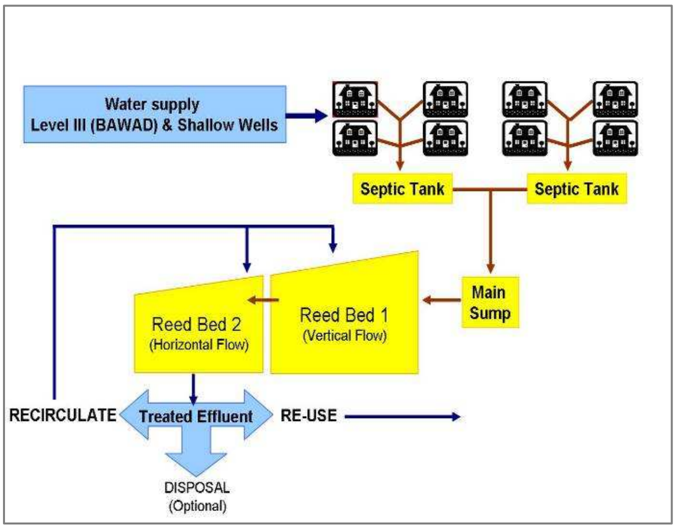


**Fig. 4:** Flow chart of the treatment system (source: City Engineering Office, Bayawan City).

**Fig. 5:** Preparation of drainage system of cell 1 of the constructed wetland (vertical flow), January 2006 (source: DILG-GTZ Program).

## 6 Design information

The constructed wetland was designed for a flowrate of 50 litres per person per day for a total population of 3,000 people (600 one-family houses[5] with on average 5 people per household) and a BOD concentration of 300 mg/l. At the last count, 555 houses were occupied (December 2008). This would result in a wastewater flowrate of 140 m$^3$/d and BOD load of 42 kg/d. The actual flowrate and actual BOD concentrations have not yet been measured (?).

Based on these design parameters the calculated required area for a design flowrate of 150 m$^3$ per day (600 families or 3,000 people) are: 1800 m$^2$ for the vertical soil filter (cell 1) and 880 m$^2$ for the horizontal soil filter (cell 2). The dimensions of cell 1 are 48 m x 36 m and for cell 2 they are 33 m x 27 m.

The total surface area is 2680 m$^2$ and the wetland has a specific surface area of 0.9 m$^2$ per person (a relatively low design figure and hence "optimistic" design – made possible by the low per capita flowrate, the sewage pre-settling in the septic tanks and the tropical temperatures).

The depth of the filters is between 2.0 m – 1.2 m from the concrete bottom to the top of the wall; including the drainage systems and about 0.60 m free board. The water flows by gravity through the distribution system and a constant head assures an even distribution of the wastewater over the whole area of the cell.

Both the village and the constructed wetland are close to the sea shore and during the rainy season groundwater rises to ground level. Both cells of the wetland were therefore built of concrete and concrete blocks. A drainage system has been positioned at the bottom of each cell which is covered by a separation layer and then the filter layer.

The plants used in the filter are locally available reed called 'tambok' (*Phragmites karka*). It was grown during the construction phase in a nursery at the relocation site. The tambok was cut for the first time in 2008 and it was decided that it should henceforth be cut annually. The reeds also act as an odour barrier during the filling process of cell 1.

The wastewater distribution system is composed of 4 concrete header tanks and a system of perforated HDPE pipes. The system is operated manually, i.e. switching on and off of the pump and emptying the header tanks into the distribution system. The header tanks are filled 2 to 3 times a day.

Since coming into operation, the system has been continuously improved. The header tanks were covered to minimise odour during the filling process and the collection sumps between the two wetland cells and after the second cell were covered to reduce algae growth. Additionally, a large storage tank for the treated wastewater was built.

The local water service provider regularly analyses the influent and effluent of the constructed wetland. This analysis includes TDS, pH, BOD, ammonia, nitrate and phosphate as well as some microbiological parameters (would it be possible to obtain some of this effluent quality data?).

The analysis of the treated wastewater showed very good pollutant removal efficiency (97% removal of BOD). The analysis is usually carried out on a monthly basis, but sometimes the lab runs out of reagents for some of the tests. For information on pathogen concentrations in the treated wastewater, see Section 7 below.

[5] In fact, 676 houses were built.

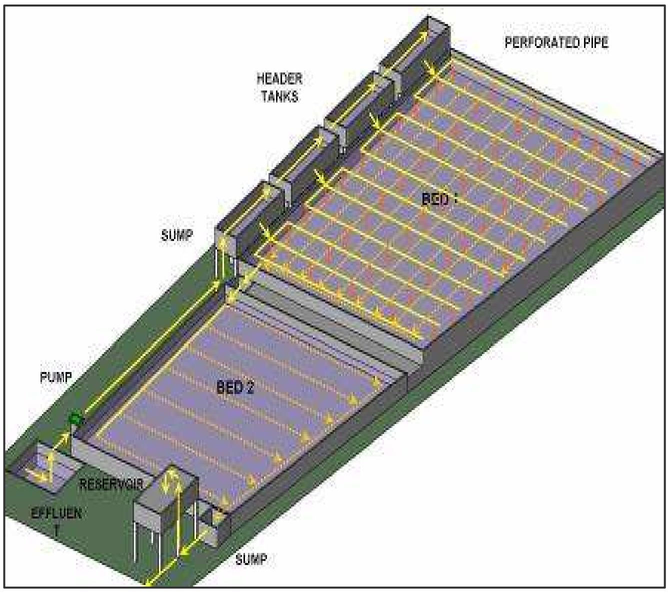


**Fig. 6:** Flow directions of cells 1 and 2 of the constructed wetland (source: City Engineering Office, Bayawan City).

**Fig. 7**: Testing distribution system of wastewater on vertical soil filter (cell 1 of constructed wetland), June 2006 (source: DILG-GTZ Program).

**Fig. 8**: Constructed wetland when construction was just completed in September 2006 (source: GEOPLAN Cebu).

## 7 Type and level of reuse

The treated wastewater was initially used in construction, i.e. for concrete production, and this reduced construction costs. It is also used for the organic cut flower and vegetable farming project of the GK Fishermen's village.

Only a basic microbiological analysis on the effluent from the constructed wetlands was conducted. However since November 2008 a more frequent and exact monitoring has been conducted using a state-of-the-art mobile lab (by whom?). The BOD removal rates were confirmed and the effluent has almost ideal concentrations of nitrate and phosphate to be used for "fertigation" (fertiliser plus irrigation) for the vegetable and cut flower project.

The more advanced analysis of total coliform however showed that the pathogen concentrations remain too high for unrestricted irrigation (but the total coliforms concentration in the treated effluent is still lower than in virtually all the rivers of Negros Oriental (10,000 - < 100,000 CFU/100ml in rivers)).

The farmers were informed of the findings and asked to apply certain safety measures as recommended by the WHO guidelines of 2006 for the safe use of wastewater and excreta[6], i.e. wearing gloves, watering the soil and not the leaves, to stop irrigating with treated wastewater four weeks before harvest etc.

The addition of a tertiary treatment step has also been discussed with the Bayawan City Administration to eliminate the high pathogen concentrations.

**Fig. 9:** Reuse of treated wastewater for irrigation in the GK Fishermen's Village in March 2008. Note: it would be preferable if the resident was wearing gloves (source: DILG-GTZ Program).

Through information campaigns during the implementation phase of the wetland project as well as during the training sessions of the organic farming project, residents have learned of the potential benefits of using treated wastewater. Its use for irrigating the vegetable fields was easily accepted.

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[6] Available: http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html

# Constructed wetland for a peri-urban housing area Bayawan City, Philippines - Draft

In 2008 a pipe system with tap stands was installed for the vegetable fields. The wastewater is pumped from the effluent sump into an elevated reservoir which supplies the irrigation system.

This reservoir is also used by the fire brigade and as a water source for construction purposes.

The use of the treated wastewater for this triple purpose substitutes the use of water from public supplies and thus results in an overall saving of money. In the irrigation system the treated wastewater is piped to the garden and distributed via a system of standpipes, thus facilitating work which otherwise would have involved collecting water from a single hand-pump. The nutrients in the treated wastewater also result in a saving on fertiliser.

## 8 Further project components

Treatment and reuse options for the faecal sludge from the septic tanks are part of the solid waste management program of Bayawan and are still in the planning stage (any news on this?.

The constructed wetland project complements other programs being implemented and developed by Bayawan City such as the Healthy City, Food Security, Integrated Solid Waste Management, the 'Character First' and the Organic Farming programs.

## 9 Costs and economics

The total construction cost for the constructed wetland was about EUR 160,000 including consultancy and labour. Bayawan City financed the bulk of this construction cost with the help of a loan from Worldbank. The DILG-GTZ Water and Sanitation program covered the costs for the international consultant, for workshops, community participation and social preparation sessions – i.e. provided technical assistance and the “soft” component of this project. An exact break-down of the construction cost is not available.

The operation and maintenance costs are estimated at EUR 3,500 per year, including EUR 200 for electricity and EUR 3,300 for labour. This is paid for by the city administration.

The households of the relocation area pay for their private water and electricity consumption but not for the operation of the wastewater treatment facility. Also the gardeners do not have to pay for using the treated wastewater for irrigation. So far the service of providing wastewater treatment is paid out of the city’s budget.

## 10 Operation and maintenance

The staff of City Engineering as well as members of the village association attended training sessions in the operation and maintenance of the wastewater treatment plant. Operation and maintenance are carried out by different teams that are employed by the City and include:

Field Operations

- Pumping and distribution; wastewater feeding schedule; recirculation (the filling and emptying of the header tanks is done manually).
- Management of treated effluent (manual operation of pumps, monitoring of effluent).
- Management of plants / vegetation (cutting of reeds once a year).
- Site security and record keeping of daily activities.

Engineering and Maintenance

- Inspection and repair of electrical lines, pumps, and other equipment.
- Regular inspection and clearing of piping system (monthly, but no cleaning was necessary to date).
- Regular inspection and cleaning of wastewater pretreatment collection system (monthly, but no cleaning was necessary to date).
- Emergency engineering work: Cleaning of soil filter in case of clogging. In June 2008 the walls of cell 1 were reinforced because of fissures between walls and the base. This was caused by hydraulic overload and the cell was at risk of breaking.

Water Quality Monitoring

- Effluent sampling and analysis (see Section 6 for details).
- Keeping a database on water quality analyses and submission of findings and recommendations to the pollution control officer of Bayawan for appropriate action.

## 11 Practical experience and lessons learnt

The constructed wetland is a quite easily built and maintained technical option for wastewater treatment. The vertical soil filter in combination with the horizontal soil filter achieves very good treatment results regarding BOD elimination and nitrification. Regular monitoring of raw and treated wastewater showed that the constructed wetland performs as expected.

Labour is comparably cheap in Bayawan. That made it possible to opt for a manually controlled filling of the distribution system. This option saved construction costs for a larger pump and reduces the operating costs for electricity.

The combination of an international and a local consultant team facilitated an intensive knowledge exchange (mainly between the consultants and the engineers of Bayawan City) and helped to introduce the vegetated vertical soil filter as a new technology option in the Philippines.

The inventiveness of City Engineering staff and the responsiveness of the consultants made it possible to continuously adjust the design to the local conditions (see also last paragraph of Section 6).

Bayawan City plans to build additional constructed wetlands in strategic areas of the city, starting with a wastewater treatment facility for the District Hospital. This is planned to begin in the first quarter of 2009. Has it been done?

What are the results from the monitoring from that PhD student from the US? Can we have the impact report by GTZ?

# Constructed wetland for a peri-urban housing area Bayawan City, Philippines - Draft

## 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 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 | |

With regards to long-term impacts of the project, the main impacts of the project are:

1. The constructed wetland has reduces water pollution and improved public health (e.g. reduced rate of diarrhoea and intestinal worms in children – although this has not yet been documented).
2. It has served as a demonstration site so that local engineers and decision-makers gain confidence in the use of constructed wetlands.
3. It has resulted in water savings where the treated effluent replaced irrigation water, water for construction purposes and the fire brigade (if there is a fire).

In November 2008, USAID conducted a survey in Bayawan on this matter (to confirm that the new treatment system has had an impact on improving public health) but has not yet shared or published the results.

## 13 Available documents and references

Bayawan City (2007) Bayawan City adopts ecosan as a tool for health and environmental management, Mayor Herman P. Sarana, presented at International Conference on Sustainable Sanitation, Dongsheng, China, 28 August 2007, http://www.ecosanres.org/icss/proceedingspresentations.htm (under: 28 August 16:00-17:30, Room #2) or: http://www2.gtz.de/Dokumente/oe44/ecosan/en-bayawan-city-adopts-ecosan-2007.pdf

Niklas, J. (2006) “Mission Report III: Implementation of a soil filter treatment plant for water reuse in Bayawan, Negros Oriental”, Consultancy Report by Oekotec GmbH, July 2006

Further documents can be requested through the DILG-GTZ Water & Sanitation Program, www.watsansolid.com.ph.

Reports from Oekotec still to be uploaded to website (?)

Video documents on YouTube (the implementation process was documented through a video documentary that covers both the social and the technical aspects of the project):
http://de.youtube.com/watch?v=psf3MrgdXJM
http://de.youtube.com/watch?v=pucWtguIJZ8
http://de.youtube.com/watch?v=jJWXBUNwAwQ
http://de.youtube.com/watch?v=HaXksWDUSDI

## 14 Institutions, organisations and contact persons

**Owner and operator of the system:**
Office of the City Mayor
Contact name?
City Hall
Bayawan
Philippines
mayor@bayawancity.gov.ph
www.bayawancity.gov.ph

**Supporting agency:**
DILG-GTZ Water & Sanitation Program,
Contact at GTZ Philippines: Hanns-Bernd Kuchta[7]
5th Fl. DILG-WSSPMO,
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**International consultant for constructed wetland:**
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www.oekotec-gmbh.com

**Case study of SuSanA projects**
***Constructed Wetland for a peri-urban housing area***
**SuSanA 2009**
**Authors: Ulrike Lipkow (formerly GTZ Philippines, now: ulrike.lipkow@gmail.com), Elisabeth von Münch**
**Editing and reviewing: Carola Israel**



**This document is available from:**
**www.susana.org**

[7] Hanns-Bernd Kuchta is program leader until the program ends in June 2010. The sanitation component of the GTZ program was completed in March 2009.

sustainable sanitation alliance

Case study of sustainable sanitation projects

# UDD toilets in rural school Hayanist, Armenia

**Fig. 1:** Project location

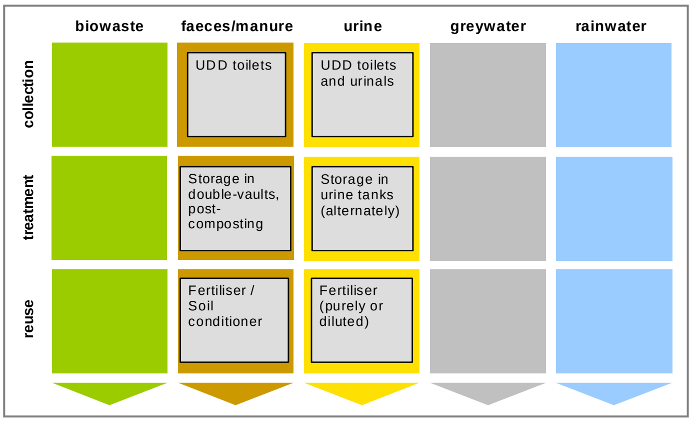


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

School sanitation in a rural area, upgrading of the sanitation system in an existing school, pilot project

**Project period:**

Start of planning: Autumn 2005
Start of construction: June 2006
Start of operation: November 2006

**Project scale:**

Rural school with 350 students and 26 staff
Total investment costs: 28,740 €

**Address of project location:**

Hayanist, Ararat Marz (province), Armenia

**Planning institution:**

QUELQUE-CHOSE Architects, Yerevan, Aleksandr Danielyan
Hamburg University of Technology, Institute of wastewater management and water protection (TUHH)

**Coordinating institution:**

Women in Europe for a Common Future (WECF), Netherlands
Armenian Women for Health and Healthy Environment (AWHHE), Armenia

**Supporting agency:**

Ministry of Foreign Affairs (TMF) Netherlands (70%)

## 2 Objectives and motivation of the project

The Armenian Women for Health and Healthy Environment (AWHHE) has implemented this project "Improvement of sanitation in rural areas of Armenia" which is part of the program "Tapping resources" funded by the Netherlands Ministry of Foreign affairs (TMF). Objectives for the implementation of an alternative sanitation concept were as follows:

- Establishment of a sustainable, affordable and safe school sanitation system
- Improvement of the user comfort: Before project implementation in 2006, the 6-17 year old students had to go to outdoor pit latrines. The new toilet building is adjacent to the school building, so that students now benefit from indoor toilets.
- Introduction of an ecological sanitation approach in Armenia and investigation of its feasibility in a rural context in the Caucasus region.
- Reducing contamination of surface water (open drainage channels) and groundwater with pathogens and nitrates from pit latrines.
- Raising public awareness with regard to the hygienic and health risks associated with poor sanitation and drinking water supplies.

The project should - amongst other goals - provide an affordable option to upgrade school sanitation. It serves as an example of how sanitary conditions in rural areas without any connection to sewer or piped water supply systems can be improved. In addition the population should become aware of the advantages of urine diverting toilets regarding water protection and gain of excellent organic fertilizer.

**Fig. 3:** The school of Hayanist (source: WECF, 2005)

## 3 Location and conditions

Armenia is a small Trans-Caucasian country that suffered severely after the collapse of the Soviet Union and through the Nagorno-Karabakh War in the early 1990s. The economic situation deteriorated dramatically. The unemployment rate in Armenia is very high, approx. half of the population have a consumption level below the poverty line. In Armenia, the under-five mortality rate[1] is currently 24 children per 1000 (http://www.childinfo.org/mortality.html). The predominant religion in Armenia is Christianity. People are used to wipe with toilet paper after defecating (see fig. 8).

To address the common problem of inadequate school sanitation in rural areas, the village Hayanist with approx. 2500 inhabitants has been chosen for an ecosan pilot project. The village would not be able to pay for the operation and maintenance of a centralised sewage system. The use of a decentralised solution was therefore seen as being the most appropriate approach in the village.

Hayanist is located 12 km southwest of the capital Yerevan and situated in a basin-shaped area with a swampy soil and a high groundwater table. The village and surrounding fields are covered with a net of open drainage channels, including small and shallow drainage channels along each street. A large majority of households have pit latrines where liquids infiltrate into the ground. Due to the high groundwater level, the depth of the pits is just one meter. Wastewater from households with a flush toilet is lead without any treatment to a drainage canal and directly used for irrigation.

**Fig. 4:** Former school latrine (source: WECF, 2005)

The majority of the households have a homestead land or a field for some vegetable or crop production. Food production however is limited by the costs of fertilizers. Due to poverty and the lack of gas supply, cow dung is used as a fuel for heating and cooking. Only 10% of the households in Hayanist are connected to the central water supply system of Yerevan. The other households receive drinking water from local artesian wells. The chemical and bacteriological parameters meet in general the limits set for drinking water, but the water quality indicates some anthropogenic pollution (nitrate, pathogens) as it occurs from pit latrines.

Armenia has only a very limited budget for the operation and maintenance of public facilities, including schools. Therefore school buildings and their sanitary facilities are in an extremely bad condition like in Hayanist. During Soviet times the school had flush toilets for teachers and students, sewage pipes connected to a drainage canal and a piped water supply system. This system is out of order, forcing students and teachers to use dirty and very bad smelling latrines outside the school, close to the drainage canal. The school used to have one simple pit latrine for about 200 boys/male teachers and 200 girls/female teachers each. In order not to have to use the latrines many students and teachers avoided drinking during school time.

Prior to the planning of the project the faeces of school children in Hayanist was tested in 2005 on the presence of helminths by the main specialist of the Republican Center of Disease Control. Of 68 children of 7-10 years old, 5 had threadworm (7%) and 2 had ascariasis (3%). Children infected by threadworm were treated and their faeces was repeatedly tested on the presence of helminths (results in section 11).

## 4 Project history

Planning of the project started in autumn 2005. The need for an improvement of the inadequate sanitation for the school children in Hayanist had a very high priority for teachers and partners. In public meetings, citizens and authorities were informed about the disadvantages of both conventional wastewater systems and latrines, the health risks of sewage as well as about the advantages of urine diverting toilets.

Upon discussions with parents, school staff and local authorities about the construction of ecosan UDD toilets for the school, the decision was made for the construction of double-vault urine diversion dehydration (UDD) toilets with access from the school. Winters in Armenia are very cold (-20℃) and visitin g outdoor latrines pose a health risk for the students. On the other hand it took efforts to convince the staff that, without water for flushing, UDD toilets can function properly and odour-poor.

For the construction of the toilet facility, permits from different institutions were needed, e.g. from the education department, hygienic inspection and local government. Several designs and discussions on the number of toilet units were needed to decrease the costs and to agree on a design acceptable for all stakeholders.

Construction of the toilet facility started in June 2006 which was put into operation in November 2006.

[1] The under-five mortality rate is the probability (expressed as a rate per 1,000 live births) of a child born in a specified year dying before reaching the age of five if subject to current age-specific mortality rates.

**Fig. 5:** The new ecosan UDD toilet facility (with 7 cubicles for 350 students) (source: AWHHE, 2006)

## 5 Technologies applied

- A toilet block with 7 male and female toilet cubicles (double-vault UDD squatting pans), 3 waterless urinals and 6 washbasins was built.
- The two faeces vaults of one toilet unit have one urine diverting squatting pan each.
- For hand washing 6 washbasins were installed. They are provided with water from local artesian wells?) and equipped with towels and soap. The resulting greywater flows into the already existing sewage pipes (without treatment).
- The local architect QUELQUE-CHOSE in cooperation with the Hamburg University of Technology made the design of the UDD toilet block. The facility was designed with the aim of providing sufficient toilets, meanwhile using minimal space and walls in order to save expensive construction materials.
- The toilet block was constructed as an extension of the existing school building.
- The basement of the toilet building houses the urine storage tanks.
- For the collection and storage of the faeces, double-vault UDD toilets were chosen to provide for a higher hygienisation safety compared to single-vault UDD toilets. It is important to keep urine and faeces separate as most of the pathogens are contained in the faeces, while the urine (from healthy persons) is almost sterile. The possibility of cross contamination (faeces to urine) can however not completely be eliminated.
- The urine of boys and girls is separately collected and stored.
- Adequate ventilation was provided by a wind driven ventilator (for details see chapter 6 and figure 7).
- The applied technology was chosen through public meetings, where pictures and posters of different toilet systems and a miniature model of a urine diversion toilet were presented.

Even though rainwater harvesting is practised in some villages in Armenia, rainwater is not harvested here due to the very low precipitation. The collected amount of water would be too few, thus not compensating for time, efforts and money spent.

## 6 Design information

Plastic urine diverting squatting pans from China were chosen instead of pedestal seats for hygienic reasons and because the children are used to squatting toilets. For practical reasons, both faeces vaults were equipped with a urine diverting pan. The vault not being in use is covered with a lid which is temporarily fixed. Therefore there is no need to change the pans if one vault is full but only the lid is put on the one squatting pan and the second pan can be used.

For each toilet there are two easily accessible faeces vaults sealed with a concrete floor. The vaults with a volume of 1 m³ each are used alternately in a 2.5-year rhythm and are filled by about 2/3 of their volume only[2].

The floor of the vaults has a slope of 1% for the drainage of residual leachate which is connected to a sewer leading to an open drainage.

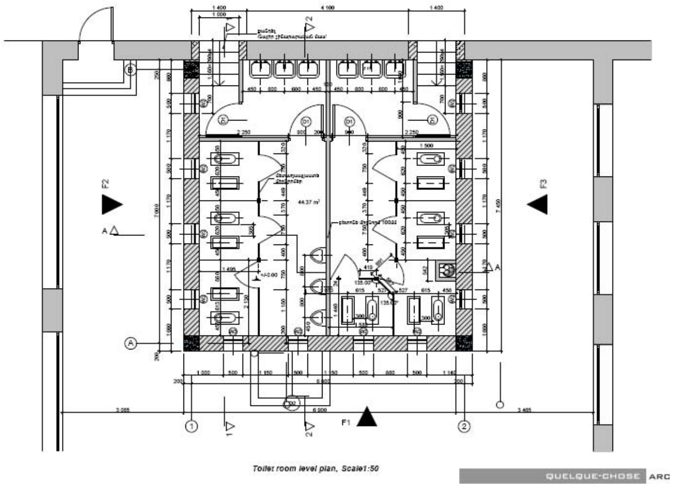


**Fig. 6:** Floor plan of the toilet block; design: Quelque-Chose (source: AWHHE)

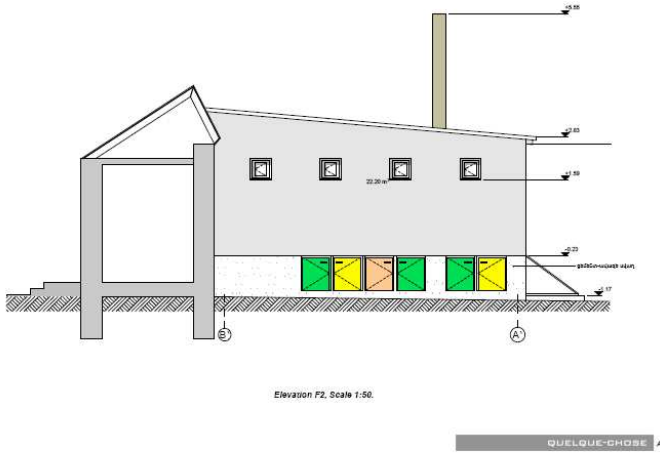


**Fig. 7:** Side view of the toilet block, design: Quelque-Chose (source: AWHHE)

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[2] The students visit school during 5 hours per day, 5 days per week for only 8 months per year. Taking into account a wet faeces mass of 0.2 kg/d and a dry matter content of 30%, the total provided faeces vault volume of 7 x 1 = 7 m³ has proved to be big enough for serving 380 people (students and staff).

Each faeces vault has an opening to the urine tank room. Air from that room together with equalised air pressure from the urine tank is evacuated by one common ventilation pipe leading to the roof where it is equipped with a wind-driven ventilator of 30 cm in diameter (see fig. 8). With this design, only one ventilation pipe for the vaults became necessary compared to former designs where every vault had one pipe.

The ventilation pipe being directly connected to the urine tank may lead to a loss of nitrogen contained in urine. If the air pipes from the urine tanks to the common ventilation pipe were removed and replaced by a very small hole in each tank, this nitrogen loss could be reduced and the ventilator capacity be increased. Furthermore, the ventilation pipe above the roof should be insulated to allow air flow also in winter.

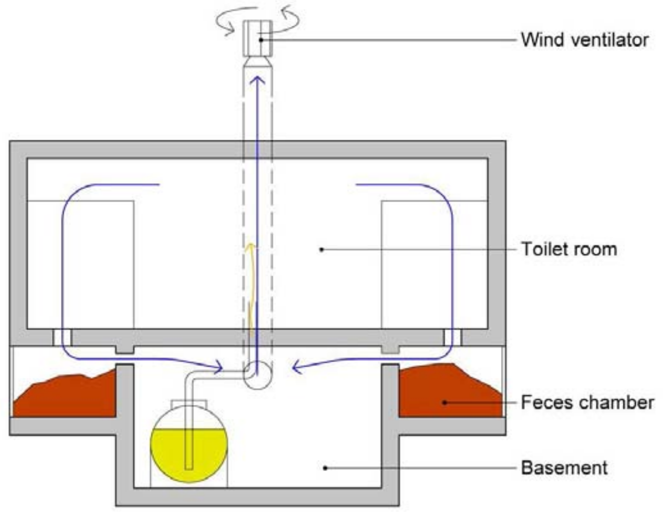


**Fig. 8:** One ventilation pipe installed for 2 faeces vaults, design: Quelque-Chose (source: AWHEE, 2006)

**Fig. 9:** Ecosan UDD toilet interior. On the left: squatting pan covered with lid and bucket with sawdust. On the right: squatting pan in use (source: AWHEE, 2006)

For boys three urinals at different height were installed. For the collection and storage of the urine from the UDD toilets and the urinals, 4 polyethylene urine tanks of 2 m³ each were installed in the basement which is located underneath the toilet block. The urine of the girls and the boys is separately collected and stored. If one tank is full, the urine is lead into the second tank. While the second tank is in use, the urine of the first tank is stored for at least 6 months[3] before it is ready for use as a fertilizer. During this storage time, most of the low part of pathogens contained in urine are killed or significantly reduced. For monitoring and emptying the tanks an easy access from outside is designed. Tanks with bigger volumes were difficult to obtain, too expensive and would not have fitted through the entrance.

The urine pipes from squatting pans and urinals are extended close to the bottom of the urine tanks in order to avoid ammonia stripping and thus the formation of bad odour and nitrogen losses when fresh urine is deposited into the tank. In this way the liquid does not get turbulent and extra input of oxygen is avoided. In most urinals (8 out of 10) condoms are used as an odour trap whereas the toilets do not have any odour trap.

The entire facility was built using local labour and construction materials as far as possible.

**Fig. 10:** Boys' waterless urinals at different heights (source: AWHHE, 2006)

[3] The students visit school during 5 hours per day, 5 days per week for only 8 months per year. Taking into account a urine volume of 0.3 L per school day and user (relatively low but usual for Eastern Europe; experience from other Eastern Europe countries has even shown a urine volume of 0.05-0.1 L per school day and user), the total provided urine tank volume of 4 x 2 = 8 m³ has proved to be big enough allowing for a storage time of at least 6 months.

**Fig. 11:** Urine tanks (4 x 2 m³) in the basement of the school (source: AWHHE, 2006)

**Fig. 12:** Faeces collection vaults of UDD toilets (source: WECF, 2006)

## 7 Type of reuse

In accordance with the WHO "Guidelines for the safe use of wastewater, excreta and greywater" (2006), urine is stored for approx. 6 months before the school director's field in Hayanist was fertilized with the collected urine. Urine was transported by a truck used for the evacuation of ordinary toilet septic tanks which reportedly had been cleaned with water before usage. The costs for urine transport were paid by the director and then reimbursed by AWHHE. At the moment the result of urine fertilization is difficult to assess because the school director mentioned that no evident result could be observed.

Faeces are not yet reused. Due to the large volume of the realized dehydration vaults it takes approx. 2.5 years to fill them and another 2 years for proper dehydration according to the above mentioned guidelines. Now 2.5 years after the start of operation, the vaults are still not full yet. Hence approx. 5 years after completion of the facility (end 2011), local farmers are planning to use the dehydrated faeces as soil conditioner for decorative plants in the schoolyard.

Storage and treatment of the excreta in the UDD toilets are supervised and monitored during the first 3 years of toilet use by AWHHE, WECF and TUHH. Results will be made available at a later stage. Urine will be analyzed on nutrients and bacteria, faeces on bacteria, parasites and eggs.

## 8 Further project components

The project included following further components carried out by AWHHE:

- To raise awareness about environmental issues and to put the urine diverting toilet in a wider context, performances and eco-games were carried out with the children.
- Workshops on the use and maintenance of double-vault urine diverting toilets were organised for teachers and students.
- Education materials, leaflets and posters for the use and maintenance of the toilets were designed and distributed.

AWHHE has implemented the project "For a Sustainable and Environmentally Sound Rural Armenia" in the framework of the "Empowerment and Local Action" (ELA) project supported by the Dutch Ministry of Foreign Affairs.

The project "Improvement of sanitation in rural areas of Armenia" (mentioned in section 2) is multidimensional and includes activities in promoting organic agriculture, improving drinking and irrigation water supply systems, promoting ecological sanitation, capacity and democracy building of communities, lobbying, advocacy, and raising awareness of the population. This project is the continuation of the TMF funded project indicated above.

In frame of these two projects, AWHHE constructed in total 3 school toilet blocks and 28 household toilets in 4 villages.

## 9 Costs and economics

The costs of the new toilet block were 28,740 € of which approx. 70% were for construction materials and 30% for the design, labour, education and training. Costs for the toilet block consisting of 7 double-vault UDD toilet cubicles, 3 waterless urinals and 6 washbasins are shown in the following table:

| Category | Total costs (€) |
|---|---:|
| Earthwork | 500 |
| Basement | 6,990 |
| Brickwork | 2,540 |
| Electric installations | 250 |
| Completion interior | 6,890 |
| Doors, windows | 4,700 |
| Sanitary installations | 1,910 |
| Urine tanks | 3,050 |
| Completion exterior | 1,270 |
| Ventilation | 640 |
| Total costs | 28,740 |

These costs include:

- Design authorisation and labour: 8,510 €
- Transportation: 1,270 €

The Chinese squatting pans were kindly provided by WECF.

In this case, the costs of 28,740 / 7 ≅ 4,000 € were extremely high. They result from the fact that material costs were very high because of the high prices of bricks and concrete. Construction materials are very expensive in Armenia because most of them have to be imported while borders with two countries are closed. Furthermore, this project was intended to serve as a well functioning demonstration project encouraging the development of other similar projects. However, toilets could be built substantially cheaper if construction material costs were reduced or execution quality was saved.

This project was cofinanced by the Dutch Ministry of Foreign Affairs with 70% of the costs.

## 10 Operation and maintenance

- A person was hired for the cleaning of the school. She was also put in charge of O&M (cleaning) of the double-vault UDD toilets. She is contracted and paid by the school administration and has been intensively instructed. She inspects and cleans the toilets daily. Tiles and if needed the toilets are cleaned with soda or vinegar (time needed: approx. 2.5 hours per day)
- The piles in the faeces vaults are levelled weekly and if needed covered with soil/ash.
- The dehydration vaults and the urine-tank are monitored by the caretaker. When one tank/vault is full, the urine/ faeces will be directed to the other compartment.
- Students are instructed to cover the faeces with either dry earth, ash, sawdust or a mixture of these after defecation to minimise the water content and thus odour and flies. In practice, sawdust is maily used. The caretaker adds these materials if necessary. Toilet paper is separately collected in bins.

**Fig. 13:** Workshop with children; pretending to try the squatting pans; picture taken during construction period, normally with separating walls (source: AWHHE, 2006)


**Fig. 14:** Educational material about UDD toilet use for boys and girls in Armenian language (source: AWHHE)

## 11 Practical experience and lessons learnt

- After realization of the ecosan project, no cases of helminths were found.
- Ecological sanitation works well in regions without central water supply or without basic sanitation.
- Transportation and handling of large urine canisters (2 $m^3$) has turned out to be difficult.
- For an adequate design of a school UDDT, the actual urine and faeces volumes to be expected should be investigated in advance taking into account country-specific nutrition habits.
- A crucial factor is the users' real understanding of the facility and the users' influence on its functioning.
- Through the good cooperation between the local project coordinator AWHHE and the school staff, the latter gained trust and confidence in the system. A feeling of ownership for the toilet facility and responsibility for maintenance and operation was encouraged.
- In this pilot project the female staff/volunteers of AWHHE were intensively and creatively involved in ecological education of the school children.
- With proper education even 6-year old children understand the principle of urine diverting toilets as a part of ecological sanitation.
- It was shown that the installation of double-vault UDD toilets is a very fast and easy to realise method to upgrade unsafe sanitary facilities and thus improve health conditions.
- There is bad odour arising primarily from urine in the toilet facility which does not disappear even when windows are open. It partly comes from both the place where the urinal

pipe enters the floor and the joint of the fixation of the female squatting pan on the floor. New sealing is expected to reduce the smell.

- To avoid bad odour in UDD toilet facilities it is important to install a well functioning ventilation system for the faeces vaults.
- In Armenia construction materials are extremely expensive in relation to the local salaries.
- Due to the economic situation in Armenia, an improvement of the currently existing inadequate school sanitation is difficult to afford without external financial support.
- The new toilet system was very well accepted by teachers and students. It increased parents' and citizens' interest in ecological sanitation. This pilot-project serves as an example not only for Armenian villages but for many Eastern European, Caucasus and Central Asia (EECCA) countries, which face similar sanitary, environmental and health problems. It has lead to the installation of UDD toilets in 3 other schools and 25 private households (partially financed by owners) in several other EECCA countries.

## 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 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 | | |
| • sociocultural and institutional | | x | | | x | | | x | |

The main long-term impact of the project is an improved public health (e.g. reduced rate of diarrhoea incidences in children). For a quantification of this impact it is planned to analyze the change in the number of absences recorded in the class-registers. It is planned to assess this in late 2010 in the frame of Emma Anakhasyan's PhD thesis.

An additional impact is an increased awareness among politicians (both high and low administrational level) so that they financially support sustainable sanitation projects.

## 13 Available documents and references

Russian and Romanian versions of the summary of the WHO "Guidelines for the Safe use of Wastewater, Excreta and Greywater, Volume 4", WECF 2008,
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Urine Diversion in Climates with Cold Winters, WECF, 2007 (English),
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Dry urine diverting toilets, Principles, Operation, and Construction, WECF, 2006 (English, Armenian, Romanian, Bulgarian, Ukrainian),
http://www.wecf.eu/english/publications/2006/ecosan_reps.php

Ecosan poster closing the loop in wastewater management and sanitation from GTZ, translated by WECF and partners (Ukrainian, Romanian, Russian, Armenian, Bulgarian),
http://www.wecf.eu/english/publications/2006/poster_ecosan.php

Ecological Sanitation and Hygienic Considerations for Women, WECF, 2006 (English, Armenian, Romanian, Ukrainian),
http://www.wecf.eu/english/publications/2006/menstruation.php

Socio Economical Gender Survey of Hayanist, WECF, 2005 (English),
http://www.wecf.eu/cms/download/2006/armenia_socio_economic.doc

Ecological Sanitation and Associated Hygienic Risks, WECF 2004 (English, Romanian, Bulgarian, Russian, Ukrainian),
http://www.wecf.eu/english/publications/2007/ecosan_hygiene.php

Further educational material on the use and maintenance of double-vault UDD toilets and information on the use of urine and compost in agriculture are available in different languages (English, Armenian, Romanian, Bulgarian, Russian, Ukrainian) from WEDC, please contact:
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**Case study of SuSanA projects**

***UDD toilets in rural school***

**SuSanA 2009**

**Authors: S. Deegener (TUHH), M. Samwel (WECF), E. Anakhasyan (AWHHE)**

**Editors: Christian Olt, Carola Israel (both: GTZ ecosan, ecosan@gtz.de)**



**This document is available from:**
**www.susana.org**

Case study of sustainable sanitation projects

# Ecological Settlement in Allermöhe Hamburg, Germany

**Fig. 1: Project location**

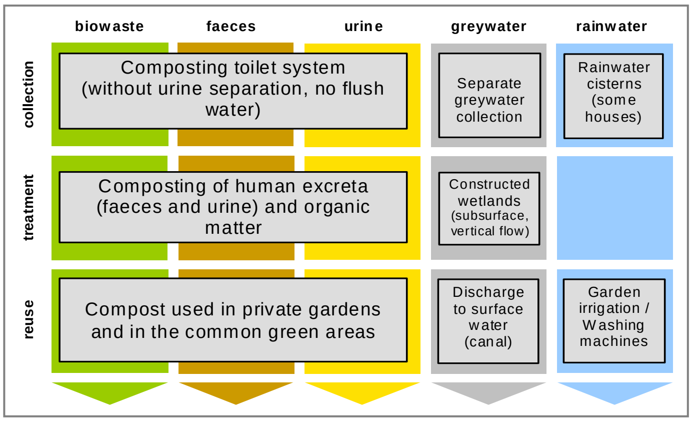



**Fig. 2: Applied sanitation components in this project**

## 1 General data

**Type of project:**
Residential settlement in urban area (full-scale)

**Project period:**
Start of planning: 1983
Construction period: 1985-2002 (in stages)
Start of operation: 1986 (in stages)

**Project scale:**
36 single-family houses, around 140 inhabitants

**Address of project location:**
Fanny-Lewald-Ring 32-92b
21035 Hamburg, Germany

**Planning institution:**
Berger Biotechnik GmbH (composting toilet systems)
AWA-Ingenieure (constructed wetland)

**Executing institution:**
Ökologisches Leben Allermöhe e.V. (a club of individuals)

**Supporting institutions:**
Government of the city of Hamburg
German Federal Ministry of Transport, Building and Housing
Hamburg Environmental Authorities

## 2 Objectives and motivation of the project

The project was planned to be a model settlement with high resource and energy efficiency through both the building and landscape architecture and by using appropriate ecological technology components. This included:

- Compact buildings, planned according to current state of the art for ecological architecture.
- Designs adjusted to the locations' environmental conditions.
- Ecological closed-loop processes via on-site wastewater treatment and therefore independence from a sewage system.
- High degree of involvement of the users in the planning, design, implementation and maintenance processes.

**Fig. 3:** Houses in middle court yard, constructed in 1986 (source: Berger Biotechnik).

## 3 Location and conditions

The ecological settlement is part of the new district Neu-Allermöhe, where 3,800 residential units were built between 1982 and 1994. It is a very green area with relatively low buildings (all less than 4 floors), 15 km southeast of Hamburg city centre. The eco-settlement in Neu-Allermöhe-Ost (New-Allermöhe-East) consists of 36 single-family houses with approx. 140 inhabitants aged from 0 to 99 years.

All inhabitants are owners of their houses and none of the houses are rented out. The two-storey twin and terraced houses differ in architecture to avoid uniformity. They are arranged around three small court yards: north, middle and south. The area of Allermöhe has many small canals. The entire area of the settlement has a high groundwater table.


**Fig 4**: Map of the settlement in 2006 with three court yards and constructed wetland ("PKA" in German). Source: Ökologisches Leben Allermöhe e.V.

## 4 Project history

This settlement is among the first ecological settlements in Germany with the initial stages of conceptual design starting in the 1970s. In 1983, the government of the city of Hamburg became involved in the planning. Together with several public authorities and the future users, an architecture competition on "ecological construction" was organised and the ecological and technical standards for the construction were determined. The construction period started in 1985, and one year later the first inhabitants moved in. The last residential houses were completed in 2002. In 2007, a community house was built in the southern court yard to put into practice the community spirit of the settlement as it was initially planned in the project conception.

**Fig 5:** Houses with green roof in northern courtyard, constructed in 1990/91 (source: Berger Biotechnik).

## 5 Technologies applied

**Composting toilet systems:**
Each household has a composting toilet system which consists of one or two toilet pedestals and a composting container in the basement to treat the human excreta (faeces and urine), toilet paper and organic kitchen waste (see Fig. 6, left and middle). Garden waste may also be composted in the composting container. Some households have an additional composter in the garden for kitchen waste and organic waste from gardening.

The toilet systems include the following models (all without urine diversion):

- 31 Berger Terra Nova composting toilet systems
- 5 Clivus Multrum composting toilet systems (1 American model and 4 Swedish models)

For further information see Section 6.

**Constructed wetland system:**
The greywater (wastewater from kitchens and bathrooms except from toilets) from all houses in the ecological settlement is led to a constructed wetland, located in the southern end of the settlement. Such a wetland is also called reed bed.

**Rainwater harvesting:**
9 of the 36 households collect the rainwater from their roofs in four underground cisterns with a capacity of 5-16m³.

**Fig. 6:** Berger Terra Nova composting toilet system with toilet pedestal (left) and composting container (middle). Separation chamber inside the bottom compartment for leachate (right). Source: A. Schöpe, 2009 (left) and Berger Biotechnik.

**Fig. 7:** Constructed wetland with reed in summer (left) and winter (right). Source: Ökologisches Leben Allermöhe e.V. (left) and A. Schöpe, 2009 (right).

## 6 Design information

**Composting toilet system:**
The architecture of the houses is adapted to the specific toilet designs. Each toilet is connected to one straight chute (downpipe) to the composting container in the basement (see Fig. 8). Up to 4 toilet pedestals can be connected to one composting container. Used toilet paper is thrown into the toilet and organic kitchen waste can be added as well. The containers have a chamber size of 1.5-3 m³ and are delivered with a starter bed consisting of 600 litres absorbing material (compost).

This waterless toilet system saves about 40 litres of water per capita per day compared to a conventional flush toilet (10 L per flush) which adds up to 2,044 m³ water savings per year for the whole settlement.

Current technical specifications and previous modifications of the toilets are:

- The toilet seat has a special oval design and offers enough security when being used by small children, so that they cannot fall down the chute (see Fig. 6, left).
- The toilet has a funnel-shaped plastic inlet for easy handling and cleaning of the toilet.
- The toilet lid has to close tightly to increase air draft and guarantee correct aeration of the composting container.
- A major part of the liquid (80-100%) added to the toilet in the form of urine/water is evaporated via the ventilation pipe[1].
- The ventilation pipe is insulated to increase air draft and avoid condensation.
- The fan in the ventilation pipe needs 29 Watt electrical power or less (fan power can be adjusted by a speed controller).
- Leachate in the container (resulting mainly from urine) can be collected in a separation chamber (see Fig. 6, right).
- A relatively wide chute diameter of 30 cm was chosen to reduce soiling of the pipes' inner surface .

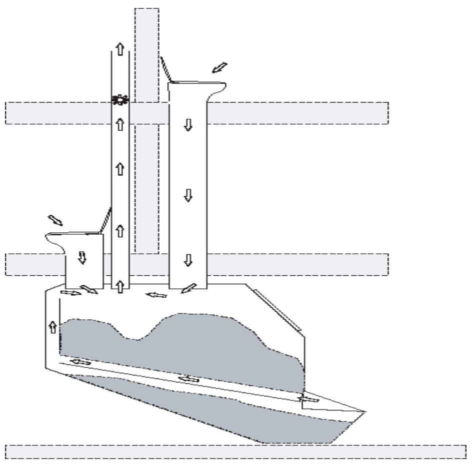


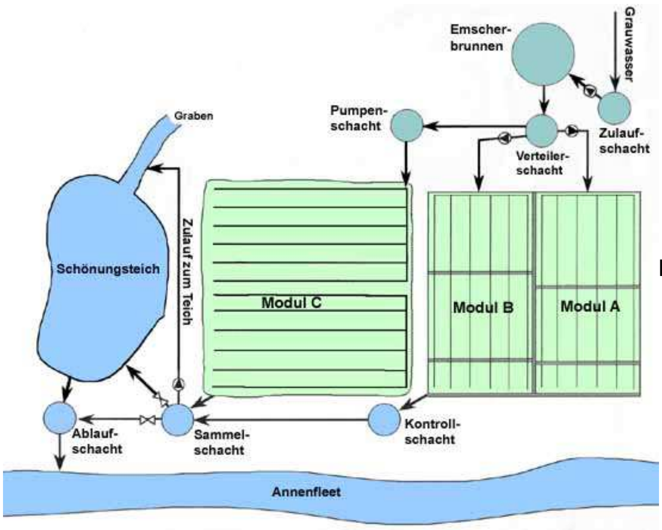
**Fig. 8:** Side view of a house with two toilets on two floors and one composting container in the basement, with removal compartment at bottom right (source: Berger Biotechnik).

**Constructed wetland system for greywater treatment:**
The constructed wetland has an area of 240 m² (currently 1.7 m² per person) and a capacity of 15 m³ per day. The actual inflow (in 2008) was 10-13 m³ per day (82 L per person per day[2]). The greywater pipes have a diameter of 100 mm. The filter material consists of sand with a depth of 1 m and is covered by gravel with a depth of 0.1 m.

Module A and B were built in 1988; Module C was built in 1992. The greywater from the houses first flows to an underground Imhoff tank[3] for grease removal. From there it is distributed in intervals to the three reed bed modules. All modules are planted with common reed plants (*Phragmites australis*) and are designed as vertical flow sub-surface constructed wetland.

The effluent from the reed beds is collected in a polishing pond and is led from there to the neighbouring surface water ("Annenfleet") (see Section 10 for further information on the effluent quality).

For effluent discharge into this canal, a permit issued under the water law of the Free and Hanseatic City of Hamburg was obtained. In case of process failure, the wetland has an emergency overflow to the municipal sewer.

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g. 9: Schematic of the constructed wetland (flow is from right to left, labels are in German). Source: Ökologisches Leben Allermöhe e.V. and AWA-Ingenieure.

## 7 Type of reuse

- The finished compost material from the composting container which is obtained after at least 2 years of composting in the container, is used as fertiliser in the household gardens and the common green area. About 40 L[4] of compost is produced per person per year.
- The leachate from composting can be diluted with water and used as liquid fertiliser during planting periods (see Section 10 for further information).
- The treated greywater (3,650 to 4,700 m³ per year) is discharged into the neighbouring channel and not reused.

## 8 Further project components

Further technical components of the ecological concept include:

- Rainwater from the area of the settlement and the roofs is collected in small basins and ditches (to infiltrate into the soil) or in cisterns to irrigate the green space. Some households also use the rainwater for their washing machines.
- 4 photovoltaic systems and 14 thermic solar heaters for warm water for some households. The photovoltaic modules cover a roof area of about 80 m² and produce a rated power of about 8 kW. The thermic solar heaters cover a roof area of about 81 m² and have about 400 litres storage capacity.

[1] For comparison: Urine production of a family of three adults per year (if all urine is collected at home) is approx. 1.4 m³ (based on 1.3 L/person/day).
[2] For comparison: wastewater production (greywater plus toilet wastewater) of average German person is currently 120 L/person/day.
[3] An Imhoff tank is a settling tank with some anaerobic treatment (similar to a septic tank). The volume of this Imhoff tank is not known.

[4] 1 L of compost weighs about 650 g to 900 g, depending on the water content.

- Eco-friendly construction materials such as wood or grass for roofs (1/3 of the houses) or recycled material for highly efficient insulation.
- Innovative energy-conserving concepts for conservatories (as extension of a house).
- Passive houses (those houses constructed most recently): Very good insulation, including thermal windows, combined with a ventilation system with heat recovery to avoid heat losses and optimise heat gains.

## 9 Costs and economics

The German Federal Ministry of Transport, Building and Housing and the Hamburg Environmental Authorities supported the construction, operation and scientific monitoring of the composting toilet systems and the constructed wetland.

**Composting toilet system:**
Initial investment costs: During the construction period, the price of one complete Terra Nova system (standard) with 2 toilets was approx. EUR 3,700 (includes quantity discount for all houses constructed in 1986-1992). Special requests raised the price to EUR 4,000 to 4,500. The costs for delivery and installation were EUR 500. In 2009, the costs for one improved Terra Nova system, delivery and installation are approx. EUR 6,500.

Operation and maintenance costs: When necessary, moving parts like the ventilation fan have to be replaced after some years of use - at the earliest after 5 to 20 years with an annual periodic cleaning (price of one fan: EUR 190).

**Constructed wetland:**
Initial investment costs: The total costs for the constructed wetland were EUR 95,000 (treating greywater from 140 people). Nowadays, such a facility is less expensive because of more economical designs.

Operation and maintenance costs: External quality checks and sampling costs are about EUR 500 per year. Additonally, the sludge removal from the Imhoff tank costs EUR 250 each time (it is removed by an external company every two years, see Section 10). Pumps and moving parts have to be renewed from time to time.

It can be calculated that with this sanitation system, the eco-settlement saves about **EUR 18,000 per year** (equal to EUR 130 per person per year) based on:

- reduced water consumption (no toilet flushing, see point 1 below) and
- no wastewater fees (greywater treated and discharged locally instead of being discharged to the municipal sewer, see point 2 below) and
- relatively low O&M costs of the wetland (point 3 below).

The assumptions for this calculation are:

1. 40 L/person/day saved for toilet flushing, for 140 residents. Water and wastewater together is charged at about 4 EUR/$m^3$ in Hamburg. So the non-flush composting toilets save about EUR 8,176 per year.
2. The produced greywater does not attract a wastewater fee as it is not discharged to the municipal sewer (normally in Hamburg: 2.67 EUR/$m^3$ for wastewater discharged). So for the 11.5 $m^3$/d of greywater produced, this results in avoided wastewater fees of EUR 11,207 per year.
3. The annual cost for the constructed wetland charged by the Allermöhe club is 25 EUR/person/year (or a maximum of 100 EUR/household/year), and this is for sampling and analysis twice per year (for COD and BOD), sludge removal from the Imhoff tank (every second year) and putting money aside for repairs, replacements and re-investment. The total annual cost for the wetland is about 1,400 EUR/year.
4. The free labour provided by the volunteers of the settlement is not included in the cost estimate.

## 10 Operation and maintenance

All operation and maintenance activities are carried out by the residents themselves (or volunteers amongst the residents), which reduces costs and increases the feeling of ownership.

**Composting toilet system:**
Maintenance of the composting container is carried out by the residents themselves. Approx. 1 hour per month is required to level, mix and aerate the compost heap and to add organic matter from the kitchen and garden to improve its structure and avoid densification. Some residents use a compost thermometer to monitor the temperature in the composter.

Finished compost material is taken out of the removal compartment (located below the composting container with "potato box principle"[5], see Fig. 6, middle) every 1-2 years depending on the incoming quantity of faeces. If 40 litres of compost is produced per person per year, a family of four has to remove about 160 litres finished compost (16 buckets of 10 litres) per year. Direct access to the cellar from the garden is provided.

The quantity of leachate inside the container depends on drinking habits, temperature and liquid content in the added organic matter[6]. Surplus leachate is collected in a chamber next to the removal container (see Fig. 6, right). It has to be emptied with a pump or a small bucket from time to time. In some households in the eco-settlement no surplus leachate occurs.

**Fig. 10:** Compost heap inside the composting container of the toilet (left), greywater in Imhoff tank (middle) and final effluent from constructed wetland (right). Source: A. Schöpe, 2009.

**Constructed wetland:**
Every year in April, volunteers from the community jointly harvest the reeds[7] from the reed beds, clean the reed beds and flush all distribution pipes. The reed is composted at the common green area. Tanks, valves and pipes are checked

[5] Moved by gravity and by muscle power (fork or aeration stick) along a 30°-slope into the removal compartment at the botto m of the container.
[6] This leachate is excess liquid (some urine which did not evaporate) which is not incorporated into the compost.
[7] The annual harvest is recommended, but not required.

again at the end of autumn. The Imhoff tank is cleaned twice a year to avoid clogging and its settled sludge is removed once every two years by a removal company and then transferred to the local wastewater treatment plant (the settled sludge is removed even when the tank is less than 50% full with sludge to avoid sludge deposits in the pipes to the wetland).

The effluent quality of the constructed wetland is tested twice a year by the Hamburg Environmental Authorities. For example, a sample taken on 12 December 2008 had a COD (chemical oxygen demand) of 16 mg/L and BOD (Biochemical oxygen demand) of 4.5 mg/l. The pH value was 7.3. The legal limit for discharge to surface water is 80 mg/L COD and 20 mg/L BOD.

## 11 Practical experience and lessons learnt

**General:**

- User involvement in, and ownership of the technology is very high due to the common vision which was the basic idea of the eco-settlement.
- Ownership is higher when the inhabitants are owners of the houses (and not tenants), as is the case here.

**Composting toilet systems:**

- The compost compartment requires monthly attention by the users.
- The right level of temperature and humidity is essential for the compost organisms. Rule of thumb: when squeezing the compost by hand, no water should come out (otherwise it is too wet) nor should it fall to crumbly pieces (otherwise it is too dry).
- Sometimes the finished compost does not slip to the removal container and has to be pushed down. To facilitate access to the compost, containers can be modified: a third access hatch in the middle of the container can be added.
- The temperature in the compost container fluctuates, depending on the material added. Adding grass, for example, increases the temperature. On average, the temperature in the composter is only a little bit higher than the temperature in the cellar.
- Maintenance work and emptying of the compost container can be very demanding especially for elderly people.
- Composting of fruit waste may result in fly breeding. In most of the cases, the flies started breeding in the compost while fruit waste was stored in the kitchen. Fruit waste should be quickly added to the compost in the container or composted outside in a separate container.
- The cellar for the composting container has to be large enough to enable maintenance work and emptying of the container and to allow good ventilation. Removal of compost is easier when there is direct access via a door from the garden to the cellar.
- More compost is produced than what can be applied in the private gardens (size of gardens: 130 - 250 m²). Hence, the compost is also used for the common green area.
- The upper end of the ventilation pipe has to be high enough to ensure the emission of air without odour being noticed at ground level. It is recommended to run the fan continuously.
- Even though some households have changed ownership, the spirit of the eco-settlement is still alive. The settlement is not connected to the municipal sewer, which means that inhabitants cannot change their toilet system to a conventional system with flush toilets, even if they wanted to.

**Constructed wetland:**

- When operation started in 1986, only little operational experience with constructed wetlands was available in Germany, which resulted in several of the legal requirements being overly cautious.
- Due to these legal requirements, the reed bed modules A and B were built with an expensive concrete lining. Experience showed that a waterproof plastic liner is sufficient and this was used in module C.
- The Imhoff tank for pre-treatment and grease collection could have been built much smaller.
- Soil subsidence required reconstruction of pipes for greywater distribution twice.
- To avoid clogging of the pipes to the wetland, settled sludge in the Imhoff tank is removed every two years. The level of settled sludge is measured with a long stick because it cannot be seen; experience is needed for that.
- The effluent quality from the reed beds does not vary between summer and winter unlike for other constructed wetlands.
- The group of volunteers (residents) maintaining the constructed wetland now has a sound know-how. This guarantees flawless operation of the system.

## 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 emphasized (weaknesses).

**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 | | |
| • sociocultural 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, 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).

Regarding long-term impacts of the project, the following can be concluded:

1. Residents living in this settlement have a smaller “footprint” with regards to water and energy use compared to the average German resident. They also make their own soil conditioner (compost).
2. The ecological settlement Allermöhe-East is a good example for a settlement using a sustainable sanitation system for more than **23 years**. Inhabitants do not only use sustainable sanitation, they are aware of the importance of sustainable solutions and also save water and energy. The settlement is a reference project with a long history which can inspire its many national and international visitors to copy the approach.

## 13 Available documents and references


- Information on the eco-settlement is available on the club's homepage: http://www.oeko-siedlung-allermoehe.de/ (in German).
- Additional information on the composting toilet system: http://www.berger-biotechnik.de (in German, English and French).
- A book on composting toilet systems: Berger, W. and Lorenz-Ladener, C. (2008) Kompost-Toiletten. Sanitärtechnik ohne Wasser. Verlag ökobuch (in German). Partial preview: http://www2.gtz.de/Dokumente/oe44/ecosan/de-kompost-toiletten-ohne-wasser-2008.pdf
- A booklet on sustainable settlements in Hamburg: http://www.hamburg.de/contentblob/135030/data/zukunftsfaehig-nachhaltig-oekologisch.pdf (in German).


## 14 Institutions, organisations and contact persons


**Executing institution:**
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**Case study of SuSanA projects**
**Ecological settlement in Allermöhe, Hamburg, Germany**
**SuSanA 2009**
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**This document is available from:**
**www.susana.org**

# Case study of sustainable sanitation projects

# Urine and brownwater separation at GTZ main office building Eschborn, Germany

**Fig. 1:** Project location

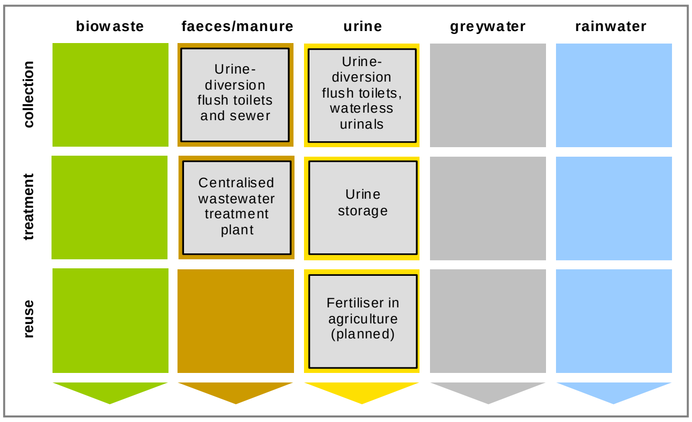


**Fig. 2:** Applied sanitation components in this project (for Phase 1 only)

## 1 General data

**Type of project:**

Demonstration project in an urban office building

**Project period:**

Phase 1: Start of construction: 2005
Start of operation: end of 2006 (ongoing)

Phase 2: Research project (treatment and reuse): planned to start mid 2009

**Project scale:**

Approx. 400 employees and visitors served by the urine separation system: 50 urine-diversion flush toilets, 23 waterless urinals, 10 m³ urine storage tank. Investment cost: EUR 125,800.

**Address of project location:**

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH,
Dag-Hammerskjöld-Weg 1-5
65760 Eschborn, Germany

**Planning institution:**

Pettersson & Ahrens Ingenieur-Planung GmbH, Germany and GTZ ecosan program.

**Executing institution:**

Maßalsky GmbH, Germany.

**Supporting agencies:**

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH.

Hessen State Ministry for Environment (HMULV). Subsidy for Phase 1 by Investitionsbank Hessen (IBH) of € 43,070.

German Federal Ministry of Education and Research (BMBF) for Phase 2.

## 2 Objectives and motivation of the project

Objectives of the project:

1. To demonstrate the implementation of an ecological sanitation (ecosan) concept (here with urine-diversion flush toilets, urine storage and reuse) in an urban context (this is just one possible ecosan technology; many others exist too). Ultimatively, if this technology was used widely in Germany, it could also prevent pharmaceutical residues contained in urine from entering into groundwater and surface water (as these substances are only partially removed in conventional wastewater treatment plants).
2. To reduce the amount of water used in the GTZ House 1 building.
3. To research important aspects of ecosan systems in Germany (social acceptance, reuse of urine in agriculture); this is planned for Phase 2.

The GTZ headquarters in Eschborn is frequently visited by international GTZ staff and decision makers, making this a good location for the demonstration of innovative ecological sanitation concepts.


**Fig. 3:** The main building ("House 1") at the GTZ headquarters in Eschborn near Frankfurt, where this project is implemented (source: GTZ).

## 3 Location and conditions

The GTZ headquarters consists of four multi-storey buildings and is located in Eschborn, a city of 21,000 inhabitants, 10 km northwest of Frankfurt am Main, the financial capital of Germany.

Approximately 1,450 people work in the GTZ headquarters(in 2009), of which the main building ("House 1") provides space on 10 floors for about 650 employees, the canteen and one large auditorium (capacity for about 250 people). House 1 has a double-Y shaped floor plan with a central section and two wings at either end. The urine diversion system is installed only in the central section of the building. The total number of persons using the urine separating toilets is difficult to estimate but may be around 400 people per working day.

## 4 Project history

The GTZ main building ("House 1") was constructed in 1976. When it was 30 years old it was completely renovated during 2004 to 2006 because the environmental performance and the technological standards of the building were not satisfying anymore, creating high operation and maintenance costs.

On behalf of the German Ministry for Economic Cooperation and Development (BMZ), GTZ is running an ecosan program since 2001 to mainstream ecosan concepts around the world.

When House 1 had to be renovated, the GTZ ecosan team promoted the implementation of an ecosan demonstration and research project. This project in House 1 was planned to be implemented in two phases:

**Phase 1:** The construction of the urine separation, collection and storage system along with the renovation works, was financed by GTZ and subsidized by the HMULV (Hessen State Ministry for Environment). The construction of phase 1 was completed in late 2006 and the installations are being used since then.

**Phase 2:**

- In mid 2006 an application for funding for a research project on urine and brownwater[1] treatment was submitted to BMBF (German Federal Ministry for Education and Research).
- The research project was proposed by GTZ, universities (University of Bonn, RWTH Aachen University and Giessen University of Applied Sciences) and industrial partners (Hans Huber AG and Roediger Vacuum GmbH).
- Approval by BMBF was granted in May 2009 and the research project is due to start in August 2009.

The planned research project, will focus on the development of treatment technologies and reuse practices, user acceptance, environmental and health issues (particularly with regards to micropollutants), legal and economic aspects, and the applicability of the system in industrialised, emerging and developing countries.

[1] mixture of flushing water and faeces

## 5 Technologies applied

**Phase 1:**

The urine separation and storage system which was installed in Phase 1 consists of:

- 23 waterless urinals
- 50 urine-diversion flush toilets for the waterless collection of urine
- A separate piping system for undiluted urine collection
- Urine storage tanks in the basement of the building

**Fig. 4:** Left: waterless urinal (Keramag). Right: urine-diversion flush toilet (Roediger) at GTZ main building; note the two buttons for flushing: the small one is for the urine flush, the larger one for the faeces flush (source: L. Ulrich, January 2009).

**Fig. 5:** Left: Plastic urine storage tanks in the basement of House 1 with connected urine pipework. Right: urine tanks with level indicating plastic pipes (source: L. Ulrich, April 2009).

**Phase 2 (planned):**

Two urine treatment options will be investigated in Phase 2:

- Treatment by prolonged storage for direct application of urine to fields (this treatment is already carried out in Phase 1).
- Precipitation of phosphorus and nitrogen from urine by the addition of magnesium oxide. This process produces the crystal magnesium-ammonium-phosphate (MAP) or struvite.

Brownwater treatment will be implemented by using a membrane bioreactor(MBR).

## 6 Design information

House 1 has a central section and two wings. The urine diversion sanitation system is implemented only in the central section, on all 10 floors.

**Waterless urinals (23 are installed)**

The Keramag waterless urinals (model Centaurus), which are made of sanitary porcelain, are equipped with a flat rubber tube as odour seal and a sieve made of high-grade steel (see Fig. 6). The flat tube opens when urine flows through it. The sieve traps pubic hair which could otherwise stop the flat rubber tube from closing properly.

**Fig. 6:** Urinal inlet sieve with flat rubber tube as odour seal (Keramag). Left: old model (mostly replaced, see Section 11). Right: optimised new model (source: L. Ulrich, April 2009).

**Urine-diversion flush toilets (50 are installed)**

The toilets by Roediger (model NoMix) have two separate bowls for urine and brownwater collection and two pipe connections for the separated wastewater fractions. They are made of sanitary porcelain. The urine is collected undiluted (without flush water) by means of a valve located below the urinal bowl: the valve is opened when the user sits down (see Fig. 7).

There are two buttons for toilet flushing (see Fig. 4): the smaller button is for the urine flush, which releases about 1-3 L of water, and with the larger button the faeces are flushed using 6 L of water[2].

**Pipework**

Two separate piping systems are implemented for separate urine and brownwater collection.

The urine flows from the toilets to the storage tanks in cast iron pipes with enamel (epoxide) coating. The pipe diameters are 100 mm (for the main collectors), 80 mm and 50 mm. A connection to the conventional sewer is installed as well, which enables bypassing of the urine tanks.

This Pipe material was chosen to minimise urine stone formation(encrustations). Plastic pipes would also be possible and are cheaper.

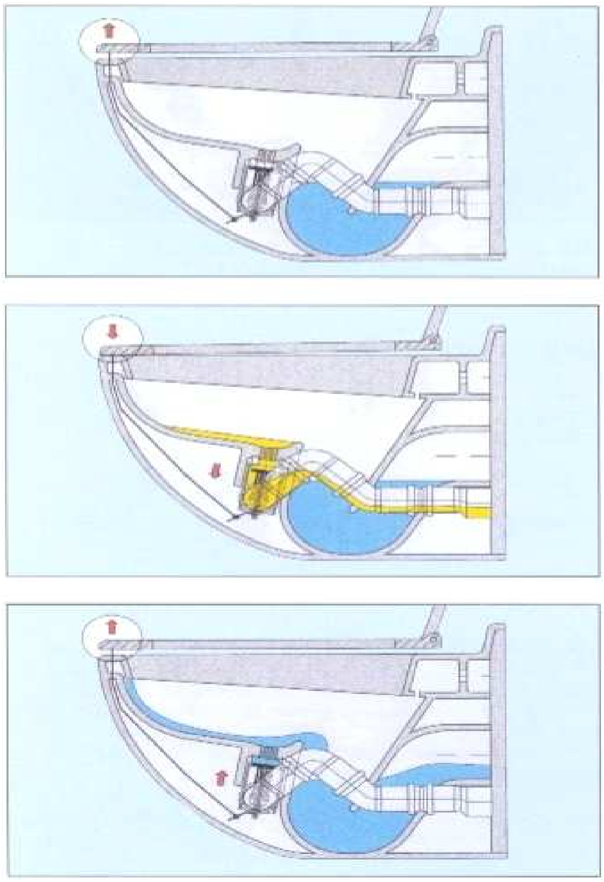

**Fig. 7:** Functional diagram of a urine-diversion flush toilet (source: Roediger). Top picture: closed valve before user sits down (idle state). Middle picture: toilet in use; bottom picture: during flushing(user no longer sitting).

**Urine storage tanks**

A total volume of 10 m³ is provided for urine collection and storage. The four polyethylene (PE) tanks of 2.5 m³ each are located in the basement of the building in a room in the car park area, and are equipped with sampling and level measuring devices. The pipework design allows filling each tank separately.

Measurements in 2008 showed that it takes about 3 months to fill the 4 tanks (corresponding to a storage time of 3 months). When the tanks are full, the urine overflows to a sewer. Therefore, about 40m$^3$ of urine are collected per year.

## 7 Type and level of reuse

Up to now urine has only been reused for demonstration purposes in pot plants in the offices of the GTZ ecosan team. Several times urine was transported to universities for research purposes: one entire tank load of 10 m³ was taken to the University of Aachen for MAP precipitation tests, and several batches of the urine were taken to the Universities of Giessen and Bonn for chemical analyses.

Reuse of treated urine will be realised in Phase 2. Under German fertiliser law, urine reuse in agriculture is not yet possible without special permits. In the upcoming BMBF funded research project, the GTZ ecosan team will try to establish such

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[2] Exact volume for the urine flush is yet to be measured on-site.

a permit for the application of stored urine as fertiliser on local agricultural fields.

When brownwater treatment is installed in Phase 2, the treated brownwater may be suitable for irrigation or toilet flushing – depending on the technology applied.

## 8 Further project components

The GTZ ecosan team regularly conducts guided tours through the facilities. A demonstration room with various urine-diversion toilet models from all over the world is adjacent to the urine storage tanks.

Due to the complete renovation of the buildings facade and the use of energy efficient heating systems and boilers the energy consumption of House 1 was substantially reduced.

The new ground design and a green roof (about 50 % of the total surface) enhance a positive microclimate and reduce rainwater runoff.

The building has won several awards including the "CSR Mobility Award" for sustainable travel management in 2008 from DMM, B.A.U.M. and VCD, and the "Bike + Business Award" in 2009 from the "Planungsverband Ballungsraum Frankfurt Rhein/Main (PVFRM)" and the "ADFC Hessen".

**Water saving**

During 2004-2006 all four GTZ buildings in Eschborn were equipped with water efficient fittings. Two of the four buildings, including the main building, are equipped with a separate service water system for toilet flushing, hand washing and cleaning, using the groundwater that has to be pumped up in order to lower the high groundwater level for the underground carpark in the building.

The groundwater which has to be pumped anyway is used as service water in preference to the more expensive municipal drinking water. Because of this groundwater pumping, greywater recycling was not a cost-effective option for the GTZ main building and has therefore not been implemented. Greywater is instead discharged into the sewer system leading to the central wastewater treatment plant located in Frankfurt-Niederrad.

## 9 Costs and economics

Table 1 shows a cost comparison between the present prototype installation and a conventional system.

These costs are based on a prior cost estimate from the year 2004 (for scenario 1) and actual costs from the year 2006 (for scenario 2).

**Table 1:** Investment costs (in EUR) for the collection system for scenario 1 (conventional system, based on cost estimate) and scenario 2 (ecological system installed at GTZ building, based on actual costs) for Phase 1.

| | **Scenario 1** (conventional) | **Scenario 2** (installed Phase 1) |
|---|---:|---:|
| Conventional urinals (23 units, 392 EUR each) | 9,016 | - |
| Waterless urinals (23 units, 315 EUR each) | - | 7,245 |
| Conventional toilets (50 units, 272 EUR each) | 13,600 | - |
| UD toilets (50 units, 1347 EUR each) | - | 67,350 |
| Blackwater pipe system | 17,500 | - |
| Urine, brownwater and greywater pipe system | - | 12,422 |
| Urine collection tank, pumps | - | 38,800 |
| **Total investment costs** | **40,116** | **125,817** |
| **Difference** | **0** | **+ 85,701** |

Compared to scenario 1, the additional costs of scenario 2 are 85,700 EUR (see Table ). The relatively high costs for scenario 2 are due to the following factors:

- Some components are currently only being manufactured in small numbers (e.g. the urine-diversion flush toilets). This has lead to unit costs for urine diversion toilets that were in 2005 about 5 times higher than the unit costs of conventional toilets[3].
- The urine tanks had to be manufactured specifically to fit into an existing room.
- Some units were designed with an extra safety factor (e.g. the urine pipe with enamel coating)
- The separated wastewater fractions can not yet be reused(onsite) thus still requiring a sewer connection. If no sewer connection was necessary, this could lead to cost savings in the case of a new building.

The use of the urine-diversion flush toilets and the waterless urinals reduce the water consumption for toilet and urinal flushing by approx. 1,200 $m^3$ per year compared to flush urinals and conventional toilets depending on the assumptions made.[4] This amount however cannot exactly be quantified because separate water meters measuring the water consumption before and after the installation of the new sanitary equipment were not installed.

Resulting from the water savings mentioned above, the calculated costs savings of scenario 2 compared to scenario 1 amount to approx. 4,800 EUR/year (see Table ).

[3] In 2009 the unit costs for Roediger NoMix toilets were EUR 780 and for Keramag Centaurus waterless urinals EUR 505(discounts possible for larger orders).

[4] Assumptions for this calculation: 200 men and 200 women (staff and guests), 220 working days per year. Men using the urinals 3 times/day at 3 L/flush (scenario 1) and 0 L/flush (scenario 2) and using the toilet 0.5 times/day at 8 L/flush(scenario 1) and 6 L/flush(scenario 2). Women activating the urine flush 3 times/day at 8 L/flush(scenario 1) and 3 L/flush(scenario 2) respectively and the faeces flush 0.5 times/day at 8 L/flush(scenario 1) and 6 L/flush(scenario 2).

**Table 2:** Estimated water-related operating costs (in EUR/year) of the two scenarios[5].

| | Scenario 1 (conventional) | Scenario 2 (installed Phase 1) |
|---|---:|---:|
| Urinal flushing | 2,200 | 0 |
| Toilet flushing | 9,600 | 7,000 |
| Kitchenettes, sanitary sinks | 3,200 | 3,200 |
| **Total water operating costs** | **15,000** | **10,200** |
| **Difference** | **0** | **- 4,800** |

## 10 Operation and maintenance

The installations which convey undiluted urine need special care because they are prone to the formation of urine scale(e.g. struvite).

**Waterless urinals**

Every evening the waterless urinals are cleaned(wiped down manually). On the highly frequented ground floor they are additionally cleaned every hour between 9:00h and 13:30h with a wet cloth and subsequently sprayed with a special odour removing cleaning agent for waterless urinals[6].

At least fortnightly the sieves and rubber tube seals should be removed from the urinals and regular toilet cleaner should be used to clean the sieves and to remove urine scale. The rubber tube seals are rinsed with water. They are replaced about once per year when the sealing mechanism does not work properly any more (not on a regular basis). The cost of one rubber tube( see Fig 6) is EUR 17.

**Urine-diversion flush toilets**

The daily cleaning routine is the same as for conventional toilets. For precipitation prevention the urine valve (in open position) needs to be soaked overnight with urine scale removing chemicals[7] every 2-3 months and soaked over night. This is done on two consecutive days by filling 200ml of this chemical into the open valve(seat pressed down to open the valve). Annually, the functionality of the valves is controlled and defective valves should be cleaned or replaced. If this maintenance routine is not followed problems will occur, see below.

Compared to conventional toilets this maintenance work is slightly more time consuming. Other than that the cleaning routine does not differ to normal toilet maintenance.

## 11 Practical experience and lessons learnt

The toilets and urinals have been in use since the end of 2006. Since that time valuable experience has been gained with the operation of the source separating collection system.

**The users' opinion on the project and on ecosan in general**

In September 2008 a GTZ internal survey about the acceptance of the waterless urinals and urine-diversion toilets as well as ecological sanitation in general was carried out. The following facts were revealed by the survey (217 participants):

- 90% of the participants pointed out that they like the idea of separately collecting urine and faeces for the application as fertiliser in agriculture.
- 71% would buy products fertilised with human excreta, whereas only 6% would not.
- 46% say urine should be permitted as fertiliser in organic agriculture, 12% think not.
- 48% would move into an apartment with urine-diversion toilets, 25% would not.
- The majority of users likes the modern design of the toilets and appreciates the installation of the novel watersaving sanitation system in the GTZ main building. However, only 5% of the users say the cleanliness of the toilet is better compared to conventional toilets, and 51% say it is worse.
- Many people complained about the higher demand for toilet cleaning after defecation and insufficient flushing strength for brownwater if a lot of toilet paper is used. 61% of the users flush the toilet more than once after usage.

**Low nitrogen content of the collected urine**

With 2.8 g/l[8] the measured nitrogen concentration for the stored urine is two thirds less than literature values for stored urine (7-9 g/l). The main reason for this is probably that nitrogen loss occurs in the form of ammonia gases being emitted through the tank's ventilation system. This could be reduced in the future by reducing the ventilation rate so that only pressure equalisation takes place. It is also possible that the urine may be diluted with some flush water.

**Experience with the waterless urinals**

The cleaning staff changes relatively often at the GTZ facilities. It has been found that thorough instruction of the staff which is responsible for the maintenance of the urinals is sometimes lacking. These problems are slightly reduced by replacing sieves and rubber tube seals with a new, optimised model (see Fig. 6) but if maintenance is neglected, then these will also cause odour problems.

As a result, the urinal sieves, and rubber tube seals were in some instances not cleaned for many weeks or months. This led to the accumulation of urinestone on the sieve(Fig. 8) as well as pubic hair and slime deposits which then cause odour problems.

[5] Costs for water supply and wastewater disposal are calculated with 2 EUR/m³ each. Maintenance costs are not included in this calculation.
[6] URIMAT MB-AktivReiniger with Kalkex
[7] 200 ml of "MELLERUD Urin- und Kalkstein-Entferner" (urine and calcium stone remover) per toilet
[8] The total nitrogen concentration in the stored urine was measured on about five occasions.

**Fig. 8**: Urine scale deposition on a waterless urinal's outlet sieve (old model). With the new model of the sieve and rubber tube seal (see Fig. 6 right), such urine scale formation and internal pubic hair accumulation is reduced (source: L. Ulrich, December 2008).

**Experience with the urine-diversion flush toilets**

The main problem with these toilets is that the urine pipe valve is susceptible to slimy struvite precipitations(see Fig. 9) this causes clogging of the valve, causing the urine to discharge through the brownwater pipe. Therefore it is crucial to apply an adequate maintenance routine, (see Section 10)[9]. As this maintenance has been neglected in this project, all valves stopped working after about two years of use and now need to be replaced(June 2009)[10].

The trade-off between sufficient flushing strength and water saving, should also be adressed in further development of the toilet bowl design. It was found that the urine flush is often not strong enough to flush away urine-soiled toilet paper. When users the flush twice, water savings are negated.

About two third of female users do not sit down on these or any other toilets in public places[11].The urine of these females is therefore not collected. This problem could be reduced by providing disinfection sprays for the seats.

**Fig. 9:** Soft urine precipitations inside a urine valve of a Roediger urine-diversion toilet. This valve was disassembled and cleaned after clogging (source: L. Ulrich, December 2008). One valve costs EUR 118 and requires a bowden cable costing EUR 51(location of valve in Fig. 7).

## 12 Sustainability assessment and long-term impacts

In Table 3 a basic assessment 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 sustainability assessment of the system. The crosses indicate the relative sustainability for each project component (column) and sustainability criterion (row). (+): strong point of project, (o): average strength for this aspect, (-): no emphasis on this aspect in the project.

| | collection and transport | | | treatment[a] | | | transport and reuse[a] | | |
|---|---|---|---|---|---|---|---|---|---|
| Sustainability criteria: | + | o | - | + | o | - | + | o | - |
| • health and hygiene | | | | X | | | | | |
| • environmental and natural resources | X | | | X | | | | | |
| • technology and operation | | | X | | | | | | |
| • finance and economics | | | X | | | | | | |
| • sociocultural and institutional | | X | | | | | | | |

[a] Not implemented yet.

**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, 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).

The following impacts of this project can be highlighted:

1. This project demonstrates the feasibility of urine and brownwater separation in an urban context to visitors from all over the world and thus helps to disseminate the ecosan concept.
2. By introducing an innovative sanitation system at its own main office building, GTZ shows its commitment to the ecosan approach.
3. The waterless urinals save water compared to conventional urinals.
4. This project has raised the visibility of the ecosan program within GTZ.

## 13 Available documents and references

Detailed design information and drawings are available on request from the GTZ ecosan programme. A presentation on this project is available here:

http://www2.gtz.de/dokumente/oe44/ecosan/en-presentation-gtz-eschborn-haus1-2009.pdf

[9] Pictures showing clogged and then cleaned valves can be seen here: http://www.flickr.com/photos/gtzecosan/sets/72157611453079661/
[10] The valves could be cleaned but are very difficult to put back into place
[11] A very small sample size consisting of fifteen females was used.

## 14 Institutions, organisations and contact persons

**Project owner and project champion**

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Keramag (waterless urinals)
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I: http://www.keramag.com

**Case study of SuSanA projects**

**Urine and brownwater separation at GTZ main office building**

**SuSanA 2009**

**Authors of version from 2006: Christine Werner, Florian Klingel, Patrick Bracken, Nicola Räth, Sonny Syahril (formerly: GTZ ecosan program)**

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**This document is available from:**
**www.susana.org**

sustainable sanitation alliance

## Case study of sustainable sanitation projects

# Urban urine diversion & greywater treatment system

# Linz, Austria

**Fig. 1:** Project location

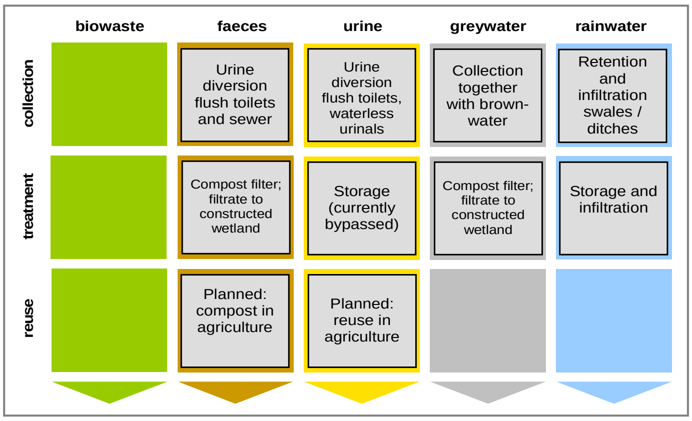


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

Medium-scale ecosan pilot project in new urban area

**Project period:**

Start of planning: 1998
Start of construction: 2004
Start of operation: 2006 (and ongoing)

**Project scale:**

Approx. 250 inhabitants in 88 flats and 270 pupils in a primary school with a childcare facility (in total 460 population equivalents).
Total costs: EUR 2.3 million up to 2008

**Address of project location:**

solarCity Pichling
Linz, Austria

**Planning institution:**

OtterWasser GmbH, Lübeck, Germany

**Executing institution:**

LINZ AG, Linz, Austria
Technisches Büro Steinmüller, Linz, Austria

**Supporting agency:**

None

## 2 Objective and motivation of the project

Worldwide, many ecosan projects have already been implemented on a small scale. However, there is still a lack of practical experiences with medium to large scale urban ecosan projects. Ecological sanitation systems can be an approach to address future water and phosphorus scarcity. Being the 2$^{nd}$ largest public service company in Austria, the LINZ AG[1] sees this project as part of its responsibility towards society.

**Fig. 3:** Buildings of the ecosan project in solarCity (source: Hochedlinger, LINZ AG, August 2009)

**General objectives:**

- Creation of a sustainable settlement in a new city district (high demand for residential buildings).
- Establishment of ecological buildings and low energy construction concepts.

**Specific objectives:**

- Implementation of innovative solutions for water supply and wastewater treatment with a reduction of the infrastructure costs for municipal wastewater treatment.
- Establishment of a holistic sanitation approach enabling the use of nutrients contained in excreta or wastewater in agriculture.
- Research into the treatment of micropollutants in urine[2].

[1] Public service company for energy, telecommunication, transportation and communal services (including wastewater collection and treatment).
[2] By PhD research of Winker (2009).

## 3 Location and conditions

Linz-Pichling is located in the southern part of Linz, a city of approx. 200,000 inhabitants. The project area is characterised by different types of houses (single houses and flats), small lakes, a creek, and the neighbouring Traun-Donau meadows and forest, the biggest joint biotope structure in Upper Austria. The ecosan pilot project is part of an innovative town planning project with many ecological features. It was developed with participation of the municipal authorities, 12 housing companies and READ (Renewable Energies in Architecture and Design) as the main architectural initiator.

## 4 Project history

In 1992 a master plan was developed for a new city district called solarCity. It envisioned up to 6,000 flats in Linz-Pichling and the associated infrastructure. Based on a study investigating sustainable energy concepts for such a settlement, in 1994 the town authorities declared their willingness to plan and finance a first model ecological settlement of 630 flats in a low-energy building standard together with four non-profit residential building cooperatives and world-renowned architects. This project was supported by the EU with EUR 600,000.
From 1995 to 1998 several architectural and landscape design competitions were carried out. Eight further non-profit housing companies and several architects and engineers joined the project, which led to the planning of 1,300 flats on an area of approx. 60 hectares.
From 1999 to 2005 this building project was implemented, and the construction phase of the ecosan project started in 2004. The construction of all parts (separation toilets, urine collection pipes, etc.) and the information for the users were carried out by the non-profit residential cooperatives. The contract between the LINZ AG and the cooperatives includes total cost coverage by the LINZ AG for retrofits to a conventional sanitation system in the case the ecosan system would fail.
In mid 2006 the ecosan system was taken into operation. The new inhabitants of the flats were informed before moving in by a small brochure containing information on the new sanitary installations and the separation concept. Public relation work was first done by the residential cooperatives, which was not successful. Later it was taken over by the LINZ AG and the city of Linz.
In 2008, the ecosan project solarCity Linz received the Project Innovation Award as regional winner for Europe in the category „Small Projects“ by the International Water Association (http://www.iwahq.org/uploads/pia/PIA%20A.pdf).

## 5 Technologies applied

This project manages the wastewater of approx. 460 population equivalents by means of urine separation, compost filters and constructed wetlands (design details are given in Section 6).
A primary school and childcare facility for 270 pupils and personnel (system 1), as well as 88 flats of three housing companies with approx. 250 inhabitants in 7 buildings (system 2) are equipped with the following ecosan components:

**System 1 (primary school and childcare)**

- 12 urine-diversion flush toilets
- 20 waterless urinals
- 2 separate pipe networks for urine and other wastewater
- 2 fibreglass tanks for urine collection and storage (total volume: 3 m³)
- 2 compost filters for pretreatment of the mixed brownwater[2] and greywater (solids removal)
- 1 constructed wetland for the treatment of the filtrate from the compost filters

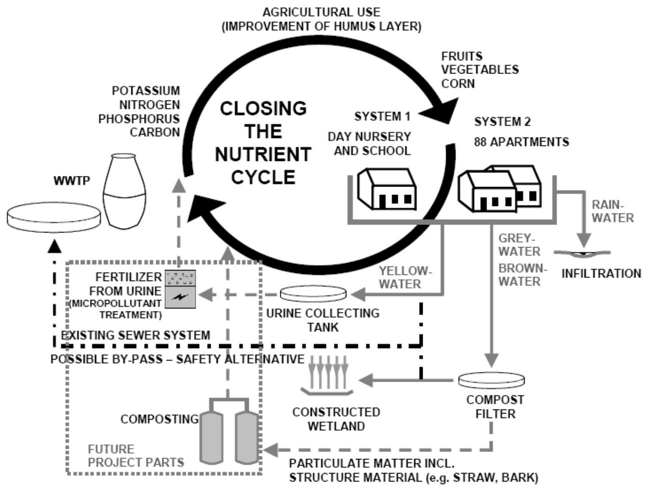


**Fig. 4:** Technological concept applied in the solarCity project (source: LINZ AG).

**System 2 (88 flats; average household size is 2.8 persons)**

- 115 urine-diversion flush toilets
- 2 separate pipe networks for urine and other wastewater
- 6 fibreglass tanks for urine collection and storage (total volume is 4.5 m³)
- 2 compost filters for pretreatment of the combined brownwater and greywater (solids removal)
- 2 constructed wetlands for the treatment of the filtrate from the compost filters

In the project area in Linz-Pichling a conventional sewer is provided: the wastewater streams of the ecosan system can be connected to the existing public sewer system (see Fig. 4). This sewer connection can be utilised in case of malfunctions or optimisation works (it is currently being used for urine and constructed wetland effluent, see Section 11).
Rainwater is infiltrated on-site through infiltration ditches.

## 6 Design information

### Urine-diversion flush toilets

The urine-diversion flush toilet model “NoMix toilet” (supplier: German company Roediger[3]), which is implemented in the school and residential buildings, is made of ceramics. Its bowl is separated into a urine and a faeces section. It requires utilisation in a sitting position because a urine pipe valve is activated by the user’s weight on the toilet seat to allow the collection of pure urine (without flush water). The valve closes when the user stands up, so that the flushing water does not enter the urine pipe but drains off through the faeces outlet in the rear. This reduces the required urine storage volume, because the urine is collected without dilution. The user has two different flush buttons available: 1-3 L of flushing water

[2] Brownwater: faeces mixed with flushing water (without urine)
[3] www.roevac.com

are used for the urine flush (volume set during installation) and 6 L for the faeces flush.

**Fig. 5:** Roediger urine-diversion flush toilet showing knob to activate urine valve at the front of the toilet bowl (source: Roediger).

**Waterless urinals**

The waterless urinals (meanwhile widespread in many Western European countries) are also made of ceramics and supplied by Hellbrok[4]. The special surface prevents sticking of a urine film that could cause odours. In the model used in system 1 (school and day nursery) a liquid with lower density than water and urine works as a sealant liquid in the odour trap. It has to be refilled regularly (see section 10). The liquid is biodegradable when discharged to the sewer.

**Fig. 6:** Waterless urinals for boys from the Austrian company Hellbrok in the school building – hung lower than for adults (source: OtterWasser GmbH).

**Urine storage tanks**

The separate urine pipe network (100 mm diameter, 1-2% slope) leads to 6 double wall fibreglass tanks in the housing area and to 2 storage tanks in the basement of the school. With a volume of 1.5 $m^3$ each in the school (total volume: 3 $m^3$) and 0.75 $m^3$ each in the residential buildings (total volume: 4.5 $m^3$), the tanks are designed for 30 to 60 days storage time[5]. They are closed (to reduce odour and ammonia losses), and the pressure equalisation takes place through the inlet pipes from the houses. The storage tanks are equipped with level indicators, a leakage warning system, an overflow to the sewer, and a fitting for emptying by a vacuum truck. The actual amount of urine produced is currently not measured.

**Fig. 7:** The two plastic urine tanks (currently bypassed) in the school building's basement have a capacity of 1.5 $m^3$ each (source: OtterWasser GmbH).

**Compost filter units (pretreatment)**

A filtration system for solids removal is the first treatment step of the greywater and brownwater mixture. The two 1-m³ filter units are located in the two operation buildings which are integrated in the hills of the artificial landscape. Apart from the pretreatment filters, the operation buildings contain a storage area for the containers for the dewatering process and all the control and maintenance facilities.

The filter units (Fig. 11) are made of stainless steel containers, serving as a carrier for a filter bag of acid-proof plastic material, which is filled with organic structure material (e.g. straw). The brownwater and greywater mixture is pretreated in the filter bag (by composting) under aerobic conditions and drains through the structure material. The filtrate runs off through slots in the base of the container and flows to a pump sump, from where it is pumped to the constructed wetland.

**Constructed wetlands**

The two constructed wetlands are of the sub-surface vertical flow type, planted with reed (*Phragmites australis*). Since the urine is separated, the remaining wastewater has a low nutrient content. Therefore, the required size of the constructed wetland is up to 1 m² per inhabitant smaller than in constructed wetlands for domestic wastewater where it is 2.5 - 3 m² per person. Two wetlands exist, each containing two beds of 8.9 m x 22 m each. Overall, a wetland area of 771 m² is available for treatment.

The intermittent batch feeding is achieved by submerged pumps. To prevent dehydration, e.g. due to low wastewater volumes during summer holidays, the wetlands can be switched to an operation mode where the wastewater is recirculated. The wastewater flowrates to the wetlands are not known.

## 7 Type and level of reuse

The reuse of urine is not yet carried out because the Upper Austrian legislation prohibits its application in agriculture.

At the moment the composting process of the compost filter material is not functional due to optimisation works (see Section 11).

[4] www.hellbrok.at

[5] For safe urine application in agriculture further storage, treatment steps or other barriers may be necessary (WHO Guidelines, 2006 http://whqlibdoc.who.int/publications/2006/9241546859_eng.pdf).

In the future, nutrient recycling (through use of urine, compost and reeds from the constructed wetlands) and on-site infiltration of the treated brownwater and greywater shall be realised in cooperation with research partners (see Section 8).

## 8 Further project components

The ecosan project solarCity provides the "hardware" for future research activities. Research partners have been chosen and a proposal is finalised. Together with these research partners and in dialogue with the authorities the final stage of the ecosan project – closing the nutrient loop by using compost and urine as fertiliser in agriculture (under consideration of micopollutants) – shall be realised in the near future (funded by Austrian research funds).
Besides the ecological sanitation concept solar energy and energy-saving technologies are also implemented in solarCity.

## 9 Costs and economics

Until 2008 the total costs of this project amounted to about EUR 2.3 million, encompassing investment, operation, maintenance, and research sponsorship. The costs are fully covered by LINZ AG, and the company is granted tax concessions (8% of the project costs). The construction costs including design and project management have been about EUR 1.7 million. Sponsorship of research (e.g. Hamburg University of Technology, ARC Seibersdorf Research GmbH, and the University of Applied Sciences Upper Austria) resulted in expenditures of EUR 0.5 million. Moreover, the operation and maintenance costs amounted to EUR 100,000 in the time from mid 2006 to mid 2008.
The inhabitants of the houses that are connected to the ecosan system are paying the normal wastewater fees (sewer system and wastewater treatment included). The calculation of the fee in Linz is a combination of number of toilets and water consumption. E.g. a family (4 persons) with 160 m³ per year (EUR 0.32 per m³) and one toilet (EUR 112 per year and toilet) has to pay yearly fees of EUR 160 per year (plus 10% tax). All inhabitants of solarCity involved in this ecosan project pay the same fees as users of conventional toilets.

## 10 Operation and maintenance

The maintenance of the ecosan system's technical equipment is carried out by the LINZ AG as the operating company. Currently the last optimisation steps are being carried out. In the future, the main work will be operation, customer service, public relations and project management.

**Urine-diversion flush toilets**

The operation of the urine-diversion flush toilets is similar to conventional toilets. However, the user has to be seated also for urination. As discussed in Section 11 the cleaning is slightly more difficult compared to conventional flush toilets.
Annually, LINZ AG inspects the toilets and provides user information and public relations work. If necessary, urine scale is removed with boiler scale remover and worn-out bowden wires (for the operation of the urine valves) are replaced. For the prevention of urine scale deposition in the urine valves, the users are provided with 1 L of diluted citric acid (20%) every year, together with information on how to use it (monthly application with open valve, exposure time over night).

**Waterless urinals**

The reliability of the waterless urinals (no odour) highly depends on regular maintenance. The urinals at the school are cleaned daily by the cleaning service and the odour traps with the sealant liquid cartridges are exchanged regularly (after one to two years) by the maintenance service of the school and childcare.

**Urine storage tanks**

Currently the urine is discharged into the public sewer system and not collected in the urine storage tanks. However, if the urine was collected and reused, the tanks would have to be emptied monthly by a vacuum truck that would transport the urine e.g. to a nearby farm for application. For this reason, there is currently no information available about the urine production per day.

**Constructed wetlands**

The technical installations of the treatment facilities, especially the pumps, are controlled by remote systems (SCADA) installed at the wastewater treatment plant Asten, which is located 2 km away.
The reed of the constructed wetlands is growing quite slowly; therefore nothing was done with it yet. If the plants were big enough they could be harvested in spring. Reeds die off in autumn, but to prevent frost they should be left on the wetland during winter time. In the future the harvested reeds could be used in the filter units as organic and structure material.

**Fig. 8:** Constructed wetland under construction (source: LINZ AG, April 2006).

**Fig. 9:** Constructed wetland (reed beds) in operation (source: LINZ AG, May 2008).

**Compost filter units**

The compost filters are still at a trial stage (see Section 11). It is planned to operate them intermittently: after filling the first filter unit, the inflow will be connected to the second unit, while the first one is resting for dewatering. The container content

then keeps dehydrating until it is transported to the neighbouring room in the operation building by fork lift. There, 6-8 full, stackable containers (1 $m^3$ each) can be stored.
After finishing the optimisation work of the filters, bulking material shall be added to the containers at least once a week. LINZ AG will then collect the containers from the storage rooms once or twice a year and empty them at a central composting ground for post-composting.

## 11 Practical experience and lessons learnt

**Surveys about performance and maintenance of the toilets**

About 90% of the people who live in the houses equipped with urine diversion toilet did not move there purposefully for the ecosan system. Therefore, the experiences made with these inhabitants provide valuable information about the general acceptance of ecosan concepts.
After half a year of operation (early 2007) the first survey was conducted by LINZ AG with a focus on the performance and maintenance of the urine diversion toilets. Some practical problems became evident, mainly resulting from the improper maintenance and use of the Roediger toilets.
67 out of the 88 households took part in the survey. 66% reported that flushing water splashes onto the toilet seat. This problem can be solved by reducing the amount of flushing water. However, 68% (among single, male occupants only 13%) complained about a weak flushing strength which does not completely carry away the solids (faeces and toilet paper) resulting in increased cleaning requirements compared to conventional toilets. This trade-off relates to the design of the toilet and should be addressed in further development and optimisation of the toilet.
71% of the polled users said that the toilets require special maintenance work, e.g. for the urine pipe valves. For the prevention of urine scale everybody used scale remover. In total, about 95% of the toilets were perceived as clean by the interviewers.
The residential cooperatives did not provide adequate user information about the ecosan system: only 77% of the households had been informed in advance about the source separation concept. Based on LINZ AG's promise for total cost coverage for retrofits to a conventional sanitation system in case of a failure of the ecosan system, one cooperative tried to convince the occupants from the beginning that the ecosan concept would never work. Therefore, the public relation work was taken over by the LINZ AG itself.
In a first step, confidence was restored by means of an on-site information campaign, along with a toilet check (particularly of the urine pipe valves) and immediate repair of toilet malfunctions. Due to this information campaign, trust restoration mostly succeeded.
According to the survey only 11% of the users had a negative opinion about the ecosan project, and the other users were positive to indifferent.
A second survey, conducted in December 2008 with 55 households, showed that the general acceptance for the ecosan project is neutral to very good, but for the urine diversion toilets the result is very bad to neutral (despite the information campaign), due to the above named issues.

**Measurement campaign for system 1 (school and childcare) in May 2007**

In order to assess the performance of the urine diversion toilets, a three-week monitoring programme was conducted in the framework of a diploma thesis for the school system (system 1) in May 2007. The analysis of daily collected samples from several monitoring points of the system showed that a part of the urine is not collected properly (elevated nitrogen concentration in the mixed brownwater and greywater stream).
Most of the losses result from improper maintenance of the urine pipe valve or incorrect use for urination (users not sitting down). The results of the monitoring program also showed that approx. 60% of the total nitrogen contained in urine is being collected here. The amount of urine collected annually is unknown.

**Operating experience with the urine diversion toilets and waterless urinals in the school (system 1)**

Experience with the urine diversion toilets has shown that they are too large for small children and therefore not suitable for primary schools. A small child (shorter than 1.4 m) cannot get into the right sitting position (compare Fig. 10), which may result in faeces ending up in the urine collection bowl of the toilet. The faeces in the urine bowl are not flushed away completely, which leads to odour problems. This problem occurred in the school but also in the flats of families with small children. In the childcare facility it is prevented by staff helping the children with the use of the toilet.

**Fig. 10:** Left: ordinary (problematic) sitting position of a child on a Roediger NoMix toilet. Right: optimal (but less comfortable) sitting position of a child (source: LINZ AG).

A raised platform around the toilet, aiming to ensure a better sitting position by maintaining the contact of the child's feet with the ground, succeeded only partially. The reason was that it was called a "baby's toilet" amongst the children. As none of them wanted to be a baby anymore they did not want to use a "baby's toilet". Due to the varying ages of the primary school children no universal solution could be found. The pupils had to be educated to use the toilet brush for cleaning purposes. Since then the cleanliness of the toilets improved a lot.
The measurement campaign for system 1 revealed that the pupils used the urine-diversion toilets for urination, but they avoided defecation. Whether this is a phenomenon related to this particular toilet type or a general behaviour of pupils (preferring to defecate at home rather than at the school) could not be identified. Another assumption might be that this time of the day is not the main time for defecation.
After two years in operation, the LINZ AG **changed the UD flush toilets at the school to conventional flush toilets** until the urine separation toilets are improved for small children. The pipes and connections still exist so that the toilets could be exchanged again at a later stage.
Due to regular operation and maintenance routines the waterless urinals are functioning well, with neither blockages nor odour problems occurring.

**Operating experience with the urine diversion toilets at the flats (system 2)**

There are some practical problems resulting from wrong or neglected maintenance, incorrect use or the design of the separation toilets:

- the urine inlet valves have to be cleaned regularly to prevent urine scale
- most of the nitrogen losses result from the malfunction of the urine inlet valve or the incorrect use of the separation toilet
- the odour problems are caused by wrong depositing of the faeces in the front part of the separation toilet
- the flushing water splashes onto the toilet seat
- it is often necessary to flush twice, because the water flush volume is not enough to carry away faeces and/or toilet paper.

LINZ AG started an information campaign to avoid problems due to wrong maintenance or use and recommended to the manufacturer of the toilet to change the design.

**Performance of the compost filters and constructed wetlands**

So far the performance of the compost filters has not been satisfactory due to clogging of the filter bags: The cellulose of the toilet paper substantially decreases the hydraulic permeability of the filters' material. Further research and optimisation work had to be conducted. Tests of different structure materials (such as bark and straw) were conducted. They showed that the adding of a pre-treatment step e.g. a settling tank would reduce the sludge load and enhance the permeability of the filter bags. The implementation of further optimisation steps will be done together with future research partners in 2009.

**Fig. 11:** Compost filter bags at trial stage, here with straw as structure material (source: LINZ AG, November 2007).

The performance of the two constructed wetlands is excellent. The measurement campaign for system 1 showed that the effluent concentrations are less than half the legally required values[6]. Nevertheless the final effluent is being discharged into the local public sewer network, because the relevant local authorities[7] have not granted a water quality discharge consent yet.

**Lessons learnt**

The ecosan technologies applied in this project are not yet fully mature and functional. There is a need for optimisation of the NoMix toilet design. The slightly increased demand for cleaning is acceptable. But for young children, e.g. at primary schools, the Roediger toilets are not suitable. The waterless urinals are trouble-free.

The project at the school has had significant problems with the urine separation flush toilets for small children who find it difficult to sit back far enough for defecation.

Public relations work, i.e. user information, is extremely crucial for the acceptance of innovative sanitation systems and the users' willingness to cooperate. The general acceptance of the innovative sanitation concept is good, despite the challenges that are brought about by the urine diversion flush toilets.

Valuable experience with the medium-scale application of compost filters could be gained in this project. One problem is that the filter units were undersized (the permeability of the filter bags turned out to be lower than expected).

Moreover, it became evident that it is important to include the local authorities from the beginning as it avoids many problems in the long run.

## 12 Sustainability assessment and long-term impacts

In Table 1 a basic assessment 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 1:** Qualitative sustainability assessment of the system. The crosses indicate the relative sustainability for each project component (column) and sustainability criterion (row). (+): strong point of project, (o): average strength for this aspect, (-): no emphasis on this aspect in the project.

| | collection and transport | | | treatment | | | transport and reuse[a] | | |
|---|---|---|---|---|---|---|---|---|---|
| Sustainability criteria: | + | o | - | + | o | - | + | o | - |
| • health and hygiene | x | | | x | | | | | |
| • environmental and natural resources | | x | | x | | | | | |
| • technology and operation | | x | | | | x | | | |
| • finance and economics | | x | | | | x | | | |
| • sociocultural and institutional | | x | | | x | | | | |

[a] No reuse practised yet

[6] According to the first wastewater emission directive of Austria ("1. Abwasseremissionsvereinbarung" in German)

[7] The German name of this local authority is: Wasserrechtsbehörde (Amt d. Oberösterreichischen Landesregierung)

**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, 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).

The main long-term impacts of the project are:
1. It has provided useful experiences to others as a demonstration project, as it is always open to visitors.
2. The experience and the cooperation with the inhabitants illustrated the demand to optimise these urine-diversion flush toilets by the manufacturer (or, possibly, to switch to a different manufacturer).

The final aim of solarCity, the use of compost and urine as a fertiliser in the agriculture, still has to be realised with research partners.

## 13 Available documents and references


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Further documents are available on request from the contact persons indicated below.

## 14 Institutions, organisations and contact persons


**Project management and owner of project**

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**Case study of SuSanA projects**

**Urban urine diversion & greywater treatment system**

**SuSanA 2009**

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## Three examples of wastewater reuse after reed bed treatment

# Dubai, Industrial Zone

**Fig. 1:** Project location

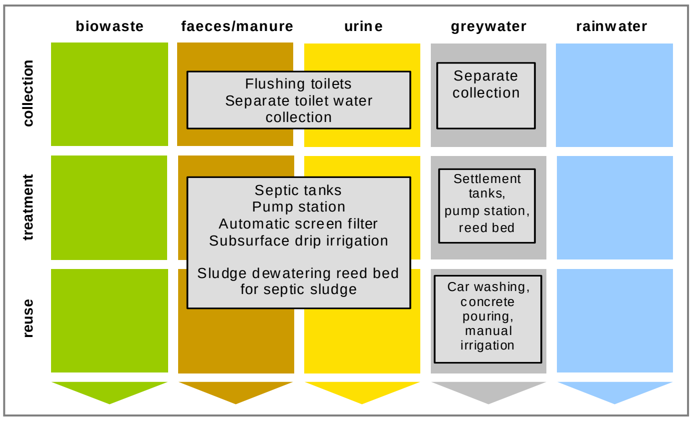


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**

Treatment and reuse of wastewater of commercial buildings (workshops, offices, car washing) – full-scale

**Project period:**

Start of planning: 2005 / 2006
Start of construction: 1 month after planning start
Start of operation: 2-6 months after planning start

**Project scale:**

60-270 persons/day, and 10 cars/d for Example 1b
Investment costs of the 3 examples in the range of € 4,500 to € 21,000

**Address of project location:**

Example 1: Waagner Biro Gulf, Al Awir Ind. Area, Dubai
Example 2: The Lagoons Sama Dubai, Ras Al Khoor, Dubai
Example 3: Dubai Municipality Jadaf, behind ship yard, Dubai

**Planning institution:**

Waagner Biro Gulf

**Executing institution:**

Respective owners / Waagner Biro Gulf

**Supporting agency:**

None

## 2 Objectives and motivation of the project

Waagner Biro Gulf is a construction company specialized in steel, bridge and marine constructions with a special branch for environmental technologies, and has demonstrated innovative solutions in the field of closed loop wastewater treatment to its clients in different settings. The main aims of a range of different projects are:

- Demonstration of generally applicable wastewater reuse options for private companies and municipalities in sub-tropical, arid climates.
- Climate-specific testing of reed bed treatment for greywater (reed beds are a specific type of constructed wetland, see Section 5), sludge dewatering with reed beds and sub-surface drip irrigation with pre-treated blackwater.

Key information from three typical project examples is provided in this document.

**Fig. 3** Project sites (clockwise): Example 1a, 2, 3, 1b (source: Waagner Biro Gulf)

## 3 Location and conditions

Dubai has a sub-tropical, arid climate with infrequent and irregular rainfall, totalling less than 130 mm per year. Temperatures range from 10℃ to 48℃. Both industrie s and the population in Dubai and the surrounding Emirates is growing very fast and public infrastructure is unable to keep up with the exploding volume of sewage. On newly built developments and industrial sites, which are not (yet) connected to a public sewer, temporary or self-contained solutions for waste and wastewater management are needed.

Presently, wastewater is often either:
- discharged via long sewer networks to the main sewage treatment plant; or, if the site is not connected to sewers:
- stored in storage tanks and later transported by tanker to a central sewage treatment plant or
- pretreated in septic tanks and then infiltrated into the ground with soakaways.

Whilst the latter approach causes problems through increased road traffic, additional unplanned loadings to sewage treatment plants, soil contamination and possible groundwater contamination etc., the installation of huge sewer lines is technically demanding and costly.

Moreover, the high water demand in this hot, dry region is in conflict with its extremey limited availability, and thus innovative technical solutions are required. To some degree this high water demand can be met through the reuse of treated wastewater as service water.

## 4 Project history

Waagner Biro Gulf LLC is a multi-national turnkey contractor and facility manager of bridges, steel structures, waste recycling, wetland wastewater treatment plants, wetland systems and marine works with "in-house" design, manufacturing and installation capacities. It also serves as partner for public authorities in a variety of maintenance and upgrading contracts.

The introduction of innovative wastewater treatment options to the clients has become one of the company´s key environmental activities in the Gulf region.

## 5 Technologies applied

Reed beds are an example for a constructed wetland treatment process (vertical or horizontal sub-surface flow, soil filter planted with *Phragmites communis* or other marsh plants). Reed bed technology is used in Dubai for treatment of car wash wastewater, greywater, blackwater and septic sludge. In the following project examples, diverse technology components were applied:

<u>**Example 1a:**</u>
**Domestic wastewater at the Waagner head office (270 staff members):**

Transport by separate gravity sewer lines for grey and blackwater. Treatment and reuse of both greywater from showers / bathrooms and blackwater from toilets and the kitchen.

- Greywater: After settling in a 2-chamber tank, it is pumped in turns onto two vertical flow sand filter reed beds, each with an area of 250 m². The outflow of the greywater reed beds is directly used for different purposes as explained in Section 7.
- Blackwater: After passing through a 3-chamber septic tank, the pre-treated blackwater is pumped through a mechanical self-backwashing filter into a 700 m² sub-surface drip irrigation, watering a gardening area, thus avoiding any direct exposure of people to blackwater.
- Settled solids from the pretreatment units of greywater and blackwater (settlement tank and septic tanks): They are pumped every two months onto a 200 m² sludge dewatering reed bed for mineralization. This is a further development of sludge drying beds in the form of a sealed earth basin with a shallow vertical flow reed planted sand filter and 1 m freebord above the filter layer to accumulate the sludge over the next 10 years.

**Example 1b:**
**Waagner company´s car washing wastewater (10 cars / day):**
3-step pretreatment by gravity, three chamber oil separator without chemicals, 20 m² horizontal flow sand filter reed bed treatment of oil separator outflow, additional treatment of reed bed outflow in reed bed for greywater treatment.

**Fig. 4** Car washwater reed bed Alawir (source: Waagner Biro Gulf)

**Example 2:**
**Domestic wastewater of SAMA Dubai site office (200 staff members):**
- 3-chamber septic tank and 100 m² vertical flow sand filter reed bed treatment for toilet blackwater
- Reuse of treated blackwater in 400 m² sub-surface drip irrigation (gardening)
- 2-chamber settlement tank and 40 m² separate vertical flow sand filter reed bed treatment for greywater
- 20 m² sludge dewatering reed bed (reed-planted sand filter bed) for mineralization of septic tank sludge

**Example 3**
**Conversion of conventional septic tank with soak away at Dubai Municipality (60 staff members)**:

- Use of septic tank as pretreatment
- Conversion of soak away to a pump station and pumping of outflow to a 170 m² vertical flow sand filter reed bed for biological and tertiary treatment of pre-treated wastewater. Analyses proved sufficient quality for drip irrigation.
- Optional additional UV treatment of stored effluent with UV lamp in stainless steel pipe.

**Fig. 5** Greywater reed bed Alawir (source: Waagner Biro Gulf)

## 6 Design information

The designs are in accordance with the German guidelines for reed beds and the Dubai Municipality Guidelines for septic tanks as well as guidelines for drip irrigation systems (see Section 13).

The reed bed (or constructed wetland) treatment system combines both aerobic and anaerobic decomposition processes in a sand layer up to 1 m thick. The polyethylene-lined and refilled basins are planted with "Phragmites Communis" and other regional marsh plants. The wastewater percolates the filter substrate vertically or horizontally to the floor drains.

Along with the microbial and fungal decomposition of organic matter and pollutants in the rooted sand matrix, chemical and physical precipitation, adsorption and filtering processes occur due to sand constituent clay-like minerals and humus particles.

Through intermittent loading of the reed beds a radical change in the oxygen regime can be achieved. After water saturation of the sand through feeding the distribution system, a drainage network at the base collects the treated wastewater. The water in the pore space of the substrate is replaced during drainage by air, thus enabling aerobic decomposition processes to begin. Further oxygen transfer into the rhizosphere from the air occurs through a special helophyte tissue in the plant stems and roots (aerenchym).

Clogging of the filter substrates (sand, gravel) is prevented by the continuous growth and decay of the roots and rhizomes of the aquatic macrophytes and the resulting soil macropores. In this way, long-term use and transport of pre-treated water into the soil matrix is guaranteed.

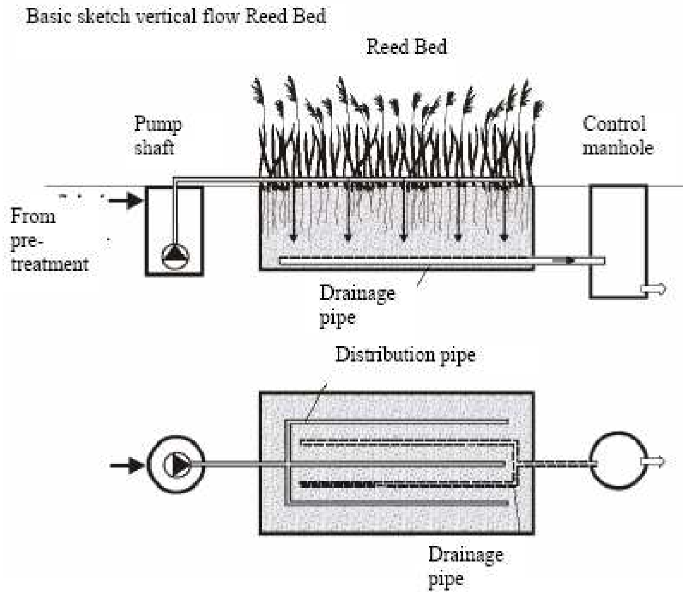


**Fig. 6** Basic sketch of a vertical flow reed bed (source: http://www.entsorgungsverband.de/uploads/media/Vortrag-Bleif.pdf)

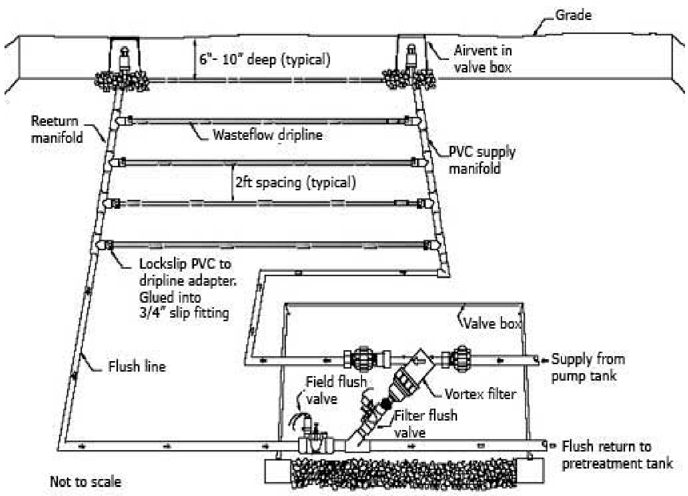


**Fig. 7** Typical drip field layout (source: Geoflow)

## 7 Type of reuse

**For Example 1**:

- Storage of treated greywater (including water from car washing) in an elevated tank and a pond for reuse for concrete mixing, soil watering, car washing and a fish ponds.
- Sub-surface irrigation of different plants including tomatoes, melons, cucumbers, date palms, flowers, bushes and grass areas. Analyses of the plants have complied with WHO Standards.

**Fig. 8** Sub-surface irrigated plants (source: Waagner Biro Gulf)

**For Example 2:**
- Storage and reuse of treated greywater for manual garden irrigation and for car washing
- Sub-surface drip irrigation system for gardens using treated blackwater
- Mineralised septic tank sludge used as a soil improver and fertiliser in landscaping.

**For Example 3:**
Storage of treated greywater for irrigation and for boat washing (after additional hygienisation using UV-radiation).

Plants irrigated with treated greywater and blackwater show excellent growth (e.g. pumpkins, oleander, palm trees). However no sub-surface plants such as onions or carrots were cultivated in order to avoid contact with the blackwater. The safest plants to minimize human exposure to the soil during planting and harvesting works are long term ornamental plants such as palm trees, grass and bushes.

## 8 Further project components

- Continuous analyses of the treated wastewater of project Example 1.
- Plants and soil are monitored, especially in the projects located at the constructors´ site (Example 2) and at the Municipality site (Example 3).
- Analyses have confirmed WHO Standard for the sub-surface blackwater irrigated crops.
- The sludge dewatering process is being monitored, and tests using sludge from other project sites are being carried out to define the maximum load.
- Experience has shown an enormous potential of this type of sludge dewatering technology in arid regions, as the drying and mineralization process is much faster than in Europe (dewatering and mineralization of sewage sludge with reed-planted sand filter). Further long term tests are necessary to find new design guidelines for arid regions.
- A greywater reed bed is divided into several parts to test the maximum loading in this climate.
- Advantages of decorative aspects of storage ponds in gardening are integrated into designs.

**Fig. 9** Greywater garden (source: Waagner Biro Gulf)

## 9 Costs and economics

Depending on the exact circumstances, the actual construction investment for reed bed systems in this region is equal to conventional systems (activated sludge plants) for up to 15,000 persons (for larger installations, the conventional systems may have lower cost than red beed systems). While Dubai is in middle of the desert, the main problem is to get the right filter sand for the system, as the construction is booming and all the crushers are sold out for years and the price for sand is enormously high.

On the other hand, the operational costs of reed bed systems in this region are about 10-30 % of activated sludge plants. This is an important advantage for clients, as often for conventional sewage treatment plants no capital is provided for operation and maintenance, leading to malfunctions and poor efficiency. The reed bed technology provides a long lasting, low-maintenance and high performance, robust alternative solution with very low O&M costs compared to e.g. activated sludge treatment plants.

It is clearly the long term economic benefits of such systems that have persuaded companies to opt for the technology. The reliable performance potential is an added bonus.

<u>Cost examples:</u>
Example 1a: Investment: €4,500
Example 1b: Investment: € 36,000. Payback could be achieved within one year by saving fresh water and tanker disposal cost.
Example 2: Investment: € 13,000
Example 3: Investment: € 21,000, yearly running cost: € 200 (electricity and labour)

Average cost break-down of reed bed systems:
On average 90% of the investment costs are civil works, like earth movement and installation of filter material and distribution and drainage pipe works. Therefore the installation costs depend mainly on the prices of filter material and day rates of earth movement equipment. The remaining 10% of the investment costs are typically for the mechanical parts, mainly submersible pumps and valves.

As the mechanical equipment is a minor part of the system, also the maintenance, running and spare part costs for the system are very low - they are the same as for a pump station.

## 10 Operation and maintenance

Constructed wetlands in general, and reed beds in particular, are simple to operate without chemical additives or complex electronic controls. They require minimal staffing levels due to their very low maintenance requirements. Consequently, operational costs are very low, whereas system lifetimes are very long.

O&M is normally done by skilled workers of the owners which can be trained by the constructors within a few days. The operation of the system consists of the following tasks:

- Daily tasks: Visual check of the system
- Weekly tasks: Change of the distribution from one bed to another (opening and closing a valve); remove reed shoots from the service ways around the beds; visual check of the pump station.
- Every three months: Discharge sludge from the pre-treatment; flush distribution and drainage system, clean pump stations

The cut reeds can be:

- disposed of on the sludge dewatering reed bed as structure material and carbon donor for the mineralisation process.
- composted with other organic waste, used as litter for animals or as organic structure material in agriculture.
- If a high enough volume is produced: used to produce ecological building materials or biomass for biogas production.

**Fig. 10** Reed bed plant for wastewater in Jadaf (source: Waagner Biro Gulf)

Sludge disposal from septic tanks is done every two to six months by vacuum tankers which dispose of it in the municipal sewage treatment plant. Alternatively, the sludge is pumped with a mobile pump and flexible hose onto a sewage sludge dewatering reed bed. This monthly effort takes less than 1 hour.

In the case of the gravity oil separator (in Example 1b) the oil has to be removed once a year.

## 11 Practical experience and lessons learnt

- The continuous availability of a large volume of stored and treated greywater in a pond makes some processes in the construction and maintenance works much easier.
- The vertical flow reed planted sand filter achieves results in the treatment of domestic sewage which allow a direct reuse for irrigation of the treated sewage without any further treatment.
- The treatment in such hot climate leads to even better results than in Western and Northern Europe (some results indicated in Table 1 below).
- Regarding manual reuse, the acceptance of treated greywater is much higher than that of treated blackwater, whereas sub-surface irrigation with blackwater is well accepted for gardening purposes due to the non-exposure to the water. However, it should be handled with care with regard to surface drainage and leakages, and well trained staff should run and maintain such a system.
- The gardens and fishponds created with the onsite treated wastewater from workers' accommodations and staff cabins have a great social value for the people there who otherwise mostly have no greenery around their work places and accommodation.
- Larger reed beds also contribute to biodiversity by serving as reserves for birds and small water animals.

**Table 1:** Typical average pollutant concentrations of reed bed effluents in the U.A.E. (source: Waagner Biro Gulf – based on 3 years of experience, approx. 20 plants treating a variety of wastewaters, and operating temperature range 25-50ºC)

| COD | BOD | $NH_4$-N | TSS | pH |
|---|---|---|---|---|
| 25 | 10 | 1 | < 5 | 7.5 |

Note: Average influent parameters for raw sewage in the region: COD 400-600 mg/l, BOD 200-400 mg/l.

## 12 Sustainability assessment and long-term impacts

A qualitative sustainability assessment is provided below:

- Technical sustainability: As described above, the treatment results are even better than in colder climates. Once started, the system does not need additives, has low energy input and requires little maintenance.
- Ecological sustainability: Beyond the practical issues related to wastewater treatment, a reed bed system does consume only little energy but saves natural resources, it produces biomass as valuable by-product, it can serve as biotope and – because it is clearly visible - it often raises awareness concerning the subject of wastewater.
- Financial sustainability: Preconditions for the system are an available area of a certain size, some design and coordination efforts in the beginning to adapt the solution to the particular context, and an investment comparable to a conventional activated sludge treatment plant (for this region and for sizes up to 15,000 people). The cost benefits become evident after some years through power saving and low maintenance. Hence, a mid term financial perspective is necessary to compare possible solutions.

As long as ecological education and awareness as well as consideration of macro-economical terms are not sufficiently developed on the decision making levels, the most powerful means to support sustainable systems are political and legislative regulations.

A basic assessment (Table 2) 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 2:** 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 | | |
| • sociocultural 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, 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 regards to the long-term impact of the project, the main expected impact of the project is improved public health (sewage overflow of septic and holding tanks is reduced), traffic by vacuum tankers is avoided and the reduction of freshwater consumption by the reuse of treated wastewater as service water. The idea of decentralised wastewater treatment and reuse is demonstrated.

## 13 Available documents and references

- Drip irrigation limits of Dubai Municipality http://www.environment.gov.ae/environment/major/informationbulletins
- Project references and results of reed bed treatment in sub-tropical climate: w.sievert@gmx.de
- Information about sub-surface drip irrigation system: www.geoflow.com http://ecotube-concept.com/index.html

## 14 Institutions, organisations and contact persons

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**Case study of SuSanA projects**

**Three examples of wastewater reuse after reed bed treatment**

**SuSanA 2008**

Authors: Wolfram Sievert supported by Jana Schlick (jana.schlick@planco.org)

Editors: Carola Israel, Elisabeth v. Münch (GTZ ecosan program – ecosan@gtz.de)

Case study of sustainable sanitation projects

# Effluent reuse from constructed wetland system Haran Al-Awamied, Syria

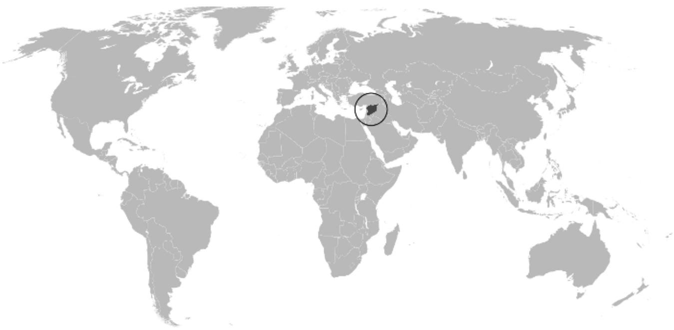

**Fig. 1:** Project location

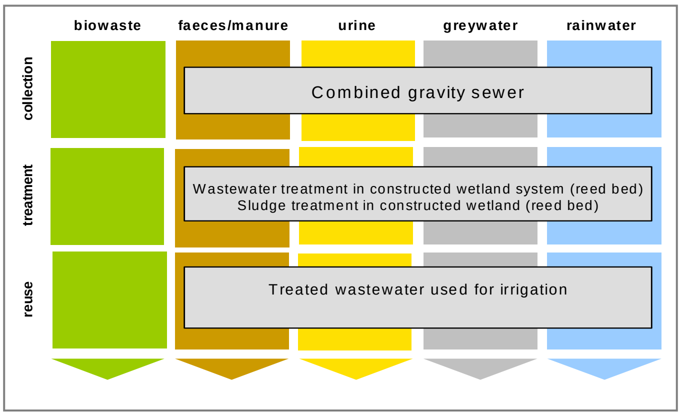


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**
Pilot project of a constructed wetland (reed bed system) for domestic wastewater treatment in a rural area, with reuse in agriculture

**Project period:**
Start of planning: 1997
Start of construction: April 1999
Start of operation: November 2000
Monitoring ongoing

**Project scale:**
Design value in 1999: 300 m³/d domestic wastewater (7000 people)
Measured value in 2009: 600 m³/d domestic wastewater (possibly now 14,000 people connected)
Capital cost in 2000: € 95,900

**Address of project location:**
Haran Al-Awamied – about 40 km from Damascus
Governorate of Rif Damascus, Syria

**Planning institution:**
Ministry of Housing and Construction (MHC), Syria
University of Damascus (Environmental Engineering)

**Supporting agency:**
Ministry of Housing and Construction Syria: 70% of capital cost
German Ministry for Economic Cooperation and Development (BMZ) via GTZ: 24%
German Embassy in Syria: 6%

## 2 Objective and motivation of the project

When this project was started, it was a pilot project and had the objective to test the suitability of constructed wetlands for the treatment of wastewater in Syria considering factors such as social acceptance, relevant legal aspects, operation and maintenance issues and financial sustainability.

A further objective was to test the feasibility of reuse of the treated effluent for irrigation in Haran Al-Awamied.

Now that the system has been operational for 8 years, the current objectives are to:

- Demonstrate long-term functioning of this system; and
- Treat the wastewater of the residents of Haran Al-Awamied

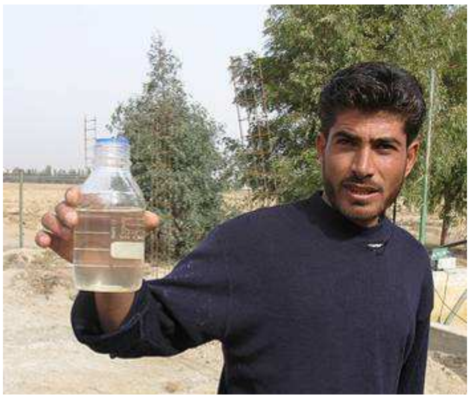

**Fig. 3:** Operator at treatment plant, showing effluent quality of constructed wetland when plant had been operational for 8 years (source: E. v. Münch, Jan. 2009)

## 3 Location and conditions

In Syria, much of the water resources are used inefficiently and uneconomically. Agriculture currently uses around 87% of the available freshwater resources for irrigation, supplemented by the use of untreated wastewater, which leads to health hazards, especially with regards to vegetables which are eaten raw.

In Syria only few of the big cities have wastewater treatment plants (activated sludge treatment plant in Damascus and Homs, Hama, aerated lagoons in Aleppo and stabilization ponds in Salamieh).

Diseases such as typhoid, fever and parasitic infections not only cause suffering but also have enormous economic disadvantages for those infected and the national economy. In the Governorate of Rif Damascus, where the constructed wetland treatment plant is installed, around 75% of the inhabitants were infected with hepatitis (Health Ministry, 1997)[1].

The pilot plant is constructed in the village of Haran Al-Awamied, in the Governorate of Rif Damascus. The village is located 40 km south east of Damascus and has a population estimated to be 17,500 (during the design phase, the estimate was 8,750)[2]. It has a semi-arid climate, with 185 mm of rainfall per year, falling within a period of four months. The residents get their water (for domestic use and for irrigation) from wells, most of which are not licensed but are “illegal”.

The inhabitants in the village are poor with farming being the main source of income. Farming consists of cattle-breeding and production of wheat, corn and cultivated fodder. The population growth in the village is high (2.3% p.a.)

Before the installation of the constructed wetland, the village’s wastewater was already collected by a gravity sewer system and used for irrigation without treatment. In Syria more than 87% of the inhabitants are connected to sewers, but few of these sewer systems are connected to treatment plants.

This village fulfilled all the selection criteria of the supporting agencies such as a good size village, existence of sewers and enough space for building and future expansion of the treatment plant.

**Fig. 4:** View of village Haran Al-Awamid (viewed from wastewater treatment plant). Source: E. v. Münch, Jan. 2009.

**Fig. 5:** Typical toilet in Syria: Squatting type with flushing. Hose on the left is for anal washing with water. Source: E. v. Münch, Jan. 2009.

## 4 Project history

The project was initiated by GTZ and MHC (Syrian Ministry of Housing and Construction, formerly Ministry of Housing and Utilities). All the preparatory work was carried out by MHC in 1998.

Construction began in April 1999, and the operation of the plant began 1.5 years later in November 2000. The treatment plant has been operating satisfactorily ever since – which is already a good sign for sustainability.

During the PhD thesis of Abir Mohamed (now working at ministry MHC), the treatment plant was closely monitored, documented and practical research carried out with it (during 1999 to 2004) – see Section 13 for how to obtain the PhD thesis.

An expansion is planned for 2009 as there is significant population growth in this village. It is still regarded as a pilot project as it is only one of two constructed wetlands in the country so far (the other one is at Yabous, and is being constructed in March 2009 under a PPP project between GTZ-Syria and the German company IPP Consult).

## 5 Technologies applied

A combined gravity sewer system had been installed in Haran Al-Awamied for the collection of rain and wastewater in 1992 by the municipality. The municipality collected the wastewater with sewer systems but they generally did not have any treatment plants (as is common in Syria). The municipality pays for the O&M costs of the sewer system.

This wastewater is transported to a wastewater treatment plant, which has the capacity to treat the wastewater of 7,000 inhabitants. The wastewater treatment plant has a settling tank for pre-treatment and a constructed wetland (sub-surface, vertical flow) for secondary treatment. Further design details are provided in Section 6.

This type of constructed wetland is also called a reed bed: Reed beds are in fact examples for a constructed wetland treatment process (vertical or horizontal sub-surface flow, soil filter planted with *Phragmites communis* or other marsh plants).

[1] No exact reference available fort his statement.
[2] In design phase: 80% of population (or 7,000 people) were assumed to be connected to the sewer. In 2009, the observed sewage flowrate was twice as high as the design value, therefore, the population has possibly doubled (this is a rough estimate).

# Effluent reuse from constructed wetland system Haran Al-Awamied, Syria

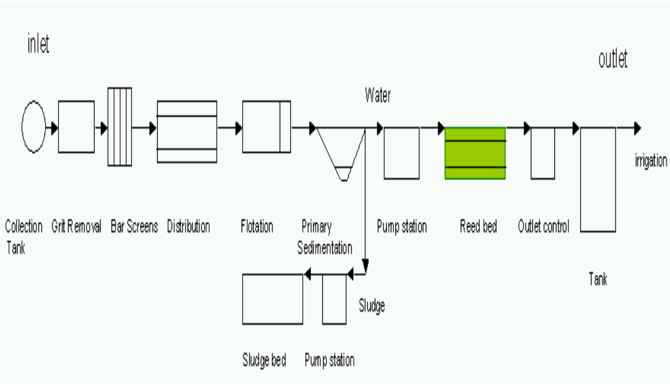


**Fig. 6:** Flow diagram of the wastewater treatment plant (reed bed system, vertical-flow, sub-surface constructed wetland) at Haran Al-Awamied (source: A. Mohamed).

**Fig: 7** Circular primary settling tank at Haran Al-Awamied treatment plant. Source: E. v. Münch, Jan. 2009.

## 6 Design information

The design value for the wastewater treatment system was 7,000 people and 43 L per person per day, which is a rather low figure compared to more affluent populations. The treatment plant thus has a design capacity to treat 300 m³/d.

However, the actual measured influent flowrate in 2009 was about **600 $m^3$/d**, due to population growth in the area. Thus, the plant is now overloaded, but appears to be functioning quite well (albeit at its limits, with some water-logging being evident). This water logging may reduce treatment plant performance[3].

The exact number of people now connected to the sewer system is not known but is estimated to be approx. 14,000 people. It was observed that in summer the wastewater flowrate is lower due to lower water availability for the residents (wastewater is thus more concentrated in summer than in winter).

The treatment plant consists of the following treatment units:

- Pre-treatment with manually-raked bar screens
- Primary treatment with a circular sedimentation tank (primary settling tanks)
- 2 vertical-flow, sub-surface constructed wetlands or reed beds (each: 68 m length, 22 m width, 1.5 m depth) for secondary wastewater treatment (total area of both reed beds: 2992 $m^2$).
- A reed bed (20 m x 10 m x 1.8 m) for sludge treatment.
- A 150 m³ collection tank for treated wastewater for irrigation purposes (with a pump to pump effluent to adjacent fields).

The specific reed bed surface area per inhabitant used in the design was **0.5 m²/person**, which means 2800 $m^2$ of surface area was required. This design figure is significantly lower than the value typically used in colder climates (3-5 $m^2$/person in Germany), although the hydraulic load (flowrate) per person is also lower in Syria (on the other hand, the organic load per person would be similar for both countries).

The reed beds are lined with PVC plastic foil (1 mm), and are filled with layers of gravel and sand, with gravel forming the upper and lower layers. The pre-treated wastewater is distributed onto the upper gravel layer and collected through drainage pipes in the lower layer.

The treated wastewater is collected in a tank and pumped to irrigate agricultural fields near the plant (see Section 7). The treatment plant reached a good effluent quality after reeds had grown (2 years), see Table 1.

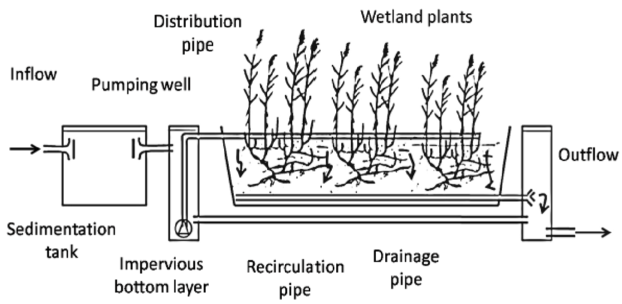


**Fig. 8:** Schematic structure of vertical flow reed bed (source: Brix and Arias, 2005)[4].

**Table 1**: Typical results for influent and effluent quality (source: Mohamed (2004))[5].

| Parameter | Influent | Effluent | Removal efficiency |
|---|---|---|---|
| COD (mg/l) | 446 | 70 | 84% |
| BOD (mg/l) | 220 | 32 | 85% |
| $PO_4$-P (mg/l) | 19.3 | 6.1 | 68% |
| $NO_3$-N (mg/l) | 1 | 45 | - |
| Worm eggs (eggs/100 mL)[6] | Typical: 100 – 1000 | 1 | - |

[3] No recent monitoring data for effluent quality was available at the time this document was written.

[4] Brix, H and Arias, C. A. (2005). The use of vertical flow constructed wetlands for on-site treatment of domestic wastewater: New Danish guidelines. Ecological Engineering 25:491—500.

[5] In the PhD thesis of Mohamed (2004), results for 9 influent samples and 9 effluent samples are shown (taken during 2-year period Dec. 2000 to Apr. 2003). The data shown in Table 1 represents typical values during that time period.

[6] Type of worm egg not recorded (probably *Ascaris*).

# Effluent reuse from constructed wetland system Haran Al-Awamied, Syria

**Fig. 9:** Overloaded, water-logged reed bed towards outlet section of reed bed (source: E. v. Münch, Jan. 2009)

**Fig. 10:** Foreground: primary sludge drying bed (was: reed bed for primary sludge conversion to soil). Background: reed beds (source: E. v. Münch, Jan. 2009)

## 7 Type and level of reuse

The treated wastewater fulfills the irrigation water quality set by the Syrian Arab Organization for Standardization and Metrology (SASMO) which are based on the WHO standards, and were recently updated (in 2008).

The treated wastewater in Haran Al-Awamied is used for irrigation with a fertilising effect due to its nitrogen and phosphorus content (see Table 1). The inhabitants in the village use the treated wastewater to irrigate their fields; the distribution is organized by the villagers themselves in cooperation with the treatment plant workers.

The treatment of the “primary sludge”, which is pumped daily from the base of the primary settling tank (Fig. 7), takes place in a reed bed. Here, the sludge is converted into humus-like material during a process taking several months.

It is planned that the humus will be further composted with the reeds cut from the reed beds and then reused in agriculture.

In January 2009, the mineralised sludge from the sludge reed bed was harvested for the first time (after 8 years of operation), and piled up next to the reed bed, see photo below. Its appearance is now earth like, dry and without any odours (observation in January 2009). The exact properties of this material have yet to be analysed, but this material can be used as a soil conditioner at or around the treatment plant.

When the converted (mineralised) sludge was removed from the reed bed, the plastic lining of this reed bed was unfortunately partly damaged.

The harvested reed plants (from reed beds for wastewater treatment) could be reused to make waste baskets and roof materials. So far, this has not happened yet.

**Fig. 11:** Mineralised, earth-like sludge taken out of the reed bed used for sludge treatment (after 8 years of operation) – this reed bed used to be where there is now liquid sludge in previous picture (source: E. v. Münch, Jan. 2009).

**Fig. 12:** Foreground: effluent tank with two effluent pipes discharging from the two reed beds. Background: reed beds and group of trainees (source: E v. Münch, Jan. 2009).

## 8 Further project components

The project site is used during workshops and training events on constructed wetlands in Syria. Based on the success of the pilot plant, the Syrian government has decided to allocate more resources to build constructed wetlands in other regions of the country.

The Ministry of Housing and Construction (MHC) is presently preparing the planning documents for a program that would combine capacity development at governorate level with investment in about 23 additional plants of the same type (during 2009-2010). Germany plans to return the credit taken by the former East German state (GDR) in the form of a development fund. This fund will be utilised via KfW (German development bank) for the construction of the 23 additional constructed wetlands treatment plants.

**Fig. 13:** Training session during a workshop on constructed wetlands in Damascus, organised by MHC: Abir Mohamed in front of reed bed (source: E. v. Münch, Jan. 2009).

## 9 Costs and economics

The costs for this project are shown below (for the year 1999/2000 for construction):

- Construction costs: € 95,900 (cost break-down shown in Mohamed (2004)[7])
- Construction costs per person (based on 7,000 people): € 13.7
- Operating costs: € 7,000 per year (design figure in 1999) – in 2008: € 9,000 per year
- Operating costs per person and year: € 1 (for design figure) or € 0.6 if population is now in fact 14,000 people.

The operation cost includes the salaries of operators and security guard, electricity for pumps (primary sludge pump), laboratory reagents and the cost to cut the reed.

The construction costs of the reed bed system were clearly less than other comparable treatment systems such as aerated lagoons (construction costs per person € 19 and the operating costs per person and year € 5.7) or conventional activated sludge (construction costs per person € 25 and the operating costs per person and year € 3.8). These costs were estimated in the report "Theoretical Statement from General Establishment for Technical Studying and Consultancies in cooperation with Ministry for housing and utilities 2002"[8].

The site of the constructed wetland was provided by the administration of Haran Al-Awamied free of charge. German technical co-operation (GTZ) then agreed to support part of the material costs. The national Syrian government agreed to take over the construction costs and later the personnel and operating costs. Additionally, the German Embassy in Damascus supported the sludge treatment part of this demonstration plant (they have a budget for environmental projects).

## 10 Operation and maintenance

The Sewerage Company in Damascus Rif operates the treatment plant and has hired four villagers, working in a two-shift roster, to operate and maintain the plant with the following tasks:

- Pump the wastewater to the two reed beds alternately
- Pump the sludge from the primary settling tank once or twice a day to the sludge bed
- Clean the screens
- Remove weed
- Harvest the reed once a year or less frequently (could be given to farmers but is currently thrown away). Note: cutting the reed is not necessary for the performance of the treatment plant.

The required behaviour of the households for the correct functioning of the wetland (most importantly minimizing the use of domestic chemicals and not to discharge any oil with the wastewater) was explained especially to women in meetings in the village and in the mosque. Most of the inhabitants are farmers and they need to use the treated wastewater for irrigation, therefore they co-operate with the ministry (MHC).

## 11 Practical experience and lessons learnt

The quality of the treated wastewater in the pilot project is monitored by the responsible Syrian ministries (agriculture, health and irrigation) and used directly for irrigation in agriculture with restricted use (current monitoring data was not available). The treated wastewater contains nitrogen and phosphate, so the soils do not need any additional fertilizers.

Thus, the residents have a great interest in a well-functioning plant. This is different from other cases in Syria, where the wastewater is transported long distances to the central treatment plant, tempting farmers to break the sewer pipes to draw off untreated wastewater for irrigation.

Another important success fact was the co-operation between diverse participants in financing the construction and operation and maintenance of the plant, which worked well notwithstanding the enormous initial difficulties and resistances, in order to overcome the water problems such as high water demand and water pollution.

This pilot project has provided valuable experience for the future of innovative closed loop wastewater management techniques in Syria:

- The planning, construction and operation of the plant was accompanied by research and observation and was the subject of a doctoral thesis (by Abir Mohamed in 2004).

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[7] Of this total amount, the Syrian government paid € 67,600; GTZ-Syria paid € 23,000 (being for PVC foil for sludge reed bed, and laboratory equipment); German embassy in Damascus paid € 5,300 for sludge reed bed construction.

[8] This report is available in the MHC (the costs were estimated in 2002)

- The ministries for housing, health and agriculture closely monitored the plant's performance.
- Reports in the local media served to raise awareness among many people of the possibilities and potential of such approaches.
- The treatment plant can be used for training purposes and field trips during workshops (see Fig. 13).

At present, the reed bed treatment plants in Syria are topic of substantial public discussions about their possible use in rural areas, informal housing estates and in isolated smaller localities. The most convincing reasons for the reed bed system are the low costs, easy construction and simple operation and maintenance.

## 12 Sustainability assessment and long-term impacts

A basic assessment (Table 2) 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 2:** 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 | |

With regards to the long-term impact of the project, the main positive impact of the project is that it has demonstrated the appropriateness of constructed wetland or reed bed systems for wastewater treatment and reuse in Syria.

At the same time, the inhabitants of the village Al-Awamied have benefited from having access to a sustainable sanitation system and being able to safely reuse treated effluent (for irrigation) and treated sludge (as soil conditioner, for the first time in 2009).

With regards to the health status of the villagers in 2009 compared to the time before the project (i.e. when wastewater was reused without treatment), it is not possible to observe a difference in health status, because the villagers buy their vegetables also from other villages, and sell their own vegetables at other markets. No health studies have been carried out yet.

## 13 Available documents and references

PhD thesis about this constructed wetland:

Mohamed, A. (2004) Design, construction and operation of a constructed wetland treatment plant in Syria – A pilot investigation on the efficiency of constructed wetlands in semi-arid, hot summer regions. PhD thesis. University of Flensburg, Germany (in German: Planung, Bau und Betrieb einer Pflanzenkläranlage in Syrien. Eine Modelluntersuchung zur Effektivität von Pflanzenkläranlagen in semiariden, sommerheißen Gebieten. Available: www2.gtz.de/dokumente/oe44/ecosan/de-pflanzenklaeranlage-syrien-2004.pdf

## 14 Institutions, organisations and contact persons

**Project owner:**
Haran-Al-Awamied municipality
Damascus Rif, Syria (no website available)

**Technical design (and operation through the sewerage company now):**
Ministry of Housing and Construction (MHC)
Eng. Abir Mohamed
E-mail: abirgh@aloola.sy

**Building Company:**
SAHER Co.
P.O.BOX: 31090
Damascus, Syria
E-mail: arbeet@scs-net.org

**Organizations:**
Syrian Arab Organization for Standardization and Metrology SASMO
P.O.Box: 11836
Damascus, Syria
E-mail: sasmo@net.sy

**Case study of SuSanA projects**

***Effluent reuse from constructed wetland***

**SuSanA 2009**

**Authors of first version (2005): A. Mohamed, F. Klingel, P. Bracken, C. Werner (all ex-GTZ ecosan)**

**Authors of revision: Elisabeth v. Münch and Rahul Ingle (GTZ ecosan) – ecosan@gtz.de, Abir Mohamed (MHC) - abirgh@aloola.sy),**

**Editing: Carola Israel**



**This document is available from:**
**www.susana.org**

Case study of sustainable sanitation projects

# Use of reclaimed wastewater in agriculture Jordan Valley, Jordan - Draft

**Fig. 1:** Project location

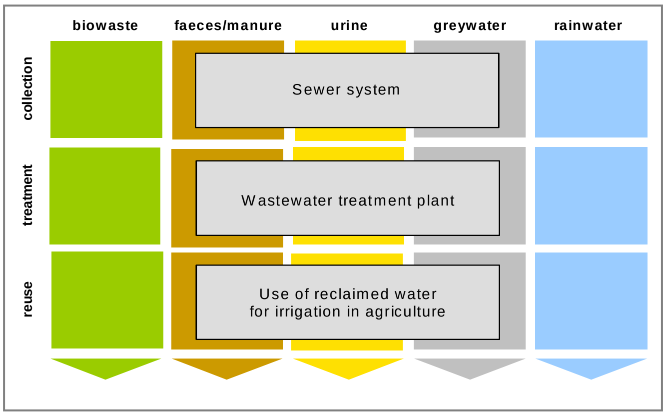



**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of Project:**
Reuse of reclaimed water for irrigation in the Jordan Valley as part of the water resources management programme

**Project Period:**
Start of implementation: 2006
Planned project end: 2015

**Project Scale:**
About 4,000 farm units with 10,000 ha irrigable area
Budget: xxx

**Address:**
Management of Water Resources
Sustainable use of reclaimed water
P.O. Box 926 238
Amman 11190
Jordan

**Planning Institution:**
Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH

**Executing Institution:**
Jordan Valley Authority

**Supporting Agency:**
BMZ (German Federal Ministry for Economic Collaboration and Development) via GTZ

*Note: this document still has some minor open queries which we are currently finalizing.*

## 2 Objective and motivation of the project

Sustainable use of reclaimed water is one of the components in GTZ Jordan's Water Programme. It is built on the good results of the previous stand-alone project "The use of reclaimed water". The goal of this component is to use reclaimed water in the Jordan Valley as a substitute for freshwater in agricultural irrigation in accordance with environmental and public health regulations.

As irrigated agriculture in the Jordan Valley consumes about 42 % of the available freshwater resources, which are also urgently needed as drinking water, the use of marginal water resources, such as brackish and reclaimed water for irrigation is highly desirable.

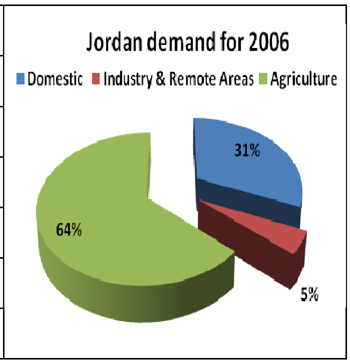
## 3 Location and conditions

The project area is situated in the middle and southern Jordan Valley extending over a length of about 50 km between Kreimeh and the Dead Sea.

The Jordan Valley is characterised by low annual rainfalls (an average of less than 300 mm at Deir Alla and 100 mm at South Shuneh). However, the mild winter season between November and April allows an off-season production of vegetables under irrigation.

**Table 1:** Water supply and demand in Jordan (Ministry of Water and Irrigation)

| | [M $m^3$] |
|---|---|
| **Water supply** | **925** |
| Domestic | 290 |
| Industry and Remote Areas | 46 |
| Agriculture | 589 |
| **Water Demand** | **1512** |
| **Deficit** | **-587** |



The majority of the farmers are small scale farmers, with an average farm unit area of about 3 ha. Complementary activities of another GTZ project (Water Management in Irrigated Agriculture) support the establishment of water user associations in order to improve the water use efficiency. Both projects belong to the GTZ Water Programme in Jordan.


**Fig. 3:** Project area (source: GTZ)

**Fig. 4:** Irrigation and mulching (A. Vallentin (GTZ), 2004)

## 4 Project history

The first step was a baseline survey regarding the legal situation and the mandates of the organisations and stakeholders involved in 2004. Then, with national and international expertise, guidelines for irrigation water quality and crop quality and for monitoring and information systems were proposed in 2005.

Interdisciplinary working groups adjusted them to the conditions in Jordan and proposed applicable concepts. At present the project coordinates between the involved agencies to initiate the implementation of the proposals and concepts.

With regard to the agricultural guidelines, the field staff identified 20 representative farm units irrigating with reclaimed water in 2003. These farm units are regularly monitored and the data are analysed at the end of the respective cropping season. First results with regard to appropriate agricultural practices were disseminated in 2004 during two seminars for agricultural extension workers and two field days for farmers in the Jordan Valley.

Project staffs have tested the agronomic guidelines through series of demo sites with pilot farmers. To ensure the widespread application of these guidelines by farmers, simplified fertigation (irrigation and fertilisation) sheets were developed and disseminated to farmers in 2007/8 through intensive joint-training sessions with local extension agencies in the Jordan Valley.

Later in 2009 these guidelines were transformed by the project into an information system (computer-based programme that allows extension workers and educated farmers to optimise their fertigation in light of the irrigation water quality, location, crop, soil type and other factors). Governmental and private extension providers were trained on the use of this programme to be able to provide extension advice in accordance with this tool.

Regarding public health and market acceptance the project team came up in 2005 with proposals and concepts for a state monitoring system and safety control guidelines for fresh fruit and vegetables with a focus on irrigation water quality in the Jordan Valley.

**Fig. 5:** Workshop (source: A. Vallentin (GTZ), 2006)

**Figure 6:** Training of extension workers (Source: Abdel-Jabbar (GTZ), 2008)

## 5 Technologies applied

Since this project is a water resources management programme for the sustainable reuse of reclaimed water no technical measures are planned. Irrigation infrastructure is already provided.

In Jordan there are 22 WWTP,s generate more than 91 MCM per year. More than 80% of this quantity comes out from As-Samra Treatment Plant recently rehabilitated to perform efficiently to meet the international standard. This plant serves 2 millions of Jordanians in Amman and Zarqa cities (the most populated cities of Jordan) and has a capacity of treating 270,000 cubic meter a day.

## 6 Design information

No construction activities planned.

## 7 Type and level of reuse

At present Jordanian wastewater treatment plants produce about 85 Mio m³ of effluent per year. Approximately 66 % of that amount is used for irrigation in the Jordan Valley. In the project region the main source of reclaimed water for irrigation is the treatment plant at Khirbet As Samra, the country's largest treatment plant with a yearly effluent of about 50 Mio. m³. This effluent is discharged into two consecutive wadies and then temporarily stored in the King Talal Reservoir, the country's largest reservoir. From there it is led via further wadis and canals to the middle and southern Jordan Valley where it is finally used for irrigation on about 4,000 farm units with an area of approx. 10,000 ha.

Reclaimed water, which is reused for irrigation, is diluted with surface and precipitation water by the passage through the wadies etc. The preferred irrigation method is drip irrigation in combination with black plastic mulch which is a very thin plastic sheet which covers the plant rows as it is shown in Fig. 7.

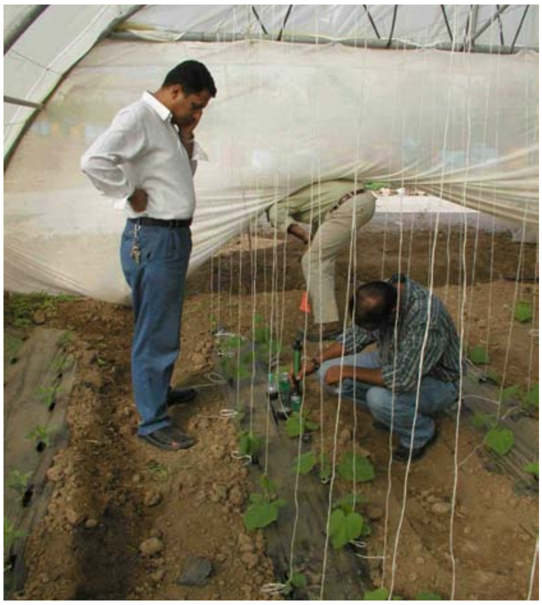


**Figure 7:** Demo plot (source: A. Vallentin (GTZ), 2006)

## 8 Further project components

- Support of co-ordination between the involved organisations and stakeholders with regard to irrigation water quality, health and environment.
- Awareness raising among water users and agricultural producers regarding possible health and environmental risks.
- Dissemination of good agricultural practices to extension workers and farmers with regard to reclaimed water use.

## 9 Costs and economics

The hydraulic infrastructure in the Jordan Valley was constructed and is operated and maintained by the Jordan Valley Authority supported by international donors. There are no investments by the project.

## 10 Operation and maintenance

The impact of irrigation with reclaimed water on soils and groundwater is monitored at selected sites in order to develop recommendations for long-term monitoring needs regarding possible adverse effects on the environment.

At present, crops produced on reclaimed water are frequently tested for biological contamination and heavy metals by the Jordan Food and Drug Administration (JFDA). Currently the project team is working with stakeholders on developing a risk monitoring and management system for the unrestricted use of reclaimed water in agriculture based on the WHO guidelines.

In the long run it is foreseen to transfer operation and maintenance responsibilities for parts of the irrigation infrastructure to water user associations.

## 11 Practical experience and lessons learnt

The use of reclaimed water for irrigation is generally a sensitive topic in the public due to lack of information. The implementation of crop quality monitoring is difficult because governmental agencies do not feel responsible for sampling and analysis of crops irrigated with reclaimed water. Providing guidelines in this field helps to clarify and improve the situation. The majority of farmers in the project area is not aware of the nutrient content of the reclaimed water and is starting to appreciate information regarding reclaimed water quality.

Results of the crop monitoring programme and a rapid assessment of consultants revealed that use of treated wastewater in Jordan meets the health-based target recommended by the WHO guidelines for the safe use of treated wastewater.

The results from the demo sites revealed that fertiliser expenditures can be cut by 60%

## 12 Sustainability assessment and long-term impacts

A basic assessment (Table 2) 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 emphasized (weaknesses).

**Table 2:** Qualitative sustainability assessment of the system. The crosses indicate the relative sustainability for each project component (column) and sustainability criterion (row). (+): strong point of project, (o): average strength for this aspect, (-): no emphasis on this aspect in the project.

| | collection and transport[1] | | | Treatmen[1] | | | transport and reuse | | |
|---|---|---|---|---|---|---|---|---|---|
| Sustainability criteria: | + | o | - | + | o | - | + | o | - |
| • health and hygiene | | | | | | | | X | |
| • environmental and natural resources | | | | | | | X | | |
| • technology and operation | | | | | | | X | | |
| • finance and economics | | | | | | | X | | |
| • socio-cultural and institutional | | | | | | | | X | |

[1] not part of this project

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

With regard to long-term impacts of the project, the main expected impacts are:

- the reduction of chemical fertiliser uses in the middle and southern part of the Jordan Valley, lowering the soil salinisation pace.
- At farm level, it is estimated that farmers would save up to 60 % of their fertilisation cost, which is equivalent to EUR 564 per hectare and can be translated into income improvments of 30 %.

At nationa level more than 80% of fertilizers used in Jordan are imported; therefore any saving in fertilizers means reduction in foreign currency transmittance to the exporting countries. As such making use of nutrients in treated wastewater save Jordan about JD 4.0 million per year.

- With the farmers' appreciation of the added value of reclaimed water and the acceptance of its reuse, water conflicts on fresh water sources are dwindling. This reduces the pressure on barely sufficient drinking water sources.

At environmental Level; Beside reuse of treated wastewater in agricultural is productive approach, its positive impact on the environment is multi-perspectives. Salinity, energy consumption and $CO_2$ emissions are among the indirect benefits.

Considering nutrient in treated wastewater lead to 5838.8 ton per year reduction in the consumption of fertilizers. This amount is equivalent to saving 86 gigawatt-hr per year (about 1% of the current Jordan electricity consumption)

Another important aspect of reduction in fertilizers use is the reduction of greenhouse (GHG) generated during fertilizers production, Based on the average gas emission per production 1 kg of fertilizers (1700 g), reduction in fertilizers use in Jordan Valley would lead to reduction 11 million kg of $CO_2$ emission.

## 13 Available documents and references


- Project Appraisal Report (2002).
- Baseline Report (2003).
- Proposal for a State Monitoring System for Fresh Fruit and Vegetables (2004).
- Proposal for Safety Control Guidelines for Fresh Fruit and Vegetables (2004).
- Proposed Steps to a Crop Quality Assurance System with focus on irrigation water quality in the Jordan Valley (2004).
- Concept for Groundwater Monitoring 2004).
- Concept for Soil Monitoring (2004).
- Practical Recommendations for Nutrient Management und Irrigation with Reclaimed Water (2004).
- Evaluation of Irrigation and Fertilizer Practices for Main Crops on Monitored Farm Units under Irrigation with Reclaimed Water in the Jordan Valley (2004).
- Guidelines for Reclaimed Water Irrigation in the Jordan Valley (2006).


## 14 Institutions, organisations and contact persons

**Institutions and organisations involved:**

- Jordan Valley Authority
- Ministry of Water and Irrigation

- Water Authority of Jordan
- Jordan Food and Drug Administration
- Ministry of Agriculture
- Ministry of Environment
- Ministry of Health
- Royal Scientific Society
- Jordan Exporters and Producers Association for Fruit and Vegetables

**Contact Person:**

Sameer Abdel-Jabbar (GTZ Jordan)
Water Programme
Reuse of marginal water
Jordan Valley Authority
E-mail: sameer.abdel-jabbar@gtz.de

**Case study of SuSanA projects**

***Use of reclaimed wastewater in agriculture, Jordan Valley, Jordan***

**SuSanA 2009**

**Authors:** Artur Vallentin, GTZ ecosan team (Jana Schlick, Florian Klingel, Patrick Bracken, Christine Werner) – these were authors of original project data sheet from 2005

**Editing and reviewing:** Sameer Abdel-Jabbar (GTZ Jordan), Rahul Ingle, Lukas Ulrich, Elisabeth v. Münch (GTZ ecosan programme: ecosan@gtz.de)

# Blackwater and greywater reuse system Chorrillos, Lima, Peru

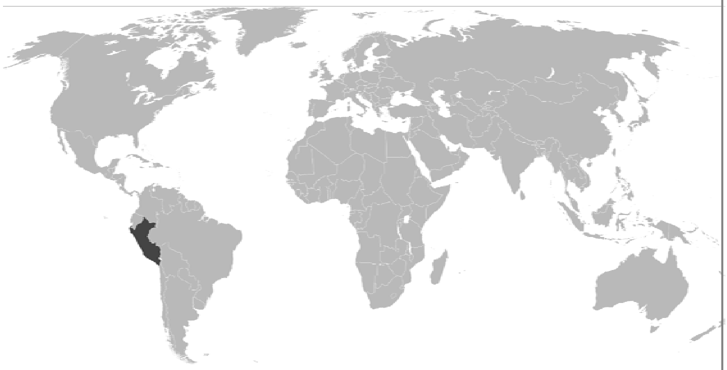


**Fig. 1**: Project location

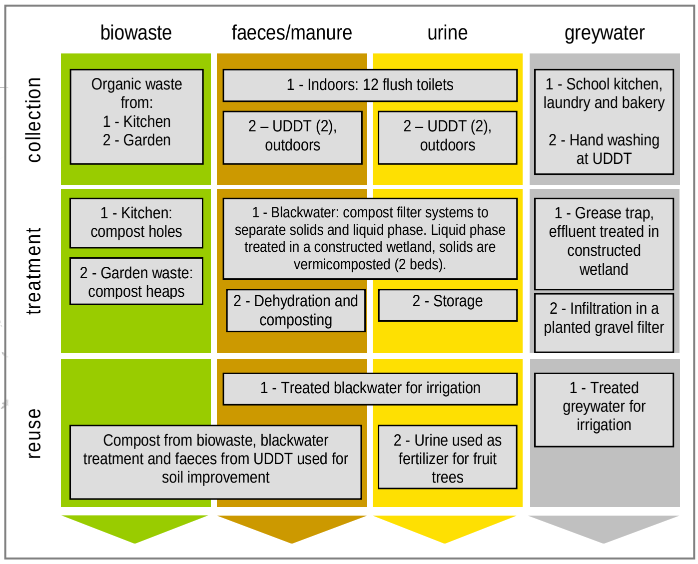



**Fig. 2:** Applied sanitation components in this project (numbers 1 and 2 refer to different flow streams)

## 1 General data

**Type of project:**
Urban upgrading - school demonstration project

**Project period:**
Start of planning: February 2007
Construction period: July 2007 - October 2008
Start of construction:
Grey- / blackwater treatment: July 2007
Urine diverting dehydration toilets (UDDTs): May 2008
Start of operation:
Greywater treatment system: September 2007
Blackwater treatment system: November 2007
UDDTs: May 2008
Extension for blackwater treatment (reed bed): October 2008

**Project scale:**
53 population equivalents (35 handicapped pupils plus personnel)
Capital costs unknown

**Address of project location:**
Avenida de los Faisanes No. 950,
La Campiña, Chorrillos,
Lima, Peru

**Planning institution:**
Rotária del Perú, Lima, Peru

**Executing institution:**
Centro Educativo Básico Especial (education centre) “San Christoferus”, Lima, Peru

**Supporting agency:**
Private donors (mostly for financing)
Work-camp volunteers (during construction period)
Pro Niño (school board of San Christoferus)

## 2 Objective and motivation of the project

The objectives of the project are:

1. Reduction of the water consumption (and the cost for it).
2. Reduction of the dusty areas by creating more extensive planted areas (which need irrigation and fertilization) to improve aesthetics and micro climate.
3. Demonstration of a closed-loop system with reuse of treated wastewater, nutrients and organics, adapted to the environmental necessities of a populated desert area and the technical possibilities.
4. Showcasing a dry sanitation system (urine-diversion dehydration toilets - UDDTs).

**Fig. 3:** Drain tube on the base of the constructed wetland for blackwater treatment during covering with gravel. To avoid perforation caused by the gravel, the 0.5 mm PVC liner (in black) needed a special protection. A second liner (in blue) was put inside.[1]

## 3 Location and conditions

The Peruvian capital Lima (8 million inhabitants) is situated in one of the world’s driest areas (9 mm rainfall per year). 15% of the total Peruvian area is a desert, but unfortunately 60% of the population of Peru lives there, 30% thereof in Lima. All of

[1] All photos by H. Hoffmann, taken in 2007/2008

them are affected by water limitation; especially the poorest people live with an extreme water stress situation: 1.5 million inhabitants are using only 20 litres water per capita per day.

About 80% of the wastewater in Lima (60% in Peru) is collected in sewers, but only 9% of the collected wastewater receives treatment. That means, 91% is discharged untreated into the ocean, or used directly for irrigation in agriculture, whereas green areas in the city centre are irrigated with drinking water. The possibilities for safe reuse of treated wastewater are generally unknown. There are no water saving policies at all as the price for water is very low.

The education centre “San Christoferus” is located in a desert area in urban Lima. It is a care facility for 35 handicapped children in the age range of 5 to 18 years. The 0.6 ha school area includes an outdoor area and six separate buildings at two locations, including a bakery, a laundry and a kitchen.

The children are mentally disabled and many of them also have physical disabilities and birth defects of various kinds (sadly, there are only few institutions and opportunities for disabled children and adults in Peru). Six teachers supported by international volunteers take care of them from 8.00-14.30 o’clock. They spend their time playing music, baking, doing handicraft, cooking and since 2007 cultivating the garden, or just playing indoors and outdoors.

Before the start of the project, wastewater from 12 flush toilets (15 litres per flush), from bathrooms with showers and 3 kitchens, 1 laundry and 1 bakery was disposed to the public sewer system.

## 4 Project history

The initial idea was to upgrade the outdoor area by installing an irrigation system and to build a new playground. Initiated by the employees of the education centre and the parents, project planning for wastewater treatment with a special focus on reuse started in 2006.

The consultant Rotária del Perú was contracted in February 2007 for the planning of a new sanitation system as well as the supervision of its installation because of the company’s experience in this area. At that time, composting of organic garden and kitchen waste was already practised. This experience with operation and reuse of organic material in the school garden was helpful for the consultants to convince the teachers and the school board to implement further reuse components.

In July 2007, construction of the playground and the constructed wetlands started with the support of a group of work-camp volunteers. More specialized installations were erected by two Peruvian workers. A lot of explanations and supervision was necessary, because most of the technologies were unknown in Peru. Finding adequate materials, such as the right sand or the lining for the wetland, filter bags for the composting filter or drain tubes was difficult.

Already the first weeks of operation for the wastewater treatment system were a success. Everybody was impressed by the excellent treatment results and later surprised by the intensive plant (papyrus) development in the constructed wetland.

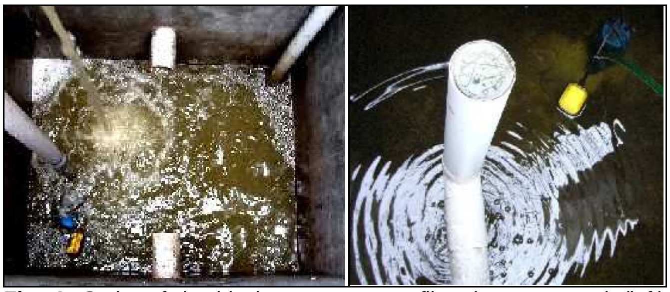


**Fig. 4:** Outlet of the blackwater compost filter (pre-treatment) (left) and effluent of the constructed wetland (papyrus reed bed) for blackwater treatment (right).

**Fig. 5:** Vertical flow constructed wetland for greywater treatment during pumping (a day after planting and before the protection of the distribution pipes with a 10 cm gravel layer) (left) and after two months, with storage tank for irrigation of treated greywater (right).

Interested in the new playground, many families and school classes came to visit the school. It became necessary to have an additional outdoor toilet for visitors near the playground. In March 2008, Rotária del Perú provided the idea for a waterless urine diversion dehydration toilet (UDDT) and financed all materials. The objective was to demonstrate the applicability of this type of toilet for schools and to showcase a dry sanitation system as a possibility to reduce water consumption and avoid water pollution. Also, the construction of an outdoor flush toilet and its pipe connection to the wetland would have been much more expensive.

## 5 Technologies applied

For the purpose of treatment and irrigation, two independent treatment systems were built:

**Constructed wetland for greywater treatment:**
Greywater (wastewater without faecal matter) from the laundry, bakery and kitchen is treated in a vertical flow constructed wetland (sub-surface), also called reed bed. The greywater passes a grease trap and is pumped in intervals (time regulated) to the papyrus reed bed (see Fig. 5, left).

**Compost filter for blackwater treatment:**
Blackwater from the flush toilets mixed with greywater from two private kitchens, showers and washing basins of all bathrooms is treated separately. It is led to a well ventilated double-chamber compost filter (“Rottebehälter” - see Fig. 6, left). The two chambers are used alternately in intervals of 6 months.

This compost filter acts as a solid-liquid separation device: Solids are retained in a special (custom-made) filter bag which is filled with straw. During the six months in use and the following 6 months, where the second chamber is in use, some composting of the solid material in the filter bag is achieved. After removing the filter bag from the chamber (Fig. 6), a secondary treatment for the retained solids is realized in a separate vermicomposter (see Fig. 7).

Here earth worms (taken from the already existing compost system) break down the organic matter and improve the composting process. The liquid passes the filter bag to the bottom of the chamber and is pumped to the constructed wetland (see Fig. 8).

In October 2008, a second vertical flow constructed wetland started operation which is now used alternating with the existing wetland to improve treatment efficiency.

**Fig. 6:** Double-chamber compost filter (“Rottebehälter”) for blackwater pre-treatment (left) and removal of a filter bag (right)

**Fig. 7:** Spreading of the retained solids from the filter bag, after 6 month (see Fig. 6) on the vermicomposting bed on a concrete slab

**Fig. 8:** Vertical flow constructed wetland (reed bed) for treatment of the liquid phase of blackwater (after 6 months of growth)

**Double-vault urine diversion dehydration toilets (UDDTs):**
The UDDTs which are constructed as outdoor toilets near the playground have two cubicles (girls / boys) with ventilated vaults for dehydration of faeces (see Fig.). When one faeces vault is full, the content (then already dehydrated for about one year) will be composted in the vermicomposter (together with the solid material filtered from the blackwater). Urine and greywater (water from hand washing) are collected separately. Greywater from the hand washing facilities is infiltrated directly into a gravel filter bed with bamboo plants next to the building (see Fig. 9). Urine is collected in two 25 litre jerricans which are located directly behind the entrance area (see Fig. 12).

**Composting systems:**
Besides the compost filter system and the vermicomposter, two other composting systems already existed before 2007: compost holes for organic kitchen and garden waste and compost heaps for biowaste from agricultural production and gardening.

**Fig. 9:** Outdoor UDDT with gravel filter bed for greywater (right hand)

## 6 Design information

The greywater treatment system was designed for 23 population equivalents, a hydraulic load of 2.5 m³ per day and an organic load of 0.58 kg $BOD_5$ per day. The blackwater treatment system was designed for 30 population equivalents, a hydraulic load of 3.3 m³ per day and an organic load of 2.1 kg $BOD_5$ per day. As blackwater and greywater were not separated before, there were no flow measurements or chemical analyses to verify these design assumptions.

**Greywater pre-treatment:**

- 1 grease trap of 1 m³ for grease and oil separation from wastewater from the kitchen and bakery. Achieved BOD reduction: 10%.
- 1 tank with a pump for the storage of the effluent from grease separation and laundry.

**First constructed wetland (greywater treatment):**

- Sub-surface, vertical-flow wetland with papyrus plants.
- Surface area: 16 m² (4 m x 4 m) = 0.7 m² per capita.
- Total depth: 1.1 m (from bottom to top: 20 cm gravel with drainage pipe (4”), 60 cm sand, 10 cm gravel with 3 distribution pipes (1”) and 20 cm freeboard).
- 3 m³ storage tank for the treated greywater with a pump for irrigation.

**Compost filter system for blackwater pre-treatment:**

- 2 compost filter beds, each with 2 chambers with an active volume of 1.44 m³ (1.2 m x 1.2 m, 1 m deep).
- Each chamber has a removable cover and a 3 m long ventilation tube (3”).
- 4 filter bags of 0.7 m³ (1 m x 1 m x 0.7 m) (custom-made product made out of a resistant plastic material normally used to shade greenhouses).
- Estimated BOD reduction: 30%.

- For the liquid collection, every unit has a deeper tank with pump.
- The liquid phase from the first unit is pumped to the second unit and from there to the constructed wetland.

**Vermicomposter:**
- Two composting beds of 0.3 m³ (0.5 m x 1 m x 0.6 m).
- The two beds are separated by a brick wall.
- The bottom is made of cement.

**Second constructed wetland (blackwater treatment):**
- Sub-surface, vertical-flow wetland with papyrus plants.
- Surface area: 45 m² (5 m x 9 m).
- Total depth: 1.3 m (from bottom to top: 20 cm gravel with a single drain pipe (4"), 80 cm sand, 10 cm gravel with 6 distribution pipes (1.5") and 20 cm free board).
- 6 m³ storage tank for the treated blackwater with a pump for irrigation

**Urine diversion dehydration toilets (UDDTs):**
- Two separate cubicles for boys and girls with a size of 1.6 m x 1.5 m (2.3 m²) each.
- Each cubicle is equipped with a sink for hand washing, a double-vault UDDT (with two urine-diversion-pedestals) and two ventilation pipes.
- The two toilet pedestals are made of ferro-cement, because the use by handicapped children requires a stable solution with space for a second helping person.
- The toilet pedestal in use has a movable plastic (polypropylene) insert for urine diversion, while the other toilet pedestal remains closed (see Fig. 12, left and middle).
- Toilet paper is collected in a waste bucket.
- After defecation, the user has to put some sawdust into the toilet. The sawdust comes from the schools own carpentry.
- The vaults for faeces collection consist of two separate chambers with an active volume of 0.21 m³ (0.6 x 0.7 m, 0.5 m depth) each. Each vault has a black metal cover at the back of the building (sunny side) (see Fig. 11).
- The men's bathroom additionally has a classic urinal, where the siphon was removed in order to connect it directly with the urine outlet pipe. Thus it is a waterless urinal.
- The UDDTs and the waterless urinal are directly connected to two 25-L jerricans for storage (see Fig. 12, right).

**Fig. 10:** Inside one UDDT cubicle (Two colourful urine diversion pedestals; only one is in use at a time, for about one year).

**Fig. 11:** Two double-vaults for faeces collection at the backside of the UDDT building (4 vaults in total).

**Fig. 12:** Toilet seats without (left) and with (middle) plastic insert for urine separation. Pipe from UDD toilet to 25 L urine jerrican (right).

## 7 Type and level of reuse

2 m³ treated greywater per school day are reused for irrigation of the garden. 4-5 m³ treated blackwater per school day are reused for irrigation of the lawns, fruit trees and flowers.

Today the school has doubled the irrigated green areas, but reduced by half the water consumption compared to 2007. Comparing the school area with the surroundings, the advantage of reusing treated black- and greywater for irrigation becomes obvious (see Fig. 13 and 14).

**Fig. 13:** Behind the fence: Desert living areas in the direct neighbourhood of the San Christoferus education centre.

**Fig. 14:** Urban agriculture at school, irrigated with treated blackwater

(Vermi-) composted organic material from the kitchen and the garden as well as solid material and dehydrated faeces from the UDDTs is reused for soil improvement.

After storage of about 1 month (longer during school holidays), urine from the UDDTs is used for fertilization of fruit trees (directly followed by watering to reduce odour during application); if the urine jerrican is not emptied then an infiltration of urine in a gravel filter bed is provided.

## 8 Further project components

The project is helping the school to develop more outdoor activities for the handicapped children, which was lacking in the past due to the school grounds being extremely dry and dusty. The new playground was built in 2007 and today, the whole school area (0.6 ha) gets irrigated and was turned into green space (see Fig. 15). The presence of trees, flowers and herbs gives the possibility to develop the senses of the children.

**Fig. 15:** Recently planted soccer field irrigated with treated blackwater (formerly a dusty area)

The higher production of vegetables and fruits which are sold for sale helps to increase the income of the school and to give scholarships to poor families with handicapped children.

This project was demonstrated and discussed during the first university course about ecological sanitation at the University for Agricultural Science UNALM (Universidad Agraria de La Molina) in May 2008 in Lima, Peru which was sponsored by the GTZ Peru water and sanitation program (PROAGUA).

## 9 Costs and economics

**Constructed wetland (for greywater treatment):**
The material costs for the wetland, including a grease trap for pre-treatment and a 3 m³ storage tank were about PEN 8,000 (Soles Peruanos) ≅ EUR 1,860.[2]

**Compost filter, vermicomposter and constructed wetland (for blackwater treatment):**
Material costs for the composter with two double-chamber composting filters for pre-treatment, the vermicomposter, the constructed wetland and a 6 m³ storage tank were about EUR 3,250.

**UDDTs:**
Material costs for the two toilets with infiltration of the hand washing water were about EUR 910. The toilet had to be tailored to the particular needs of the handicapped children (with additional space for a carer). For example, two separate pedestals were build instead of one ferro-cement bank with two holes, and this made the toilets more expensive.

The total construction costs of the project (including labour costs) were not determined, because it was financed by diverse donations and supported by volunteers.

## 10 Operation and maintenance

The operation of the facilities is done by the gardener (housekeeper) of the school, who is living with his family on the school compound. He has to organize the control of all pumps. Once a week, he has to put straw in the compost filter, after 6 months he has to swap the filter chambers and to remove the solids from the filter bag for secondary composting in the vermicomposter (see Fig. 6 and Fig. 7). Once a year, he has to clean all drainage pipes of the constructed wetlands.

An even more important task is the organization of the daily reuse of the treated grey- and blackwater (see Fig. 16), because unfortunately the irrigation system is not working automatically. In the beginning of the project, the effluent tanks often overflowed and the water in the wetland dammed up due to irregular irrigation practices. The operation is organized by the gardener (housekeeper) and by German volunteers, who work there for a year.

**Fig. 16:** Daily garden irrigation (in this case with treated blackwater) in the dry climate of Lima.

[2] Exchange rate July 2007: EUR 1 ≅ PEN 4.3.

## 11 Practical experience and lessons learnt

The implementation of ecosan components always needs qualified engineering staff with sufficient experience, especially in countries where the technology, here constructed wetlands, is not well known yet. The system is relatively complex with many sub-components, whilst only a population equivalent of 53 people is served.

**The following two points are important to consider:**

- In case of flow stream separation (blackwater / greywater), the load can differ extremely from reference values. This can lead to overloading and clogging of the wetland.
- The selection of materials and the construction process have to be controlled to avoid irreparable mistakes, like for example the perforation of the plastic liner (water loss), too fine or too coarse sand (clogging or bad efficiency), unequal distribution of wastewater, no possibility to clean the distribution and drainage system, wrong plants, etc.

In this project, the total wastewater flow was calculated correctly, but the constructed wetland for greywater only receives 1.5 m³ per day and the constructed wetland for blackwater more than 4 m³, sometimes up to 6 m³ per day, mainly because the seals in the flush toilets do not close tightly or the flushing device is not used correctly. The high water flux to the compost filter bag dissolves a lot of solids, which are then transported to the wetland (see Fig. 17).

**Fig. 17:** Increased blackwater flow in the composting chamber (filter bag) due to water leakage in the flush toilets.

Unfortunately, this wetland also has very fine sand. In Lima, finding sand in the right grain size is very difficult and there was not enough money available to wash it.[3] The effluent quality is excellent, but clogging can only be controlled by alternately disconnecting a third of the wetland for one week in order to recover the permeability. Valves for regulating the inflow to the wetland were included in the design after the decision for the fine sand was made, because the wetland tends to clog (see Fig. 18).

The compost filter system for blackwater pre-treatment was never used before in Peru. Operation showed that it is a very good system for warm climates. The composting process is rapid. If used for post-treatment, a three-month composting period without adding further blackwater is enough to properly treat the content of the filter bag.

**Fig. 18:** Distribution system on the second constructed wetland (for blackwater treatment) before planting, showing valves on the left (in red) to avoid clogging (intermittent loading).

Because of the clogging problems of the wetland sand, a second wetland for the treatment of the liquid phase of the blackwater was built in late 2008. Linked to these measures, the old valves in all flush toilets were exchanged with new, tightly closing valves with a water economizing low flush function. This measure reduced the production of blackwater by approx. 50%. Now only 3 m³ blackwater per school day have to be treated, and this enabled the additional connection of a neighbouring house to the wetland.

The “harvest” of the compost is not a problem. It does not smell at all and the gardener enjoys mixing the humid, obviously nutrient-rich compost with his always dry garden compost. Four filter bags in two double-chambers operating in three-month cycles would improve the process.

A neglected maintenance task is to put a little bit of straw into the active compost filter once per week. It seems that the gardener and all the other staff members do not like to see the fresh faeces. After 2-3 weeks without any straw, the chamber begins to smell, and even if they know why this happens, nobody feels responsible.

During the construction time, the project was met with mistrust by all employees and teachers. First, they mentioned the danger of accidents for the children and later the odour from the wastewater which supposed to appear with the new system – and everybody who looked once into the compost filter bag complained even more.

People were wondering what would happen in summer, because during this time the wastewater always used to smell before. The first summer came and nothing bad happened: The plants on the wetlands were growing, no wastewater was visible and the treated effluent was clear. Those employees who did not have to operate the system forgot about their complaints after half a year.

The operation of the UDDT began in May 2008, but experience already has shown that at least one year of frequent explanations, orientations and help or sometimes even “do it yourself” by the trainer is necessary before a UDDT is fully accepted.

[3] „Washing” means sieving and washing sand to remove dust and obtain a certain grain size.

# Blackwater and greywater reuse system Chorrillos, Lima, Peru

**Fig. 19:** Constructed wetland (reed bed) for greywater treatment planted with two species of Papyrus, after 1 year of operation.

## 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 SuSanA Vision Document 1) this project has its strengths and which aspects were not emphasised (weaknesses).

**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 construction, operation and monitoring of 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, 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 refer to the SuSanA Vision document "Towards more sustainable solutions" (www.susana.org).

The main impact of the project is the reduction of potable water consumption by 50% through complete grey- and blackwater reuse and therefore reduction of costs. The higher production of vegetables and fruits for sale helps to increase the income of the school and to give scholarships to poor families with handicapped children. Furthermore, the children benefit from greener surroundings (50% of the school area) and more outdoor activities.

It is an important demonstration project for environmental education purposes. Schools, teachers, students, public authorities, architects, engineers and private persons are invited to see that saving water through dry sanitation methods, reuse of treated wastewater and the use of composted organic waste can improve the quality of life.

## 13 Available documents and references

Rotária del Perú and the Colegio San Christoferus provide a project description (in Spanish), which was published at the first national sanitation conference PERUSAN 2008 in Lima, Peru. Rotária del Perú made a short description (in German) of the construction for a sponsor group in Switzerland. On the recently inaugurated website of the Colegio San Christoferus information is available in English, German and Spanish.

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**Case study of SuSanA projects**

***Blackwater and greywater reuse system.***
**SuSanA 2009**

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**This document is available from:**
**www.susana.org**

sustainable sanitation alliance

Case study of sustainable sanitation projects

# Co-composting faecal sludge & organic solid waste Kumasi, Ghana

**Fig. 1:** Project location

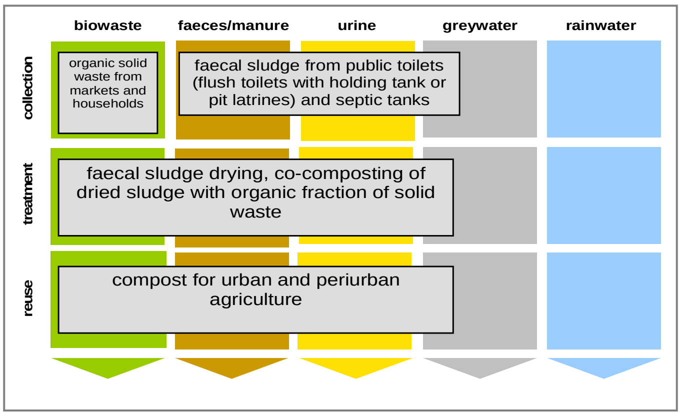


**Fig. 2:** Applied sanitation components in this project (urine and faeces are mixed with some flush water from pour flush toilets and with some anal washwater).

## 1 General data

**Type of project:**

Research and demonstration project: Combined treatment of faecal sludge and organic solid waste for reuse in agriculture (pilot scale in urban area).

**Project period:**

Start of planning: July 2001
Start of construction Oct. 2001
Start of operation: Feb. 2002 (not continuously in operation, depending in research phase)

**Project scale:**

Total land area covered: ~500 m²
Faecal sludge treated: 45 m³ per month
Capital investment costs: EUR 16,500

**Address of project location:**

Buobai, 15 km East of city centre of Kumasi, Ghana

**Implementing institutions:**

Joint planning by 4 institutions led by International Water Management Institute (IWMI):

- International Water Management Institute (IWMI); executive institution, Accra, Ghana
- Department of Water and Sanitation in Developing Countries (SANDEC) of the Swiss Federal Institute for Aquatic Science and Technology (EAWAG), Dübendorf, Switzerland
- Kwame Nkrumah University of Science and Technology (KNUST), Accra, Ghana
- Waste Management Department of Kumasi Metropolitan Assembly (KMA), Kumasi, Ghana

**Supporting agencies:**

- Ministry of Foreign Affairs, France
- National Centre of Competence in Research (NCCR) North South, Switzerland (e.g. funding of PhD students)
- KEZO, Switzerland (Waste Disposal Services Zurich Oberland, German name is: Zweckverband Kehrichtverwertung Zürcher Oberland)

## 2 Objective and motivation of the project

The objectives of the project were:

- To gain scientific knowledge on the technical and operational aspects of co-composting (co–composting refers to having two input materials: organic solid waste and faecal sludge).
- To evaluate socio-economic aspects of co-composting as well as the impact of compost utilisation on crop and soil
- To raise awareness and know-how of co-composting as a waste recycling option
- To train people in being able to operate co-composting plants (capacity development component)

The main focus of the project is the production of hygienic and nutrient rich compost made from organic solid waste and faecal sludge and its utilisation in agriculture for sustainable food production.

The co-composting plant was designed as a fully functioning small-scale facility; however it is operated at pilot scale with the objective to serve as an experimental site rather than having a high waste turnover and compost output. The ultimate aim of this process is to contribute to improving the faecal sludge management situation in Kumasi and hence improve public health.

## 3 Location and conditions

Kumasi is the second largest city in Ghana, West Africa. The city has 1 million inhabitants (growth rate of 3% per year).

**Fig. 3:** Co-composting facility (open windrow system) in Kumasi (source: IWMI, 2003).

The city is an industrial centre with formal industries in timber, food processing and soap manufacturing, together with informal activities in woodwork, vehicle repair, footwear, furniture manufacture and metal fabrication.

About 38 % of Kumasi residents use public toilets: There are about **400 public toilet facilities** in Kumasi, equipped with either flush toilets with a holding tank or KVIP latrines[1] with two pits per latrine (used alternatively) or one pit per latrine. Another 26% of the population use household water closets linked to septic tanks and seepage pits. Only 8 % of the population is connected to a sewerage system and the remaining 28% of the population have no toilet facilities at all (practising open defecation instead).

The residents in Kumasi produce daily 860 tons of solid waste and 500 $m^3$ of faecal sludge (human excreta and water) collected from on-site sanitation systems (septic tanks, pit latrines and unsewered public-toilets). Approx. 70% of the produced solid waste is biodegradable (organic) which can be co-composted together with the faecal sludge and utilised as a fertiliser and soil conditioner.

Of the 500 $m^3$ /d of faecal sludge produced, only 1.5 $m^3$/day is treated in the pilot plant. Kumasi has a full-scale faecal sludge treatment plant (formerly, the faecal sludge treatment plant at Buobai was used; currently, the FSTP at Dompoase is the main plant used). The pilot plant was only established to investigate the aspect of co-composting. And it is not a daily operation as the FSTP.

The overall faecal sludge treatment situation in Kumasi is as follows, according to Vodounhessi and von Münch (2006) (see Section 13): "*The collection companies discharge the collected FS at the privately operated FS treatment plant (FSTP) at Dompoase and there is now no longer illegal FS dumping in the city. This has been successful through the strictness of the District Assembly rules and the community participation in denouncing defaulters. The FSTP is located at the Dompoase solid waste landfill site and consists of five anaerobic, one facultative and two maturation ponds to treat FS and landfill leachate. The facility became operational in January 2004. The treated liquid effluent is mixed with the underground drainage from the solid waste landfill and discharged into Sisai River without further treatment, despite questionable effluent quality (based on visual observation; no analytical data available).*

*The former FSTP, a pond system at Buobai, was in operation during 2001-2003, but is currently no longer operational because the sedimentation ponds are full and yet to be emptied. Also, the community surrounding the plant was not satisfied with the quality of the effluent discharged in the neighbouring river.*"[2]

The climate is sub-equatorially wet with two rainy seasons, the major one from late February to early July and the minor one from mid September to early November.

Crop production is practised at different sites: approx. 70 ha in open space urban farming (vegetables, tubers[3] and cereals) while more than 12,000 ha in peri-urban farming. Backyard gardening is also commonly practised within the city as well as peri-urban cultivation of maize and plantain.

The under-five child mortality rate[4] in Ghana is currently 115 children per 1000, and the trend since 1999 is sadly in an slowly increasing direction (http://www.childinfo.org/mortality.html).

## 4 Project history

The drivers for this project were IWMI and Sandec together with the project partners, led by IWMI (see Section 14). Significant milestones were building the plant, acceptance by the community and first batch of compost produced.

The pilot co-composting plant is located within the **Buobai faecal sludge treatment plant** which was built to treat part of the FS generated in the city. The Buobai faecal sludge treatment plant has two anaerobic, two facultative and one maturation pond (currently it is no longer in use for faecal sludge treatment as mentioned in Section 3).

The construction of the pilot plant started in October 2001 and the operation started in February 2002. The plant has been in operation ever since then. Over the years, considerable knowledge was gained and large quantities of compost were produced for field trials. The plant is seen as a facility to gather useful information for future upscaling by the municipal assembly.

The plant is currently not operational because the research funds for this project are currently depleted and KMA has not taken the pilot plant over. Therefore, no more composting is taking place since January 2009. IWMI still keeps one worker in charge while IWMI develops the next research steps on the one hand and engages the waste management department in discussion for next steps

IWMI is continuing with scientific investigations and is preparing a guideline on co-composting which will be made available to the municipal assembly (KMA). Whether a full-scale co-composting plant will be built or not depends on KMA. Currently, KMA does not consider it a high priority (one problem is that the reference point for composting in Ghana is still the failed large scale Teshi plant in Accra).

## 5 Technologies applied

The basic technology chosen for this project consists of two main process steps:

1. Faecal sludge drying on unplanted drying beds and
2. Windrows co-composting of dried faecal sludge (FS) and organic solid waste (oSW).

[1] KVIP stands for "Kumasi ventilated improved pit latrine": an alternating VIP latrine (= double pit latrine in the USA) while a conventional VIP is not alternating.

[2] In August 2009: There is currently no discharge at Buobai faecal sludge treatment plant. There is a KMA staff member who guards the place though. KMA still plans to use it but according to the waste management director, they are still searching for fund to adequately compensate the community.

[3] A tuber is a type of crop with the edible part under the soil surface (examples include yam, cassava, cocoyam).

[4] The under-five mortality rate is the probability (expressed as a rate per 1,000 live births) of a child born in a specified year dying before reaching the age of five if subject to current age-specific mortality rates.

# Co-composting faecal sludge & organic solid waste Kumasi, Ghana

Co-composting of FS and oSW is advantageous because the two materials complement each other well: FS has a relatively high nitrogen content while oSW is high in organic carbon and has good bulking properties.

FS (excreta mixed with water) is collected from unsewered public toilets (type of toilet is described in Section 3) and household septic tanks by vacuum trucks within the city of Kumasi and transported to the project site for drying on sludge drying beds. Due to its too high moisture, fresh FS is unsuitable for direct aerobic composting. Hence a solid-liquid separation is needed to produce sludge of adequate water content for co-composting. For solid-liquid separation, sludge drying beds including a sand-gravel filter medium for drainage were built. They are loaded with the faecal sludge (a mixture of public toilets sludge and septic tanks FS in the ratio of 1:2). The drying process is enhanced by evaporation and gravity percolation.

**Fig. 4:** Faecal sludge drying beds (source: Olufunke Cofie, 2002).

The dried FS is removed from the drying beds once it has become spadable (after 10 days) and stored prior to co-composting.

The **leachate** (also called drainage or percolate) from the drying beds is collected in a percolate storage tank and discharged into the facultative stabilisation pond of the Buobai faecal sludge treatment plant before final discharge into a nearby stream.

**Municipal solid waste** from markets or residential areas is collected and delivered by trucks to the composting site. This waste is sorted manually. The organic fraction of the SW and the dried FS are mixed in a ratio of 3:1 and composted using an open windrow system where the feedstock is aerated by manual turning. During a composting cycle, the following activities are carried out: turning, watering, temperature measurement, weighing, sampling and laboratory analysis (analysed for physicochemical and microbiological properties). The matured compost is sieved, packed in bags (50 kg each) and stored prior to reuse e.g. in field trials.

This technology has been chosen because it is easy to build and operate, has low costs, can be implemented on a decentralised basis, no energy supply is needed and it is suitable for tropical regions such as Ghana. The drying bed is a more efficient solid-liquid separation system than the settling/thickening ponds commonly used in Ghana. Its efficiency however depends on climatic conditions and of the type of both filter material and feedstock.

Thermophilic conditions (i.e. temperatures greater than 50℃) are achieved through the composting process. These high temperatures are effective in killing pathogens such as Ascaris eggs contained in excreta. Thus, both wastes are converted into a hygienically safe soil conditioner and fertiliser.

## 6 Design information

Two unplanted drying beds were built with a surface area of 25 $m^2$ each (to hold 15 m³ excreta with a depth of 30 cm). They consist of different layers of a gravel-sand filter material of different thickness and particle sizes. Design criteria and assumptions used for the pilot plant in Kumasi are shown in Table 1 below.

The composting area is a roofed and sealed composting pad of 10 x 12 m. The composting pad has a slight slope of 1% towards the centre where a narrow drainage channel is located. This serves as a drainage system in case of leachate generation. The maturation area is a roofed and sealed pad of 7 x 6 m.

Further technical details are provided in Fig. 3 and Table 2 below. These can be applied for similar climatic conditions and faecal sludge characteristics in other countries.

**Table 1:** Design criteria and assumptions used for pilot plant in Kumasi

**Faecal sludge dewatering**

- volume of FS treated: 15 $m^3$/cycle = 45 m³/month = 1.5 m³/d
- 3 dewatering cycles/month
- 3 faecal sludge truck loads/cycle (1 truck carries ~5$m^3$)
- ratio of public toilet sludge to septage sludge = 1:2
- surface of sludge drying beds: 50 m²
- hydraulic load on drying beds: 30 cm/cycle
- FS volume reduction through dewatering assumed: 90%
- dried sludge produced: 1.5 $m^3$/cycle = 4.5 $m^3$/month

**Co-Composting**

- ratio of organic SW to dried FS = 3:1 (by volume)
- 1 month thermophilic composting + 1-2 months maturation
- 1 composting cycle starts each month
- required volume of organic SW: 3 x 4.5 = 13.5 m³/month
- assumed organic fraction in household waste: ~50% (being less than 70% indicated in Section 3 for taking into account a safety margin because waste composition may vary in time)
- required volume of unsorted SW delivery: approx. 27 $m^3$/month
- raw compost produced: 4.5 + 13.5 = 18 $m^3$/month
- volume reduction through co-composting: 50%
- mature compost produced: ~9 $m^3$/month = 4-5 t/month (density = 0.5 t/m³)

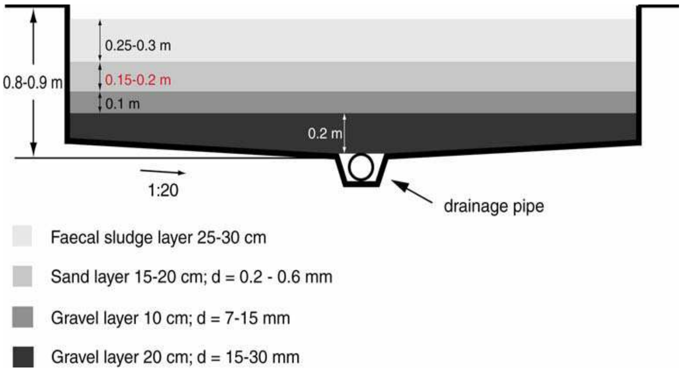


**Fig. 5:** Structural principle for a drying bed profile (for faecal sludge dewatering).

**Table 2:** Technical details and characteristics recommended for faecal sludge dewatering in drying beds.

**Sizing of the beds**
- 15 days drying cycle
- 25 – 30 cm sludge layer on beds
- 100-200 kg TS/m² / year (TS stands for total solids)
- 0.08 $m^2$/cap

**Raw sludge characteristics**
- Partly stabilised (septage or mixture of septage and public toilet sludge with ≤ 30 % share of public toilet sludge)

**Sand characteristics**
- Sand particles do not crumble
- Sand easily available locally
- Sand thoroughly washed prior to application onto the gravel base

**Production of filter layers**
- Reduce pressure flow via splitting chamber, inlet channel, and splash plates

**Drying bed removal efficiency**
- 97% SS (suspended solids), 90% COD (chemical oxygen demand), 100% HE (helminth eggs)

**Biosolids**
- 0.1 m³ per m³ fresh FS
- Hygienisation necessary prior to use in agriculture as biosolids

**Percolate**
- Quality fairly comparable to tropical wastewater
- Salinity too high for irrigation
- Percolate treatment e.g. waste stabilisation ponds or constructed wetlands

## 7 Type and level of reuse

The compost has been tested for its impact on the germination capacity and early growth of selected vegetables commonly grown in the urban and peri-urban areas (tomato, sweet pepper, lettuce, cabbage, spring onion and carrot). The germination capacity varied between 70-100% for all vegetables, which is an acceptable range. Some of the compost was given to selected urban farmers from the Gyenyasi Farmers Association in Kumasi for its application on their farms. The feedback received was encouraging. There was no difference in performance between this compost and poultry manure for lettuce production.

Furthermore the compost was tested on a demonstration field with maize and compared with a control field without compost application. The field with compost achieved a significantly higher crop yield than the control field.

The compost has been used to grow cereals and vegetables. Also the composting plant operators use it for their own production. This is a demonstration plant to convince policy makers, researchers, farmers, city planners and waste managers of the merits of compost production from faecal sludge.

It is important to find out the perceptions of the farmers as the direct beneficiaries and to determine if a project of this nature is financially and economically viable. Therefore, a study on farmers' perception of excreta-based compost and willingness to pay was carried out. The results of this study were that a large number of farmers (83%) were willing to use excreta-based compost. However, the actual amount that farmers were willing to pay was low (between EUR 0.1 to 2.5 per 50-kg bag)[5] which was far below a price which would cover production costs.

The farmers who were skeptical (17%) feared that the excreta component could still spread infections and thought that consumers might avoid crops being fertilised with excreta-based compost (there is however no evidence that consumers would avoid crops that were fertilised with excreta-based compost).

**Fig. 6:** Lettuce farm fertilised with compost at Gyenyasi farmers Association in Kumasi (source: Nikita Eriksen-Hamel, 2002).

Research on the produced compost has shown that the compost quality is within an acceptable range. The composting process is efficient in reducing the Ascaris eggs concentration to a safe level. Ascaris eggs viability is reduced from 40-60% in the raw FS to less than 10% in the final compost with a total count of <5 Ascaris eggs/gTS (TS stands for total solids). The viable Ascaris eggs are <1 viable Ascaris eggs/gTS, thereby complying with the WHO guidelines of 2006 for the safe use of excreta[6]. The macro- and micro-nutrients as well as heavy metal contents are within an acceptable range.

Thus this compost made of FS and organic SW will not pose health risks to farmers and consumers. The necessary health and safety plans are available on site. Safety equipment (boots,

[5] For comparison: Common compost used in Kumasi is poultry manure which at the time of calculation was free except for transport cost.

[6] http://www.who.int/water_sanitation_health/wastewater/gsuww/en/index.html

overalls, gloves and nose masks) are always used by the workers. Hands are thoroughly washed with soap and disinfectants. The workers periodically undergo medical check-ups. SW rejects (non-organic component) are properly land filled by the KMA Waste Management Department.

Compost is not sold to farmers but given to them for free or used by the plant operators for field tests. The reason why it is given away for free is because the plant was not for commercial use but just meant to gain technical knowledge on co-composting of faecal sludge and organic solid waste. However the farmers are willing to use excreta-based compost provided its nutrient content is high enough and it is available at an affordable price.

## 8 Further project components

Due to the implementation of this project, an increased awareness can be observed among farmer groups in using excreta-based compost. Many farmers understood that co-compost made from human excreta and organic solid waste is a safe product and poses no health risk to them. Scientists and engineers carried out training of project assistants and MSc and PhD students who also worked on various system components. The project offered many Northern and Southern students the opportunity to do applied research on this subject.

The scientific investigations were carried out by IWMI and other research partners from Eawag/Sandec and KNUST, coordinated by the project leader.

## 9 Costs and economics

Total investment costs were about EUR 16,500 which were funded mainly by the Ministry of Foreign Affairs (France). Operation costs (PhD students, video documentary, initial operation and maintenance costs) were funded by NCCR North-South and KEZO (in Switzerland).

The first phase (2001-2004) was funded by France and the project partners own budgets, in particular, IWMI and Sandec (funding from KEZO). The second phase (2005- 2008) was funded by NCCR North-South through PhD research. Funding for 2009 has been a constraint.

Operation of the co-composting plant is labour intensive. Solid waste sorting is the most costly activity contributing to approx. 30% of the total operation and maintenance costs.

It was estimated that the amount of compost produced from the pilot plant will be approx. **37 tons/year**[7]. A subsequent study valued the compost produced at the plant to be approx. EUR 3.5 per 50-kg bag.

If the plant was working at full scale the production costs would decrease or possibly increase (e.g. in cases where manual shoveling had to be replaced by machines). These figures however refer to this demonstration project only and are not applicable for other full-scale projects.

The operation and maintenance costs include mainly just labour. There are normally no electricity or chemicals costs (except for research activities). The labour costs vary for different activities at the plant e.g. waste sorting was about 30% of total cost. The labour costs vary with the number of compost heaps under investigation during the different research phases.

The combined process of FS drying and co-composting is costly for a private company and hence requires a considerable government subsidy especially for the initial investment. Sales revenues would hardly cover operating expenses.

The economic analysis showed that the plant is economically viable, though financially it is not. However, the project has numerous external benefits (such as reducing waste volume, transport costs, increasing the agronomic value of compost and improving public health). Thus compost production - even without a market - saves money at other places which in turn could be used to subsidise such a co-composting plant.

## 10 Operation and maintenance

Collection and transportation of excreta and solid waste to the project site are performed by the Waste Management Department of KMA (Kumasi Metropolitan Assembly).

The plant manager is responsible for the management and supervision of the operation of the plant. Two labourers work under the supervision of the plant manager. The labourers are not employed by KMA but normally paid by the project (although there is currently a problem with the funding). Hence, KMA is currently not paying for the O&M costs of the plant.

The operational activities can be summarised as follows:

- FS delivery
- FS loading on drying beds
- De-sludging of drying beds
- Solid waste delivery
- Solid waste sorting
- Mixing and piling of co-composting feedstock (dried FS and organic SW)
- Turning of windrows and watering
- Sieving and bagging of the compost
- Sampling (for analysis and agronomic field trials)

The maintenance activities consist of a periodic changing of the filter medium of the drying beds when it is clogged: The top layer (sand) is then removed from the drying bed, the underlying gravel layer is washed and the top layer replaced by new sand. Time intervals for changing of the sand filter can range from several months to more than 15 years depending on the sand quality: In order to reduce the risk of clogging, sand with no or a low amount of silt/clay has to be used (to be obtained e.g. by washing).

General cleaning of the site is carried out periodically to keep it tidy. Grass is planted to beautify the place and to minimise erosion.

## 11 Practical experience and lessons learnt

Functional improvements of the drying beds are necessary to guarantee a continuous and sustainable compost production: Improvements are needed on the filter quality and how to control the effect of rainfall.

[7] The plant was not operated continuously to full capacity due to the research focus. Information about the exact amount of compost produced over the years is currently not available.

The co-composting plant has experienced the following operational problems:

- Occasionally, long delays in waste delivery to the site occur (due to logistical problems with the waste collectors) which consequently cause a disruption of the operation.
- If there is excessive rain then the sludge drying process takes longer than the usual 10 days, as the drying beds are not covered (clogging of the beds may also occur in this case).
- It has been observed that the nitrogen content of the compost is lower than would be required for high yield of short duration crop production as practiced in the urban areas. This is due to nitrogen losses during both faecal sludge drying and the composting process itself.
- Some measures (e.g. reduction of the compost turning frequency, fertiliser enrichment) are taken in order to reduce these nitrogen losses. An enriched form of the compost called *Comliser* (mixture of compost and chemical fertiliser) is prepared and tested with farmers (see references in Section 13).

Addition of pure urine to the compost to increase the nitrogen content was considered but not carried out yet. IWMI, as one of the research partners, is in the process of developing a follow up research

The compost is generally of high quality as sorting of the solid waste (to removed inorganic matter, e.g. pieces of plastic and metal) is done very carefully and diligently be the plant workers.

Social problems faced were as follows:

- A few years ago, the residents of the Buobai community prevented trucks from delivering waste to the site on several occasions, making operation of the plant impossible. They claimed that KMA had used their land for setting up a faecal sludge stabilisation pond without compensating them for the land. So they used their power on this co-composting project to force KMA to act. It took a combined effort of IWMI and KMA to solve the conflict by meeting with the chief and the community.

## 12 Sustainability assessment and long-term impacts

The fact that this pilot plant has been operating for 7 years can be taken as a good sign for sustainability. However, for financial sustainability, external support or subsidies are needed.

A basic assessment (Table 3) 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).

The long term impacts of this project are:

1. The erection of a demonstration plant has served to demonstrate to policy makers, engineers, farmers, city planners and waste managers the merits of co-composting.
2. This co-composting demonstration plant has become well-known and served as a basis for similar projects in Senegal and Mali funded by Sandec.

Improved public health of residents in Kumasi would be a long-term impact if the plant was upscaled to treat a significant proportion of the faecal sludge produced in Kumasi. This is the ultimate goal.

**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 | |

## 13 Available documents and references

A video documentary entitled "Co-treating faecal sludge and solid waste: the Buobai co-composting pilot project, Kumasi, Ghana" was prepared in 2003 describing the activities and operation of the project and giving an overview of the sanitation situation in Kumasi and Ghana at large (Maradan, J. and Schaffner, R. (2003) Co-treating faecal sludge and solid waste. The Buobai Co-composting Pilot Project, Kumasi, Ghana, video documentary)[8].

Various documents (reports, theses, papers) are available as listed below (shown in reverse chronological order, starting from 2004).

**Published papers**


- Olufunke, C., Doulaye, K., Silke Rothenberger, Daya Moser and Chris Zurbrügg (2009) Co-Composting of Faecal Sludge and Organic Solid Waste for Agriculture: Process Dynamics. Water Research Abstract and pdf file for purchase available at http://www.sciencedirect.com or doi:10.1016/j.watres.2009.07.021
- Noah Adamtey, Olufunke Cofie, Godfred K. Ofosu-Budu, Seth. K. A. Danso and Dionys Forster (2009). Production and storage of N-enriched co-compost. Waste Management: 29 (2009) 2429–2436. Abstract and pdf file for purchase available at http://www.sciencedirect.com.
- Miezah, K. Ofosu-Anim, J. Budu, G.K.O., L. Enu-Kwesi and O.Cofie (2008) Isolation and identification of some plant growth promoting substances in compost and co-compost. International J. of Virology. 4 (2): 30-40. Abstract and pdf file for purchase available at http://www.sciencedirect.com.
- Kuffour, A.R., Awuah, E., Anyemedu, F.O.K., Strauss, M., Kone D. and O.Cofie (2008) Effect of using different particle sizes of sand as filter media for dewatering faecal sludge. In: Richards B.S and Schafer, A.I. (eds). Water and Sanitation in International Development and Disaster Relief.


[8] It is available to order from this website: http://www.nccr-north-south.unibe.ch/document/document.asp?ID=1907&refTitle=NCCR&Context=NCCR

Proceedings of International Workshop Edinburgh, Scotland, (UK), 28-30 May 2008. 347 – 354. Available via ecosan literature database: http://www.gtz.de/en/themen/umwelt-infrastruktur/wasser/8745.htm

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- Agbottah S., Awuah E., Cofie O and A. Montangero (2007) Anaerobic Treatment of Percolate from Faecal Sludge Drying Beds – Journal of the Ghana Institution of Engineers Vol. 5 (1&2): pp. 25-30
- Koné, D., Cofie, O., Zurbrügg, C., Gallizzi, K., Moser, D., Drescher, S., Strauss, M. (2007) Helminth eggs inactivation efficiency by faecal sludge dewatering and co-composting in tropical climates. *Water Research* **41**(19), 4397-4402. Abstract and pdf file for purchase available at http://www.sciencedirect.com..
- Cofie, O., Agbottah, S., Strauss, M., Esseku, H., Montangero, A., Awuah, E. and Koné, D. (2006) Solid-liquid separation of faecal sludge using drying beds in Ghana: Implications for nutrient recycling in urban agriculture. *Water Research* **40**(1), 75-82. Abstract and pdf file for purchase available at http://www.sciencedirect.com.
- Vodounhessi, A. and v. Münch, E. (2006) Financial Challenges to Making Faecal Sludge Management an Integrated Part of the Ecosan Approach: Case Study of Kumasi, Ghana, Water Practice & Technology, **1**(2), http://www.iwaponline.com/wpt/001/wpt0010045.htm

**MSc Theses** (soft copies are available on request)

- Vodounhessi, A. (2006) Financial and Institutional Challenges to Make Faecal Sludge Management Integrated Part of Ecosan Approach in West Africa. Case Study of Kumasi, Ghana. MSc thesis, UNESCO-IHE Institute for Water Education, Delft, the Netherlands. http://www2.gtz.de/Dokumente/oe44/ecosan/en-financial-institutional-challenges-ecosan-2006.pdf
- Quarshie, S. (2005) Filter material and loading rate for the optimal dewatering of faecal sludge. M.Sc. thesis in Water Supply and Environmental Sanitation, Dept. of Civil Engineering, KNUST, Ghana
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- Boateng, O. (2003) Composting market and household solid wastes with dewatered faecal sludge: changes in microbial and helminth egg population. M.Sc. thesis, Dept. of Biological sciences, KNUST, Ghana
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- Esseku, H. (2002) Use of drying beds for faecal sludge/septage pretreatment: monitoring a pilot scheme at Buobai-Kumasi. M.Sc. Thesis in Water Supply and Environmental Sanitation, Dept. of Civil Engineering, KNUST, Ghana

## 14 Institutions, organisations and contact persons

International Water Management Institute (IWMI)
**Role:** Project leader responsible for overall scientific coordination and project implementation.
Contact person: Dr. Olufunke Cofie
West Africa Office
PMB CT 112, Accra, Ghana
http://www.iwmi.cgiar.org/index.aspx

Swiss Federal Institute of Aquatic Science and Technology (EAWAG), Department of Water and Sanitation in Developing Countries (SANDEC)
**Role:** Co-implementer and student supervisor
Contact person: Dr. Doulaye Koné
P.O. Box 611, Ueberlandstrasse 133
CH-8600 Duebendorf, Switzerland
http://www.sandec.ch/

Kwame Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana
**Role:** Supervision of students
Contact persons: Prof. Esi Awuah (Civil engineering Dept.) and Prof. Robert Abaidoo (Biological Sciences Dept.)
http://www.knust.edu.gh/

Kumasi Metropolitan Assembly (KMA), Waste Management Department
**Role:** Logistic support, waste collection and transportation[9]
Contact person: Mr. Anthony Mensah
http://www.kma.ghanadistricts.gov.gh/

**For further information contact:**
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E: o.cofie@cgiar.org

Case study of SuSanA projects
*Co-composting of faecal sludge & organic solid waste*
**SuSanA 2009**
**Authors: Olufunke Cofie (IWMI), Doulaye Koné (Eawag/Sandec)**
**Editing and reviewing: Christian Olt, Carola Israel, Elisabeth v. Münch (GTZ ecosan team, ecosan@gtz.de)**



[9] In the future, KMA should become the owner and operator of this facility once it is completely handed over (currently, KMA is a partner in the operation).

sustainable sanitation alliance

Case study of sustainable sanitation projects

# UDD toilets at a Girls Secondary School Kalungu, Uganda - Draft

**Fig. 1:** Project location

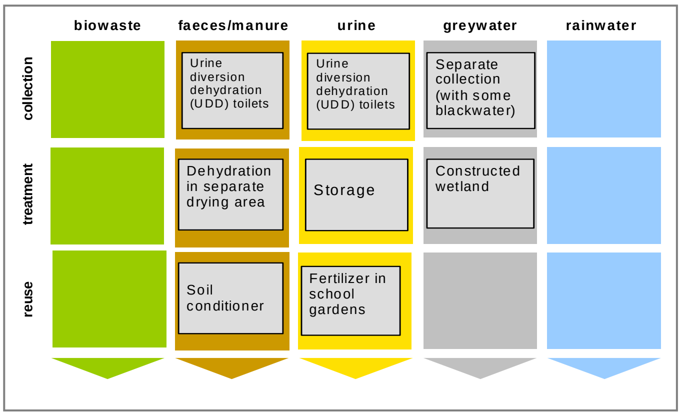


**Fig. 2:** Applied sanitation components in this project

## 1 General data

**Type of project:**
Sanitation and water supply at a rural secondary school

**Project period:**
Start of planning: 2000
Start of construction: 2003
Start of operation: 2004 (and ongoing)

**Project scale:**
Upgrading of water supply and sanitation facilities for 350 students and teachers - how many of these 350 are teachers, how many are students?
Construction cost: approx. EUR 70,000

**Address of project location:**
Kalungu, Masaka District, Uganda

**Planning institution:**
EcoSan Club Austria (ECA)
Consulting Firm: Technisches Büro Lechner (TBL)

**Executing institution:**
Norman Construction and Engineering Services, Kampala, Uganda (construction)
Technisches Büro Lechner (supervision)

**Supporting agency:**
Manos Unidas - explanation on what this is exactly?

*This case study is still in draft form. We are currently in touch with the relevant project people to clarify some minor questions.*

## 2 Objective and motivation of the project

The objectives of this project at the Kalungu Girls Secondary School were to:

- reduce groundwater and drinking water pollution caused by inadequate sanitation systems.
- improve both quality and quantity of drinking water supply.

## 3 Location and conditions

The school "Sacred Heart Sisters" is located in a hilly area in Kalunga with a high groundwater level and surrounded by small villages. The initial sanitation situation before 2003 was as follows: Wastewater from the teachers' quarters and sisters' house (are the sisters also teachers? If not, what are they there for?) (flush toilets and greywater from kitchen and showers) was drained in soak pits. The students used 35 pit latrines. Greywater from showers and the kitchen was discharged in a creek outside the school's compound. Due to the high ground water level, the soak pits and pit latrines located directly upstream of the school and the nearby villages' water spring, the situation was dangerous for human health.

In Uganda, the under-five child mortality rate[1] is currently 130 children per 1000 (http://www.childinfo.org/mortality.html), which is very high but at least there is currently a clear downward trend towards fewer child deaths.

**Fig. 3:** School compound of "Sacred Heart Sisters" school (source: EcoSan Club, year?) Perhaps a better photo would be one that shows the school itself, too?

[1] The under-five mortality rate is the probability (expressed as a rate per 1,000 live births) of a child born in a specified year dying before reaching the age of five if subject to current age-specific mortality rates.

# UDD toilets at a Girls Secondary School Kalungu, Uganda - Draft

Explain where Kalungu is in comparison to Kampala? How big is Kalungu?
What sort of pupils go there? Is it a boarding school?
How is it funded?
Is it a rural or an urban school?

## 4 Project history

In the year 2000, the project started with a first site visit (by whom?) to gain an overview of the situation. After preparing a feasibility study (who?), a first meeting (who met?) with the school administration was organized to discuss the major issues of the required water supply and sanitation improvements. In 2003, detailed planning, design, construction, supervision and training sessions were carried out by TBL with support of the EcoSan Club. Construction was carried out by Norman Construction and Engineering Services. Two site engineers, organizing and supervising the construction work of local contractors, were employed for the duration of the project implementation.

How was this school selected? Why was in particular Ecosan-Club contacted? Who made the connection?

The idea of having a demonstration toilet for teachers and visitors came up during the discussions to convince the users of the advantages of UDD toilets. Constructing the same type of toilets for both students and teachers seemed to be the most suitable way to ensure a proper use of the toilets with support of shared knowledge.

Based on that idea, the design of the demonstration toilet unit was developed in a participatory way: The details of the unit were developed together with the teachers to create a consciousness of ownership and responsibility. A series of possible designs were presented to the teachers and any decisions (e.g. location of the toilet, sitting or squatting type; urinal for men) were discussed with them.

## 5 Technologies applied

The project consists of the following three main components:

1. For the students, the existing pit latrines were replaced by 45 urine diverting dehydration (UDD) toilets. This technology is in line with the National Strategy to promote ecological sanitation in Uganda (reference?). UDDTs were selected in preference to composting toilets because maintenance for these toilets is less complicated than for composting toilets, though secondary treatment of faeces might be necessary (carried out here via further drying).
2. For the teachers, a UDD toilet building was built which also serves as a demonstration unit for visitors. It is located near the main entrance of the school and has an attractive design.
3. The remaining wastewater (greywater with a small share of black water from the sisters' house where flush toilets are still used) (why are there still flush toilets at the sisters´ house? How many sisters are there, how many toilets?) is treated in a horizontal subsurface flow constructed wetland. The reasons for choosing this technology were as follows:
   - Simplicity of construction
   - Low operation & maintenance efforts and costs
   - Enhanced nutrient removal is not required since the amount of nutrients is low due to the implementation of a UDD toilet system.
   - Legal environmental standards (what are they?) in Uganda can be fulfilled.
   - The subsurface flow constructed wetland has no free water surface (i.e. no fly breeding)
   - Effluent is not reused but infiltrated in the soil

How is greywater collected? Are you using a small-bore sewer system? Was it already in place?
Any waterless urinals used in student´s toilets? If not, why not?

**Fig. 4:** Now students' toilets – 45 UDDTs (source: EcoSan Club, year?)

**Fig. 5:** Interior of a students' UDD toilet showing UD squatting pan (source: EcoSan Club, year?)

**Fig. 6:** Demonstration UDD toilet for teachers and visitors (source: EcoSan Club, year?)

# UDD toilets at a Girls Secondary School Kalungu, Uganda - Draft

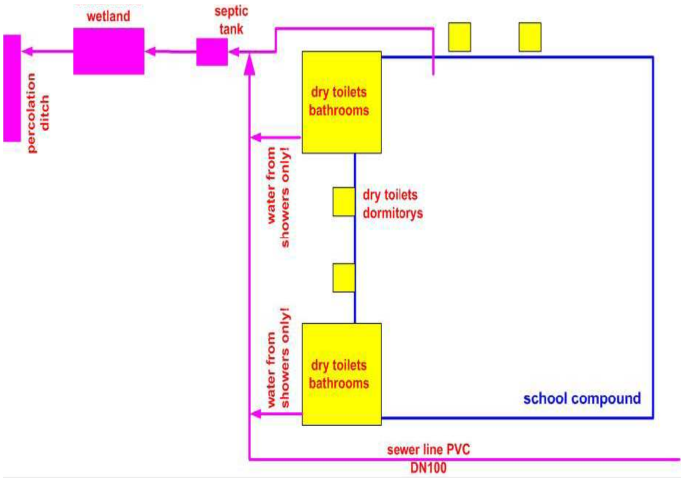


**Fig. 10:** Scheme of the new sanitation system; flow is from right to left (source: EcoSan Club)

**Fig. 7:** Wooden faeces collection basket in vault of UDDT (source: EcoSan Club, year?) (who is this person? Maintenance staff?)

## 6 Design information

UDD toilets (single-vault) for students

The UDD toilets are built in blocks, which allows the operator (who is the operator?) to empty the faeces chambers from the back of the building. Each toilet consists of an elevated concrete floor including a plastic squatting pan (produced by Cress tank, Uganda). Via the squatting pan, faeces, anal cleansing material (=toilet paper?) and ash is collected in a wooden basket located in a dehydration chamber und the squatting pan. These baskets are emptied after every school term (i.e. every 3 months) and brought to an outside drying area for further dehydration for six months. The drying area is situated close to the school to avoid long transport distances. (Any odour issues with this?)

Urine is led to an underground tank (how big? Plastic? Why underground, is that just because of the slope required?) which is situated behind the toilets. Urine can alternatively be led to a soak pit for infiltration into the ground. The four soak pits are next to the toilets. Experience has shown that all urine is used in agriculture and none infiltrated in these soak pits.

Demonstration toilet for teachers and visitors

The demonstration toilet was built with an attractive design. A designer made a first draft, before the school teachers contributed further ideas during a workshop.

Urine from the demonstration toilet is collected in 20 litre jerry cans while the collection of the faecal material is identical to the students' toilets. The demonstration unit is additionally equipped with a urinal (waterless?) to reduce the amount of urine wrongly entering the faeces chamber.

How much urine is collected?
How much faeces is collected?

Constructed wetland

For the treatment of the greywater and some blackwater from the few flush toilets, a horizontal subsurface flow constructed wetland system was built. Wastewater is pre-treated in a settling tank to remove solids (by sedimentation and flotation) before it flows by gravity to the inlet of the constructed wetland. The sludge from the settling tank is regularly emptied (at least once a year) and the material is dried together with faecal material from the UDD toilets at the drying area.
Flowrate of wastewater? Area of wetland? Is it 100m²? Size of setting tank?

The inlet of the constructed wetland comprises coarse aggregate (diameter of 60-80 mm) (that seems big?) in order to distribute the wastewater horizontally before it enters the actual treatment part consisting of sand (diameter of 4-8 mm (sand with 8 mm seems big?)). The bottom of the filter bed has a slope of 1%. At its lower end another area of coarse aggregate and a drain pipe (PVC DN 100) collects the purified greywater which is piped via an outlet manhole to an underground percolation ditch (10 m of drain pipe DN 100 in a layer of coarse aggregate and covered with excavated material and soil).

Depth of layers? Lining at bottom? Which plants are planted?

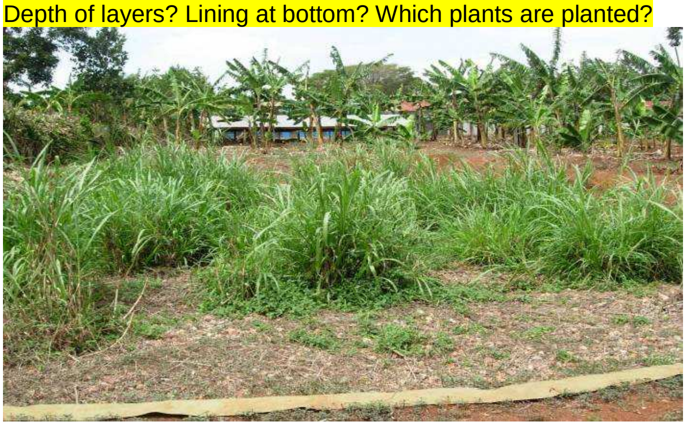

**Fig. 8:** Constructed wetland, planted with xxx (source: EcoSan Club, year?)

## 7 Type and level of reuse

The possibility of reuse (for urine and faeces) was one of the main motivations for the school administration to support the project since a farm producing food for the school is adjacent to the school compound.

The **dried faeces material** from the drying area is screened via a coarse-meshed sieve before being reused as a fertilizer and soil conditioner in the surrounding banana and matoke plantation or as a soil conditioner in the school gardens. The sieved-out material like sanitary pads and toilet paper is burnt.

**Fig. 9:** Covered drying area for collected faeces from UDD toilets (source: EcoSan Club, year?)

The **urine** from the UDDTs is collected in an underground tank (students' toilets) or in jerry cans (teachers' toilet). After storage (for at least 1 month for application on fodder crops and more than 6 months (are you really storing for 6 months? That´s very long) for application on food crops), the urine is used as a liquid fertilizer in agriculture with a dilution of 1:5 (1 part urine to 5 parts water)[2]. Fertilized cultures are banana trees, pepper, cabbage, carrots and spinach.

More details here on how exactly these fertilisers applied? Worked into the ground, under the top soil cover?

The treated greywater is infiltrated into the ground and not reused. (why not? Is there no demand for irrigation water?)

There has been an increase in agricultural productivity, however this has not been quantified. Agricultural products are not sold but entirely consumed at the school itself.

## 8 Further project components

Water supply

The existing water catchment of the spring near the school compound was renewed including filtration, pump and overflow: A solar driven submersible pump and a drinking water tank were installed and the piping network was partly renovated.

Water for general use (but not for drinking) is now pumped from the new water catchment unit to the existing main water tank and distributed to the users (school, sisters and teachers). The (? ->) overflow being filled during pump running (<- ?) time is made available for the local population (how many?). This facility is large enough to include an additional storage tank for the local population in the future. In addition, a borehole with a hand pump (to avoid pollution of spring water by surface water) was installed to be used for drinking water supply on the school compound.

How much water is used from both sources?

## 9 Costs and economics

A cost comparison was carried out during the planning phase of the project, meant to serve as one piece of information among others for the decision making. The two compared options were:

- Option 1 (this is the built option): Ecosan concept with 45 UDD toilets and separate greywater treatment: a sewer and a horizontal-flow subsurface constructed wetland (area approx. 100 m²).
- Option 2: Conventional sanitation with 30 flush toilets; wastewater is collected in a sewer and treated according to Ugandan standards. The main components are: a sewer, a mechanical pre-treatment, a pumping station and a vertical-flow subsurface constructed wetland (area approx. 500 m²).

For the cost comparison the following costs were considered:

- Capital costs
- Operating and maintenance costs

The calculation is based on the following assumptions: Timeframe is 50 years, replacement costs depend on lifespan of individual parts of the system, interest rate is 8%.

The results in Table 1 show the calculated capital costs of both options. The costs are indicated in Euros calculated at an exchange rate of UGX 2060 = EUR 1 (Sept. 2004).

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

# UDD toilets at a Girls Secondary School Kalungu, Uganda - Draft

| Option 1 (ecosan) | no. | unit | unit cost [€] | total cost [€] |
|---|---|---|---|---|
| piping | 250 | m | 8 | 1,911 |
| manholes incl. covers | 5 | pcs | 49 | 243 |
| fittings | 1 | lump-sum | 850 | 850 |
| filter unit | 1 | lump-sum | 3,823 | 3,823 |
| greywater treatment system | 100 | m² | 30 | 2,973 |
| UDD toilets | 45 | pcs | 194 | 8,738 |
| sum | | | | 18,538 |

| Option 2 (conventional) | no. | unit | unit cost [€] | total cost [€] |
|---|---|---|---|---|
| piping | 250 | m | 8 | 1,911 |
| manholes incl. covers | 5 | pcs | 49 | 243 |
| fittings | 1 | lump-sum | 850 | 850 |
| filter unit | 1 | lump-sum | 3,823 | 3,823 |
| pumping station | 1 | lump-sum | 971 | 971 |
| wastewater treatment system | 500 | m² | 30 | 14,867 |
| flush toilets incl. plumbing | 30 | pcs | 291 | 8,738 |
| sum | | | | 31,402 |

**Table 1:** Calculated capital costs of two alternative options – Option 1 is the option which was built (source: EcoSan Club)
Table 1 is just capital costs, right?

The cost comparison between an ecosan concept (Option 1) and a conventional concept (Option 2) shows clearly that also financial reasons support the decision to invest in ecological sanitation. The main difference is caused by the significantly smaller wastewater treatment system for Option 1 and the additionally required pumping station for Option 2. Urine diversion significantly reduces the nitrogen load which results in a reduction of the required expenditure for the biological wastewater treatment system.

The actual total costs for construction and consultancy were approx. EUR 70,000, O&M costs are approx. EUR 500 per year for one full time person and some minor spare parts.

Why EUR 70,000 when table 1 says EUR 18,538?
The construction costs were about EUR 200 per person (based on 350 people) which is high! (Why so expensive?)
The entire cost was paid by Manos Unidas?
The school had to pay nothing? Who pays for the yearly O&M?
Was an estimate made to compare O&M of both options?

## 10 Operation and maintenance

Teachers and students were trained (who did the training?) in principles and proper operation of the newly constructed units, in particular the UDD toilets. The involvement of the teaching personnel responsible for health issues was particularly emphasized. For the teachers a brief written summary on the principles of UDD toilets, their operation and maintenance was prepared (by whom?). The responsible personnel for operation and maintenance (gardener) was trained both on-site by the contractor's personnel and in a training course at the Lacor Hospital (why at this hospital?) in Uganda.

Who exactly does maintenance? Do students do anything? What needs to be done?

**Fig. 13:** User training for urine diversion dehydration toilets (source: Ecosan Club)

## 11 Practical experience and lessons learnt

Since the project has been implemented, the school became "famous" in Uganda and worldwide for the innovative sanitation concept, and even featured in a documentary, see Section 13. Delegations from all over the country and from abroad come to visit the school toilets regularly. The students and the teachers are proud of their toilets which are kept clean and well maintained. The headmaster reported that visitors and students' families are copying the idea (these developments are yet to be documented).

The experience shows that several reasons contributed to the well working sanitation system:

- Teachers and students use the same type of toilets and the teaching personnel is convinced of this new technology.
- All stakeholders were involved in the planning from the beginning of the project; critical design decisions were made by the users.
- The presence of the civil engineers (=?) was utilized to sensitize and train teachers and students.

Were there no problems at all?

During an interview in February 2006 with the operator (who is the operator?) of the sanitation system and the school administration, both parties stated their satisfaction. Especially the administrator underlined the high value of the produced fertilizer for the school gardens. More information can be found in Jemsby (2008).

## 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 emphasized (weaknesses).

**Table 2:** 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, 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).

The main long-term impact of the project is improved public health. (although this has not been quantified yet? -> reduced school absenteeism?) A detailed monitoring regarding the quality of dried human excreta has been carried out by the EcoSan Club from 2004 to 2006 which showed very satisfying results.

The main results of the monitoring were (in 2006): give reference to this report?

- The implemented infrastructure is still in a good condition and is used.
- Both faeces and urine are used in the school gardens as fertilizer.
- Treatment of the faecal material is based on a long storage and drying period combined with a relatively high addition of ash.
- Apart from one sample (out of X samples in total) no pathogenic organisms were found in the dried material. Which pathogens were tested?

Has this project had any “knock-on” effects? Has it been copied? Does is serve as a demonstration site? Has is had wider impacts in Uganda?

## 13 Available documents and references


- Jemsby, C. (2008) The most famous toilets in Uganda. In: Sanitation Now. Stockholm Environmental Institute, pp 4-7. http://www.ecosanres.org/sanitationnow2008.htm.
- Müllegger, E., Lechner, M. and Jung, S. (2006) Sanitation for a Girls school in Uganda. Presentation for the 4th World Water Forum, March 2006, Mexico City. http://www.ecosan.at/download/WorlWaterForum_presentation.pdf.
- **Video clip** from Human Excreta Index movie (2005): http://www.susana.org/index.php/lang-en/cap-dev/videos/the-human-excreta-index
- Lechner, M. (2004) Kalungu Girls Secondary School – Improvement of Water & Sanitation Infrastructure (project report). http://www.ecosan.at/download/projects/kalungu.pdf


## 14 Institutions, organisations and contact persons

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E 2: janet@crestanks.co.ug
E 3: crestank@africaonline.co.ug
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School administration

Sacred Heart Sisters
Sr. Noelina or Sr. Maria Gaczol
Kalungu, Uganda
E-mail adress?

# UDD toilets at a Girls Secondary School Kalungu, Uganda - Draft

Case study of SuSanA projects

*UDD toilets at a Girls Secondary School*

SuSanA 2008

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**This document is available from:**
**www.susana.org**

# Improvement of sanitation at Kanawat health center Kanawat, Uganda

**Fig. 1:** Project location

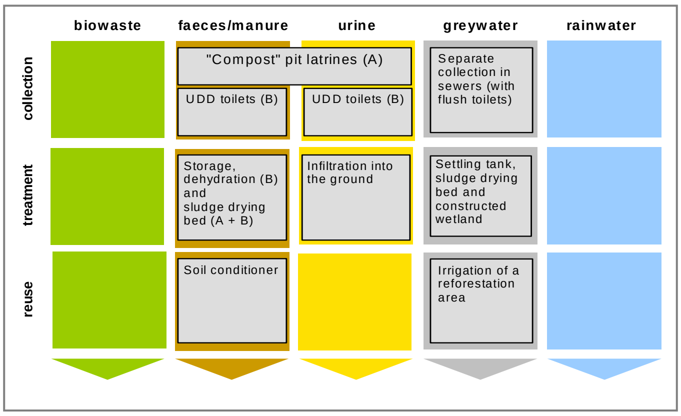


**Fig. 2:** Applied sanitation components in this project (A and B refer to two types of toilets used)

## 1 General data

**Type of project:**
Improvement of the sanitation system of a rural public health center

**Project period:**
Start of construction: January 2004
Start of operation: July 2004 (and ongoing)

**Project scale:**
Sanitation facilities for approx. 150 patients and 15 staff members.
Total cost approx. € 20,000 for consultancy and realization of 6 pit latrines, 1 UDD toilet block with 4 cubicles and other infrastructure components.

**Address of project location:**
Kanawat, Kotido District, Uganda

**Planning institution:**
EcoSan Club

**Executing institution:**
Norman Construction and Engineering Services, Kampala, Uganda

**Supporting agency:**
Austrian child care organisation "Dreikönigsaktion" (DKA): 100% fund

## 2 Objective and motivation of the project

The objectives of the project were to:

- improve the hygienic situation of the Kanawat Health Center with regard to water and sanitation as well as clinical waste.
- prevent the spreading of water-related diseases.

## 3 Location and conditions

The health center is located in Kotido District in the North-Eastern Karimojong region of Uganda. The is characterized by short rainfalls with long dry and hot periods. The different Karimojong tribes living in this region are still following a semi-nomadic lifestyle, mainly based on traditional livestock keeping and subsistence agriculture. The health center was founded in 1976 by Comboni missionaries and is being used by about 150 patients per day, and this number is steadily increasing.

In Uganda, the under-five mortality rate[1] is currently 130 children per 1000 (http://www.childinfo.org/mortality.html).

**Fig. 3:** Shower and laundry washing area of the Health Center (source: EcoSan Club, 2004)

The sanitary situation before project implementation was as follows:

- Wastewater produced in the Health Center, nurses' houses and staff quarter (originating from some flush toilets and

[1] The under-five mortality rate is the probability (expressed as a rate per 1,000 live births) of a child born in a specified year dying before reaching the age of five if subject to current age-specific mortality rates.

greywater from kitchen and showers) was collected in settling tanks and the overflow was drained into soak pits.

- Pit latrines served as toilets for patients' family members on the health center's compound. Due to hard rocky soil it was not possible to dig sufficiently deep pits. Thus, the toilet slab was raised by approx. 1.20 m above ground to achieve a sufficient storage volume and to ease emptying. Adjacent to these pit latrines, shelters were provided to be used as showers which however were misused for defecation. The Health Center staff used pit latrines located near the staff houses.
- Wastewater was not treated at all. Drinking water wells within the compound were directly located near the pit latrines, showers and soak pits. Thus, the situation was dangerous for human health.
- In addition also the incinerator for the burning of medical waste was located on the small compound of the Health Center. Due to the malfunctioning of the incinerator, black and dense smoke polluted the air and insufficiently burnt medical waste was dumped uncontrolled.

## 4 Project history

In 2002 the Austrian NGO named "Dreikönigsaktion" (DKA) started to support the health center in a first phase with an electrical solar system to supply electricity day and night independently of fuel (before that a generator with insufficient fuel supply was the only energy source).
In 2003 the second phase of the project addressed the hygienically insufficient conditions regarding sanitation, washing facilities and waste discharge.

Planning, technical design, supervision of the construction works and parts of the user training were carried out by EcoSan Club. Realization of the project was carried out by Norman Construction and Engineering Services. One site engineer, organizing and supervising the construction work of local contractors, was employed for the duration of the project implementation. The construction was completed in July 2004.

## 5 Technologies applied

The project consists of following 6 main components:

1. The 6 old pit latrines for the patients were reconstructed as pit latrines that can be emptied (without urine separation, for details see section 6), hereinafter referred to as "compost" pit latrines (however, the term "compost" is misleading because in fact there is no composting process taking place here). This decision was due to the following reasons:
   - The previously existing latrines which were already located above-ground had a large storage volume.
   - Local staff is familiar with their maintenance.
   - The pit content was planned to be reused at the Health Center's own cottage plantation for soil conditioning.
   - A change of users' behavior is not required.

2. A urine diversion dehydration (UDD) toilet block with 4 cubicles was constructed for the staff in order to avoid problems related to conventional latrines and to demonstrate modern technologies. The staff was regarded as able to modify their user behavior according to the demands of such a toilet system, which they did. The toilets are equipped with urine diversion squatting pans produced by Cress tank in Uganda (for details see section 14).

3. Renovation of showers and laundry washing place, connection to a sewer system in order to avoid mosquito breeding and groundwater pollution.

4. A PVC sewer was built in order to collect the remaining wastewater from the Health Center's flush toilets, showers and laundry washing place.

5. The sewer drains into a wastewater treatment system consisting of a settling tank, a sludge drying bed and a horizontal subsurface constructed wetland for secondary treatment of the settling tank's outflow. When reaching a certain level (ideally every 3 months, realistically once a year), the sludge from the settling tank is stirred and discharged by gravity via a pipe into the drying bed.

6. This treated wastewater is collected in a concrete tank to be reused as irrigation water (see section 7). The water tank is designed to store the maximum daily wastewater flow which was estimated to be 5 m³. Surplus water overflows to a subsurface percolation trench irrigating tree plantations.

**Fig 4:** New UDD toilet block with 4 cubicles for the staff (source: EcoSan Club, 2004)

## 6 Design information

<u>"Compost" pit latrines</u>

The existing pit latrines were not significantly changed, only the vaults were renewed to support some composting to take place by providing emptying openings and a small extension with a metal cover for solar heating of the vault.

The health center management feared a misuse of urine diversion toilets by the patients and thus decided to stick to the traditional latrine system.

The bottom of the latrines has been sealed ex post with cement mortar. Liquids are discharged by a sewer into the constructed wetland and faecal material is emptied manually.


**Fig. 5:** New "compost" pit latrines for patients after reconstruction, side view (source: EcoSan Club, 2004)

**Fig. 6:** New "compost" pit latrines for patients, rear view, showing access openings for the removal of faecal sludge (source: EcoSan Club, 2004)

UDD toilets

The UDD toilet vaults can be emptied from the backside. Each toilet consists of an elevated concrete floor including a sealed plastic squatting pan (produced by Cress tank, Uganda). Ash is added after each defecation in order to absorb the moisture of the faeces and to raise the pH level so as to enhance pathogen destruction. The squatting pan leads faeces (together with anal cleansing material and ash) to a wooden basket located underneath in an above ground dehydration vault. These dehydration vaults are covered by metal sheets in order to benefit from solar heating. The baskets are emptied once a year and brought to an outside drying area for further dehydration. The drying area is situated close to the toilets in order to avoid long transport distances. After further drying the material is used as a soil conditioner.

Urine is infiltrated via a soak pit into the ground because its usage is not intended by the beneficiaries (see section 7). The soak pit is located next to the toilets.

Constructed wetland

For the treatment of the remaining wastewater (some flush toilets and greywater) a horizontal subsurface flow constructed wetland system was built on an area of 45 m² growing indigenous non-fruit plants. Wastewater is pre-treated in a settling tank to remove solids (by sedimentation and flotation) before it flows by gravity to the inlet of the constructed wetland. The faecal sludge from the settling tank is regularly emptied (ideally every 3 months, realistically once a year) and the material is dried together with faecal material from the UDD toilets at the drying area.

The inlet of the constructed wetland comprises coarse aggregate (diameter of 60-80 mm) in order to distribute the wastewater horizontally before it enters the actual treatment part consisting of sand (diameter of 4-8 mm). The bottom of the filter bed has a slope of 1%. At its lower end another area of coarse aggregate including a drain pipe (PVC DN 100) collects the purified wastewater which is piped via an outlet manhole to an underground percolation ditch in the nearby reforestation area (10m of drain pipe DN 100 in a layer of coarse aggregate and covered with excavated material and soil).

**Fig. 7:** Constructed wetland (5m x 9m) before greening in 2004 (source: EcoSan Club)

**Fig. 8:** Constructed wetland in 2006 (source: EcoSan Club)

## 7 Type and level of reuse

The project focused on the improvement of the hygienically poor situation while reuse was rather a minor point due to urgency of the first target.

But within a few months the use of the treated wastewater gained attention and local project partners started the construction of an irrigation system for its use in a reforestation area near the Health Center (different owner).

Urine is infiltrated via a soak pit into the ground. Currently there is no demand for urine as a fertilizer since the Health Center does not own plantations that could use urine as a fertilizer.

Dried faeces from the UDD toilets, so called "compost" from the pit latrines and the settling tank's faecal sludge discharged onto the sludge drying bed are buried in furrows next to the Health Center's own cottage plantation for soil conditioning.

## 8 Further project components

A low cost medical waste incinerator based on a project of the Applied Sciences Faculty of De Montfort University in Leicester was constructed. Burnt residues are disposed in a covered and fenced dumping area, built on request of the project owner.

**Fig. 9:** Medical waste incinerator constructed on the Health Center's compound, 2004 (source: EcoSan Club)

## 9 Costs and economics

A detailed cost breakdown is not available. However, the actual entire costs for construction and consultancy were approx. € 20,000. O&M costs are approx. € 500 per year as salary for one full time operator and some minor spare parts. Those costs are covered by the Health Center's budget.

## 10 Operation and maintenance

The responsible person for O&M is employed by the Health Center. He was trained in two workshops on water supply and sanitation at the Matany Hospital (September 2003, June 2004). He has also implemented parts of the ecological sanitation concept at his own home.

His main O&M activities are:

- Checking of the treatment plant
- Cleaning of the settling tank
- Emptying the UDD toilets
- Maintenance of the "compost" pit latrines
- Checking the sewer for blockages and removal of blockages

An O&M manual was prepared together with the water and sanitation workshop participants in June 2004. Back-stopping for additional questions on-site was provided by the EcoSan Club for 2 years after implementation (i.e. up until 2006).

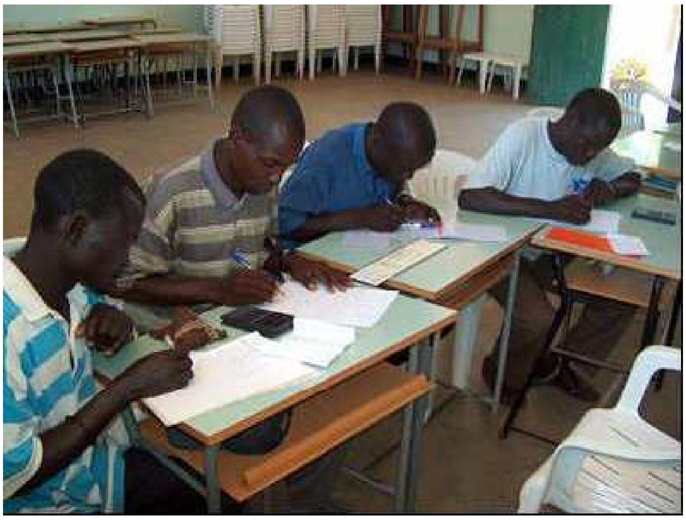

**Fig. 10:** Sanitation workshop at Matany Hospital, Uganda, 2003 (source: EcoSan Club)

## 11 Practical experience and lessons learnt

The hygienic situation of the Health Center has improved a lot and a certain demonstration effect has been achieved. The new system still allows for further improvement and additional options.

In the case of wastewater reuse, it could be noted how a well functioning treatment system created a demand for the "product" (i.e. treated wastewater) just due to its availability and thus contributes to a multiplying effect.

However, the aspects of hygienization and reuse of faeces and urine could not be considered in detail due to financial restrictions and the special setting of this project (majority of temporary users, focus on dealing with health problems rather than agriculture).

Experience has shown that the partly reconstructed pit latrines to so called "compost" pit latrines did not lead to satisfying results. Due to their poor design and subsequently difficult maintenance the "compost" pit latrines never worked properly.

Other problems were the limited capacity of workers to read and understand technical drawings, the lack of knowledge of sanitation concepts and the partly poor workmanship of local construction companies. Thus, a certain extent of constructive adaptations became necessary which delayed the project and increased the costs.

# Improvement of sanitation at Kanawat health center Kanawat, Uganda

## 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 emphasized (weaknesses).

**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[1] | | |
|---|---|---|---|---|---|---|---|---|---|
| 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 | |

[1]) Reuse of the treated wastewater only (urine and faeces are not reused)

**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, 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).

The main long-term impact of the project is the prevention of the spreading of water-borne diseases. A two year monitoring (2004-2006) showed that the toilets are well accepted by both staff and patients, that the treated excreta (dried faeces from UDD toilets) is used in the Health Center's cottage production and the treated material is pathogen poor.

## 13 Available documents and references


- Müllegger E. (2004): Kanawat Health Center – Improvement of Sanitation Infrastructure (project report). http://www.ecosan.at/download/projects/kanawat.pdf
- Information on low cost medical waste incinerator, Applied Sciences Faculty of De Montfort University Leicester: http://www.mw-incinerator.info/en/101_welcome.html


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**Case study of SuSanA projects**
***Improvement of sanitation at Kanawat Health Center***
**SuSanA 2009**
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sustainable sanitation alliance

Case study of sustainable sanitation projects

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

**Fig. 1:** Project location

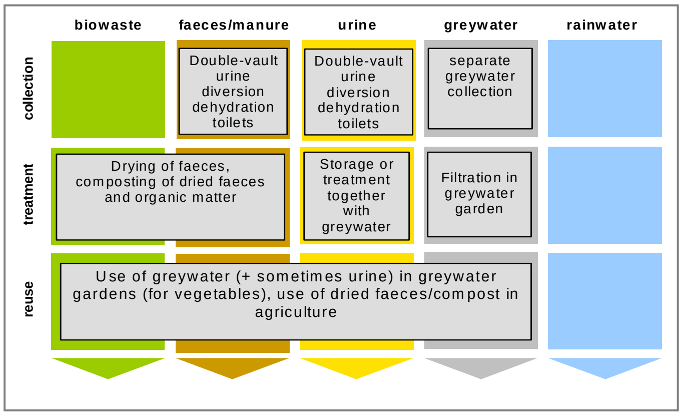


**Fig. 2:** Applied sanitation components in this project

## 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*.

## 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.

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

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 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:**

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

- 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 (cite report):

- **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 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

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

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

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

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

## 14 Institutions, organisations and contact persons

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**Case study of SuSanA projects**

***Peri-urban urine diversion dehydration toilets (abandoned)***

**SuSanA 2009**

**Authors of original version from 2005: Christine Werner, Florian Klingel, Patrick Bracken, Jana Schlick, Tim Freese, Wang Rong (all formerly GTZ ecosan team)**

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**This document is available from:**
**www.susana.org**

## Appendix :

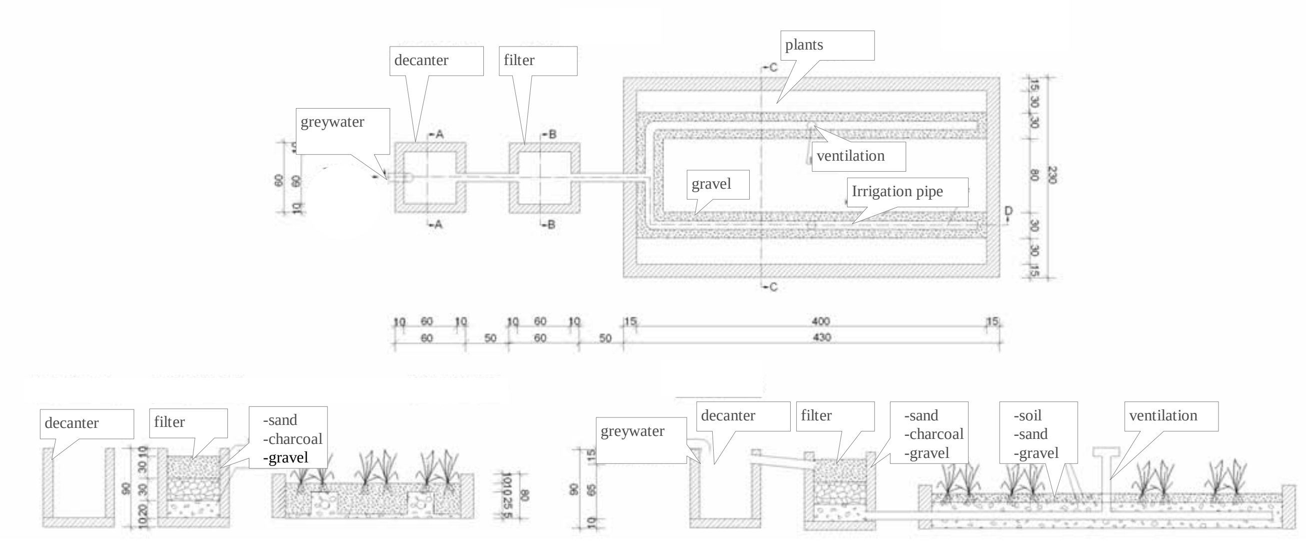


**Fig. 11:** Plan view and cross sections of the greywater garden (source: OtterWasser, 2003)

sustainable sanitation alliance


The SuSanA publishes case studies of sustainable sanitation projects to demonstrate the wide range of possible systems for sustainable sanitation systems. These case studies are useful for decision makers, planners, engineers and the interested public.

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