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

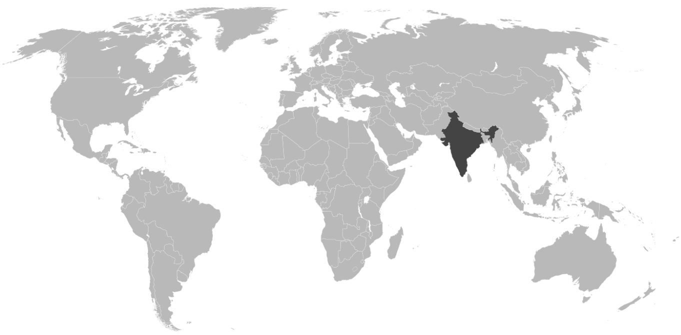

Fig. 1: Project location

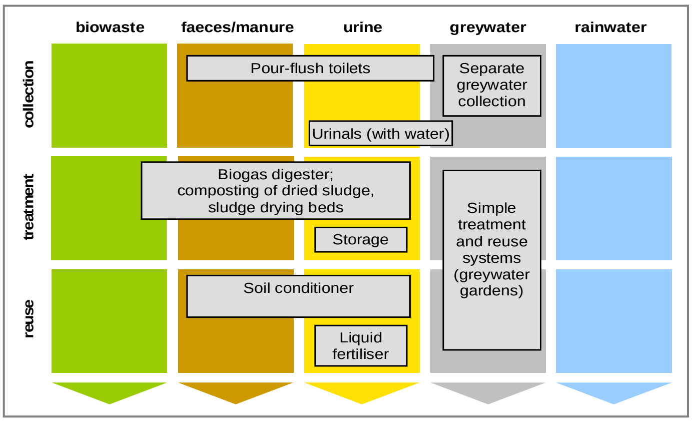

Fig. 2: Applied sanitation components in this project

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 onwards

Project scale:

Vocational training institute with variable number of students (up to approx. 240) and guests attending meetings, workshops; 22 pour-flush toilets and biogas digester

Capital cost :

unknown

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, Sustainable sanitation - ecosan program

Executing institution:

Navsarjan Trust (an Indian NGO)

Supporting agency:

Swiss Agency for Development and Co-operation (SDC) and German Federal Ministry for Economic Cooperation and Development (BMZ) via GTZ

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 with first-hand experiences on sustainable sanitation concepts and further dissemination of knowledge on ecosan in the state of Gujarat.

To help in the improvement of sanitation, specifically in rural areas, 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 vocational training institute "*Dalit Shakti Kendra*" (DSK) was built on an area of 32,000 sq. meters in Nani Devti village near Sanand, about 30 km southwest of Ahmedabad City in the state of Gujarat, west of India in 1999. The institute buildings constitutes of administration, kitchen, a workshop, a hostel and a Community Training Centre. The institute is used by a variable number of students (up to approx. 240) and approx. 20 staff members (some of them living on the campus). Thus the number of people staying on the campus is approx. 260. At times, this number can significantly increase when people attending meetings and/or workshops at DSK are staying overnight.

Fig. 3: Navsarjan Vocational Training Institute "*Dalit Shakti Kendra*" (DSK) in Nani Devti village (source: seecon gmbh, March 2009).

Before this project was implemented, the domestic wastewater (i.e. blackwater from toilets and greywater from the kitchen and bathrooms) from the hostel building, the administration and kitchen building and the workshop building was collected and infiltrated into the ground by a soak-pit located close to the hostel building. A second soak pit close to the administrative building infiltrated wastewater from the Community Training Centre.

The following reasons have led to a malfunction of this system:

- Due to lack of maintenance (sludge removal of the soak-pits), sludge accumulated at the bottom and on the 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 leading to the transmission of diseases).
- During monsoon season a near to surface aquiclude (solid, impermeable area overlying an aquifer) prevents rapid infiltration of rainwater, therefore groundwater level of the first groundwater storey raises to just 1.5 m below ground level.

For these reasons, and to meet the needs of an expansion of the institute (average number of students in 2003/04: approx. 125; present number: up to approx. 240), 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 the state of 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 SDC, a vocational training institute called "Dalit Shakti Kendra" was established in 1999 to provide technical training in various fields to Dalit youth and to link them up with institutions providing financial assistance for self-employment.

The sustainable sanitation project “Dalit Shakti Kendra” is one of the first ecosan pilot projects implemented in the context of the Innovative Ecological Sanitation Network India (IESNI). This network was established through a joint initiative of GTZ and local as well as international partners in April 2004 and aims to promote innovative ecological sanitation approaches in India.

[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).

The planning process for the new sanitation concept started in July 2004 and construction commenced in February 2005. The new sanitation system was inaugurated in August 2006.

5 Technologies applied

The new sanitation concept includes the following components:

Water supply

The entire water used at the campus is groundwater from lower depth(approx. 200 m). The water is pumped into a surface storage tank and then pumped to an overhead storage tank.

Due to its high salinity, water used for cooking and drinking is treated in a reverse osmosis plant. The brine (approx. 3,000 litres/d) resulting from the production of approx. 1,000 litres of drinking water per day is collected on the roof of the kitchen building and used as flushing water for the pour-flush toilets. Water spent for non-portable purposes such as showering, etc. is not pre-treated but used directly.

Pour flush toilets and biogas plant

A new and conveniently located (75m from Community Training Centre and less than 75m from the Hostel) common sanitation complex was built for the approx. 250 people staying on the campus on an average. The sanitation complex consists of 22 toilet cabins (11 for females and 11 for males) arranged in a circular shape around a biogas plant located in the center (Fig. 4).

Fig. 4: New sanitation complex with 22 pour-flush toilets and biogas plant built in 2006 (source: seecon gmbh, October 2009).

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. 5) and are supplied by the Indian company Shital Ceramics.

Fig. 5: Pour-flush squatting pan ("rural pan") and water seal ("P-trap") (supplier: Shital Ceramics, India).

Compared to conventional flush toilets, these toilets reduce water consumption and keep the blackwater relatively concentrated. The brine from the reverse osmosis plant for production of drinking water is used to flush the toilets.

The decision for a biogas plant was made in order to treat the blackwater (mixture of urine, faeces, anal cleansing water 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 sludge drying beds.

Urinal centre

The former common toilet centre has been converted into a urinal centre (Fig. 6). Two independent enclosures provide urinals for ladies (Fig. 7) and gents (9 and 13, respectively). The urine is collected in 4 tanks (Fig. 6) and pumped to storage/hygienisation tanks when full. This is done to make the urine available by gravity while being transported to the fields with jerry cans or container carts.

The urinals are waterless urinals and require to be flushed 2-3 times in a day only.

Fig. 6: View of urinal centre, the 4 urine collection tanks (in the foreground) and the storage/hygienisation tanks (atop roof) (source: seecon gmbh, January 2008).

There are separate urinals for women (Fig. 7). The urine is drained through the drain channel at the edge of the room and collected in the tanks.

Fig. 7: View of ladies squatting urinals (source: seecon gmbh, August 2006) supplier Shital

UDDTs for night-time use

Three single vaulted urine diversion dehydration toilets (UDDTs) have been constructed (2 near the hostel and 1 behind the Community Training Centre). This was done by students from the Massachusetts Institute of Technology (MIT) in 2007 to serve students and staff members as "emergency toilets" during the night.

Greywater from dishwashing and kitchen area

A new stall for dishwashing (Fig. 8) was built. It was planned to lead the dishwashing stall effluent via a vertical flow organic filter (filter material: rice husk) to a storage tank.

Fig. 8: View of new stand for washing dishes (source: seecon gmbh, March 2007).

As construction of the filter tank was not done according to the plans, the design had to be adapted during implementation and changed the direction of flow of the effluent (vertical flow as per design changed to horizontal flow filter).
In the beginning several trials were done using straw as a filter material in the horizontal flow filter, but the straw was permanently flooded. The straw started degrading and lost its filtration effect.
Soon it was realized that a behavioral change may help in overcoming the nuisance with the filter. A new procedure for washing dishes was implemented (see Fig. 8 and Fig. 9):

1. Wipe plates using wood ash (removes biowaste, grease and oil) (Fig.10); spent ash is collected and cocomposted
2. Rinse plate to remove the ash (1st and 2nd washbasin)
3. Clean plate with soapy water (3rd washbasin) and
4. Rinse plate (4th and 5th washbasin)

This has proved to better as biowaste does not clog the filters.

Fig. 9: Newly designed instruction board on “How To Wash Plates” (fixed above the dishwashing stall) (source: seecon gmbh, October 2009).

Fig. 10: 1st step of cleaning plates: removing grease/oil by wiping out plates/utensils with wood ash (source: seecon gmbh, October 2009).

Fig. 11: View of new stand for washing utensils at outdoor kitchen area (source: seecon gmbh, March 2009)

In addition to the dishwashing stall a stall for washing kitchen utensils (Fig. 11) was built. The effluent from this stall was (after being treated in a vertical flow organic filter to retain solid matter)was directly applied in irrigation of nearby bushes and trees.. However, after a few months a short sewer was laid and the water is drained to the tank that also receives the effluent from the dishwashing stall. Biowaste from the kitchen utensils is cleaned with ash before washing them and the spent ash is cocomposted (Fig.11). The water is then supplied for irrigation by a solar panel operated pump

Greywater from showers

2 new shower blocks comprising shower facilities (total number: 40), washbasins and laundry facilities (Fig. 13) have been constructed behind the hostel building (Fig. 12) and next to the Community Training Centre to serve people staying at the campus.

Fig. 12: View of showers installed at the hostel building, the footpath in front of the showers is used for washing clothes (source: seecon gmbh, August 2006).

Fig. 13: Students washing clothes in front of the showers (source: Navsarjan, August 2006).

Greywater collected from the showers and laundry area at the hostel is discharged to elevated greywater gardens (Fig. 15) for infiltration. They are elevated to prevent flooding by surface water during monsoon season. Any surplus of water that does not infiltrate into the soil is collected in a tank and is reused for irrigation purposes during dry periods.

Fig. 14: Elevated gardens for the infiltration of greywater (source: seecon gmbh, December 2006)

Greywater from the shower block at the Community Training Centre is discharged to nearby bushes/trees.

Sludge drying beds

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

Organic solid waste management
Kitchen waste is disposed off 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
Due to ongoing construction works (extension of the workshop building) exact figures on user specific domestic water consumption cannot be provided at present.
Biogas plant
Based upon the following design parameters the volume of a floating-drum type biodigester (Fig. 16) with a water jacket was estimated to be about 30 m^3:

- approx. 300 users per day
- specific blackwater production of per flush per person is approx. 2.5 litres (i.e. faeces, urine and approx. 2 litres of anal cleansing and flush water). However the observed value is 4.5 litres.
- up to 75 kg of buffalo dung per day
- 30 days retention time

Fig. 15: View of floating drum-type biogas plant (with water jacket) for treatment of blackwater (source: seecon gmbh, October 2009).

Because of the high groundwater table during monsoon season the local engineer proposed construction of the biogas plant to be done in reinforced cement concrete instead of brickwork. To prevent buoyancy of the biogas plant, the thickness of the base has been increased to 45 cm and the base protrudes the outer diameter of the cylindrically shaped digester body by 50 cm. At an inner diameter of 2.75 m and a clear height of 4.55 meters (approx. 25 cm less than shown in the technical drawings) the net digester volume is approx. 27 m^3.

Organic filter for treatment of greywater from dishwashing
Surface area of the vertical flow organic filter was set at 1 m^2. Filter assembly design included (from top to bottom):

- 20 cm freeboard
- 50 cm organic matter (e.g. rice husk, coconut fibres, etc.)
- 5 cm sand (intermediate layer) and
- 15 cm graded gravel (drainage layer)

Construction of the filter, which should have been raised above ground level, was supposed to be done just besides the washstands to gain most benefit from difference in heights available. But, fearing that foul odour may be emitted from the filter, construction of the same took place below ground at some distance. By fixing the outlet pipe of the filter at the same height as the inlet pipe the filter was converted into a horizontal flow filter. To avoid short circuit flow, a baffle was constructed to divert incoming water downwards. But, as the filter tank was designed for vertical flow only it didn't even provide sufficient retention time for sedimentation. Providing no treatment whatsoever, it is now strived for reducing organic pollution of the water as far as possible by asking user to clean their plates with wood ash (from cooking fires) before actually washing the plates.

Elevated greywater gardens at the hostel
The design (surface area) of the greywater gardens was only done according to space available, no specific hydraulic surface load had been taken into consideration, as any surplus of water that isn't taken up will be collected.
The surface area of the elevated greywater gardens for infiltration of greywater from bathrooms at the hostel building is about 20 m^2 (length: 6m; width: 3.50 m) and approx. 40 m^2 (length: 10m; width: 4m), respectively.

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. The cost of LPG being around 10USD the total cost savings is 8 to 12%.

Fig. 16: One out of many small gardens used for growing vegetables (e.g. spinach, brinjals, etc.) and fruits at DSK campus(e.g. bananas) (source: seecon gmbh, January 2009).

- The **digested slurry** from the biogas plant is used as a soil conditioner, e.g. for growing seedlings.
- **Urine**, which is collected (with some water) from the urinal centre, is applied after storage as a nitrogen-rich liquid organic fertilizer at the campus to grow vegetables (e.g. brinjals, etc.) and fruit trees (e.g. banana, etc.) (Fig. 17).
- **Greywater** from dishwashing is used after rudimentary treatment to irrigate nearby bushes/trees.

8 Further project components

The duration of vocational training course has been reduced (from max. 3 months) to 52 days. Due to the higher fluctuation in people using the sanitation facilities at DSK, increased efforts had to be undertaken in awareness raising and training on how to properly use the different facilities especially for cleaning the plates and kitchen utensils so as to reduce the organic loads in the grey water.

9 Costs and economics

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.

Detailed information on costs is unavailable.

10 Operation and maintenance

Operation and maintenance is a major issue in the success of any sustainable sanitation project. Therefore trained institute staff does operation and maintenance. Two gardeners and one “ecosan person” are responsible for the maintenance of the grounds.
Different approaches for student involvement have been tried out so far (e.g. groups of approx. 10 students share one toilet and the responsibility for its maintenance).

Operation and maintenance tasks at the toilet complex with biogas plant

- Supervision of the biogas plant
- Regular painting of the floating drum to avoid corrosion.
- Manual transport of the slurry to a tank located 15 m away from the biogas plant.
- Regular cleaning of the toilets

Operation and maintenance tasks at the urinal block

- Flushing and cleaning the urinals 2 to 3 times a day
- Pumping the urine to the overhead urine tanks once a day
- Carrying the urine with jerry cans or container carts to the fields

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.

Biogas plant and sludge drying beds:
The design water consumption of 2 litres for flushing of excreta to the biogas plant proved insufficient. At present about 4 - 5 litres are used for cleansing and flushing after defecation. With up to 250 people staying at the campus (at present), the volume of the floating-drum type biodigester (i.e. approx. 27 m^3) has become insufficient for proper treatment of blackwater. Therefore upgrading of the existing digester (adding an anaerobic baffled reactor (ABR) to the system) or construction of an additional toilet centre with treatment facility is under discussion right now.

The existing sludge drying beds, which had been constructed by digging shallow basins, are exposed to heavy rains in monsoon and in consequence to flooding in this period. In order to reduce the moistening of the compost, raising of the sludge drying beds above ground level is being discussed.

Treatment of greywater from dishwashing
Using wood ash for removing oil and crease from plates and dishes works well, but the present concept depends on good will of all users.

UDDTs for night-time use
The overall design of the UDDTs (implemented as Single Chamber Urine-Diversion Dehydration Toilets) and the shallow cleansing water collection bowl (see Fig. 18), which resulted in spilling of the anal washwater into the faeces hole (the anal washwater section on the left of the pan was found to be too small). Also as the anal washing was located just behind the feaces hole, it was visually discomforting for the users during anal cleansing. This reasons led to closing-down of the toilets.
It is therefore preferable to separate the anal cleansing from the pan.

Fig. 17: Urine-diversion squatting pan that allows separate collection of urine, faeces and anal washwater (source: seecon gmbh, 2006)supplier – Aries.

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.

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)
2. The learning effect for students to see wastewater as a resource
3. 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.

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).

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

14 Institutions, organisations and contact persons

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Suppliers of UDDT squatting pans:

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Case study of SuSanA projects

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

SuSanA 2009

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