Lessons Learnt from Running an Eco-Sanitation Toilet Centre in Rajendra Nagar, Bangalore

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ABSTRACT

Bangalore based NGO ACTS (an acronym for Agriculture, Crafts, Trades and Studies) established an eco-friendly public toilet centre in Rajendra Nagar Slum and a processing and reuse site for source separated faecal matter and urine at the ACTS Rayasandra Campus in 2001. This was the time when the majority of households in the huge slum with inhabitants of different castes, religion and race, did not have their own toilets and had access to only one functioning community toilet. Lack of sanitary facility did not only bring inconvience but also hygienic and social problems to the community, in particular the women. Women and children faced sexual harassment while defecating in the open field before dawn or after dusk. The toilet centre promised to bring about considerable improvement in such conditions.

Although the ACTS ecosan toilet centre was successfully in operation for 5 years, serving about 500 to 600 users per day, the originally designed logistics system has often been discussed controversially. Hence a socially and culturally more acceptable, sustainable and hygienic safe collection, transportation and processing scheme was developed and implemented with support of seecon gmbh and GTZ (German Agenceny for Technical Co-operation) in 2005.

The demonstration phase of the ACTS sanitation project in Rajendra Nagar expired on January 8th 2006 (as also the lease agreement with the local Government) and the experiences gained during this 5 year period are now being studied and implemented for up-scaling the ACTS sanitation project in Bangalore and its surroundings, focusing and aiming on providing socially and culturally acceptable, hygienic safe and sustainable sanitation facilities to the unserved.

IMPLEMENTATION AND UPGRADING OF AN ECO-FRIENDLY PUBLIC TOILET CENTRE IN RAJENDRA NAGER, BANGALORE

Before 2001 the majority of households in Rajendra Nagar Slum, a huge slum with inhabitants of different caste, religion and race, did not have their own toilets and residents had access to only one functioning communal toilet. As the lack of toilets is only one indication of the appalling living conditions for many thousands of slum dwellers, particularly women, the establishment of a public toilet centre was considered to be a matter of very great urgency. Sexual harassment and rape had been an associated problem as women so far had been forced to defecate in the open field before dawn or after dusk. [1]

Implementation of an eco-friendly sanitation project in Rajendra Nagar

In 2001 the local NGO ACTS (an acronym for Agriculture, Crafts, Trades and Studies) established an eco-friendly public toilet centre in Rajendra Nagar, Bangalore, and a processing site for source-separated flowstreams (urine and faeces) at the ACTS Rayasandra
Campus for Higher Education with technical support by seecon gmbh.

The objectives of establishing an eco-friendly sanitation project in Rajendra Nagar had been manifold: [2]

- Improving living conditions in the slum, minimizing the risk of disease spreading during monsoon flood periods and increasing women's security;
- Recycling of nutrients and organics due to the collection, treatment and reuse of urine and faeces for the production of fertilizer and compost, respectively;
- Generation of income for the development of the slum by charging for the use of the toilet, selling of fertilizer and bananas produced;
- Finally changing attitudes of people and encouraging them to consider human urine and faeces as a valuable resource

The eco-friendly public toilet centre was designed in such a way that squatting slabs were raised about 1.5 meter above ground level and drilled with 3 holes for the separate collection of faeces, urine and water used for primary washing hands (see Figure 1).
Collection of urine and faeces (including anal cleansing water) was done in barrels that were stored in compartments below the squatting slabs. Once a day the barrels were picked up and conveyed to the ACTS Rayasandra Campus, which is situated about 12 km from Rajendra Nagar. Faecal matter was co-composted with waste paper and biodegradable waste and urine was applied as nitrogen-rich liquid fertilizer to banana plantations after storage.

Water used for primary washing hands was drained to an infiltration bed in front of the toilet block and any surplus of water that didn't trickle away was collected in a subsurface collection tank that was emptied when full.

Figure 1. ACTS Public Toilet Centre in Rajendra Nagar (left) and squatting slab providing 3 holes for source-separate collection of water used for primary washing hands, urine and faeces (right)

Upgrading of the eco-friendly sanitation project in Rajendra Nagar

Although the ACTS eco-friendly demonstration toilet centre was successfully in operation for many years, the originally designed logistics and processing concept was often discussed to constitute not only a cultural, but also a hygienic problem. Hence a socially and culturally more acceptable, sustainable and hygienically safe collection, transportation and processing scheme was developed and implemented with support by GTZ (German Agenceny for Technical Co-operation) and seecon gmbh in 2005.
The objectives of grading-up the collection, transportation and processing scheme have been:

- Improving working conditions in regard to hygiene by draining any surplus of wash-water, that doesn't infiltrate into the soil, to a nearby sewer;
- Improving the collection and logistics scheme in such a way that shifting of urine and faecal matter drums is abandoned;
- Hygienically safe treatment of faecal matter in a biogas plant and recovery of valuable energy in form of biogas;
- Using the biogas as a substitute to LPG (Liquefied Petroleum Gas) in cooking at Rayasandra Campus.

With the improved pump and haul system, holding tanks replaced the barrels for the separate collection of urine and faecal matter. Transportation was done with the existing truck, which was equipped with a vacuum suction unit for evacuation of faecal material and a self-priming pumping system for emptying of urine tanks (Figure 2).

(source: ACTS)

(source: ACTS)

Figure 2. Upgrading of the ACTS eco-friendly sanitation project (clockwise from top left: evacuation of faecal matter with newly installed vacuum system; emptying of urine collection tanks; reuse of urine as nitrogen-rich liquid fertilizer on banana plantations; biogas plant for the hygienically safe treatment of faecal matter; sludge drying beds for advanced treatment of digested slurry; use of biogas in cooking)

The composting trenches at the ACTS Rayasandra Campus were dismantled and Suma Khadi Gramodyoga Sangha, a local NGO, did the designing and construction of a new biogas plant for the hygienically safe treatment and recovery of valuable energy in form of biogas. Subsequent treatment of the digested slurry was done in sludge drying beds and the biogas was used as a substitute to LPG in cooking (Figure 2).
Any surplus of wash-water that wasn't taken up by the planted infiltration bed was drained to a nearby municipal sewer.

LESSONS LEARNT FROM THE DEMONSTRATION PHASE

After 5 yeas of successfully running an eco-friendly sanitation project in Rajendra Nagar, Bangalore, the following stories of success and lessons learnt can be presented:

- Planning an eco-friendly sanitation project is not a green-desk-job but needs *stakeholder involvement.* Awareness raising programs, capacity building and regularly follow-ups are to be considered crucial for the successful implementation and operation of such a project.
- Special attention has to be given to *social and cultural factors*. Thus special focus had been given to awareness raising and capacity building of women, as they would play an important role in the overall process. To enable a breakthrough local women got alongside the planning team.
- The initial stages when people had to be guided with *visual demonstrations on how to use the toilet properly* were quite hilarious as well as frustrating.
- We soon overcame resistance. But over the five years there was *growing acceptance* and then although two more public toilets were built close to this toilet, people continued using the eco-friendly toilet.
- Although dealing with the poor we took care *to provide proper electricity, sufficient water and kept it very clean* by washing the floor regularly, which was appreciated by the people. We learned that those must not be sacrificed especially as we are talking about ecosan.
- *Upgrading our facilities was a constant desire*. We saw the importance of *listening to the needs of the users*, as well as the comments of visitors. Gradually we saw the difference tiled walls and floors would make and this was provided.
- One of our struggles was manual handling of the drums with urine and faeces. We heard *complaints from outsiders and responded*. We designed our mechanized system. But even this did not give us a 100% solution. This time it was the bad odour emitted as soon as the system was turned on.
- Treatment of faeces started with basic composting but could not avoid some actual contact with faeces as workers operated. Although obtaining high-grade manure and finding this very useful in various situations, we looked at other options and considered biogas production. *The mechanised system serves the collection and discharge very well and biogas production has been commendable*. We are now looking at upgrading this mechanised facility for optimal usage both for collection as well as discharge into the biogas system. Minimising of odour is a priority.
- The eco-toilet started because of the *request of women* and we gradually learned what a boon it was for them. Most of our toilet-users comprised of women,

especially the younger groups. We learned that this was because of the privacy and absolute safety they lacked in other facilities.

- We are now seeing that *sufficient numbers of toilets as well as urinals* need to be provided as especially women seem embarrassed to stand in queues.
- One practical concern has always been both the *quality as well as the quantity of water* we provided. We are now looking into this matter.
- *The right personnel make the big difference*. We did not experience any theft of drums, buckets or damage to any systems within the toilet because the two wardens who were taking care of the toilet performed their duties very sincerely and were always available at the toilet premises. They needed to be motivated (not through money) but just through good interpersonal interaction.
- The slogan *"ecosan - an approach to human dignity, community health and food security"* is clearly implemented by the project: The project shows a positive impact on the dignity and health of the toilet users and the urine and the faeces are successfully used to produce high quality food (bananas) and biogas.
- *"Closing the loop"* in terms of nutrients-cycles between urban areas (consumer areas) and rural areas (production areas) is feasible and opens new economical options.
- A strong local *organizational embedding and a good long-term management* of the ecosan-technology are key prerequisites for a successful and sustainable project operation. Wherefore a strong local project partner and manager are crucial for the project.
- *Communication* plays an important role to prevent misunderstandings and political problems. Involvement of "critical voices" helps to develop the projects efficiently. Public or individual concerns have to be considered as deciding inputs for project planning, improvement, adjustment, etc.
- The project development has to consider and synthesise relevant *political, institutional and technical issues* into an integrated system and communication design.
- Even generating income and workplaces the project depends on external financial support. This problem could be solved developing new contracting systems *involving and obligating the local authorities* (public-private-partnership approach).
- *Long-term experiences and international embedded research are very important:* After 5 years of project operation, communication the project reached a national and international recognition.
- *Failures* are unavoidable and have to be considered essential elements of the learning process.

COST-REVENUES ANALYSIS OF UPSCALING

In connection with the phasing-out of the demonstration project in Rajendra Nagar and the intended upscaling of the eco-friendly sanitation project a cost-revenues analysis based upon experiences gained during the last five years of successfully running an eco-friendly public toilet centre in a slum area and assumptions in regard to capital costs, operation & maintenance requirements, travel costs, the fertilizer equivalent of human

excreta, the nutritional requirements of banana plants and the income generation by collection of user fees and selling of bananas was conducted.
The findings of this analysis, which are summarized in Table 1 and presented in detail below, indicate that running a large scale eco-friendly sanitation project, which is relying on a pump and haul service system for collection and transportation of source-separated flowstreams, can be economically viable under certain conditions (e.g. optimizing frequency of service runs, collection of user fees, reuse of biogas as a substitute to LPG, reuse of recyclates in agricultural production and selling of produce, ...).

	without interest [INR]	with interest [INR]
capital costs:		
5 toilet centres	2,250,000 – 3,000,000	3,150,000 – 4,500,000
treatment facilities (biogas plants, large capacity urine storage tanks)	1,300,000	2,800,000 – 3,180,000
2 trucks equipped with vacuum suction units	3,000,000	5,400,000 – 6,000,000
Total	**6,570,000 – 7,320,000**	**11,350,000 – 13,680,000**
recurring costs:		
operation of vehicle (fuel, insurance,taxes, maintenance, …)	315,000 – 500,000	315,000 – 500,000
wages (caretakers, drivers, aids to drivers, plantation manager, …)	440,000	440,000
O&M of toilet block	50,000 – 80,000	50,000 – 80,000
land lease and banana suckers	170,000	170,000
Total	**975,000 – 1,190,000**	**975,000 – 1,190,000**
income:		
user fees	360,000 – 730,000	360,000 – 730,000
savings due to use of biogas as a substitute to LPG in cooking	515,000 – 620,000	515,000 – 620,000
selling of banana	940,000 – 1,600,000	940,000 – 1,600,000
savings due to use of humanure instead of chemical fertilizers and selling of compost	170,000 – 770,000	170,000 – 770,000
Total	**1,980,000 – 3,690,000**	**1,980,000 – 3,690,000**

Table 1. Estimated capital costs, recurring costs and revenues for an upscaled sanitation project

Capital costs

Estimated capital costs for construction of 5 numbers of 12-seated public toilet centres comprising two independent enclosures for ladies and gents that provide lavatories, urinals and washbasins are Rs. 2,250,000 to Rs. 3,000,000 (without interest, but including costs for a small bore well for water supply). Construction of biogas plants (3 plants having a digester volume of 60 m3 each) for the hygienically safe treatment of source-separated faecal matter is estimated to be ca. Rs. 1,000,000. Provision of large capacity tanks for storage of urine before its application as liquid fertilizer to agricultural land is estimated to cost Rs. 300,000. Costs for 2 trucks that have to be equipped with vacuum suction units (one for hauling of urine and faecal matter each) are estimated to be Rs. 3,000,000.

Recurring costs

Considering a round-trip distance of ca. 40 to 50 km per day, operation (fuel, insurances, maintenance, road taxes …) of 2 suction trucks will be about Rs. 315,000 to Rs. 500,000 per year. Wages (10 caretakers @ Rs. 2,000/person,month; 1 driver @ Rs. 4,000/month; 1 aid to the driver @ Rs. 2,000/month; 1 plantation manager @ Rs. 4,000/month; 1 aid to the plantation manager @ Rs. 2,000/month; administration charges) will arise to about Rs. 440,000 per year. Annual operation and maintenance costs (electricity bills, expenses on cleaning utensils and soap for washing of hands, …) of the toilet centres are calculated to be Rs. 50,000 to Rs. 80,000. Annual costs for renting of 5 hectares of agricultural land in the surroundings of Bangalore and for acquisition of banana suckers are Rs. 170,000.

Income

Annual revenues of the toilet centres are estimated to be Rs. 360,000 if half the number of users of toilets makes payments @ Rs 1/use (use of urinals shall be for free). At present costs of Rs. 425 per cylinder of LPG (@ 14,2 kg), savings due to use of biogas as a substitute to LPG in cooking are calculated to be ca. Rs. 460,000 to Rs. 620,000 per year. Based upon an average yield of 25 t/ha [13] to 35 t/ha [7] (@ 3,000 plants/ha) and a market price of Rs. 750 to 900 [8] per Quintal (=100kg) of Bananas (Robusta Variety) the average income per year is estimated to be Rs. 940,000 to ca. Rs. 1,600,000. Annual savings due to the use of humanure (urine and compost) instead of chemical fertilizers and selling of compost will arise to Rs. 170,000 to Rs. 770,000.

TRANSFERABILITY OF WASTEWATER MANAGEMENT SYSTEM

A wastewater management system that facilitates source-separate collection, treatment and reuse of greywater (wastewater from all non-toilet plumbing fixtures), blackwater (toilet wastewater) and yellow water (urine) may not only be installed in new buildings but also in existing infrastructures such as residential buildings, housing societies or colonies as domestic wastewater discharge in Indian houses is usually separated in blackwater and greywater at the source, as most houses are having separate outlet pipes for those flowstreams.

Collection, treatment and reuse of blackwater

With a holding tank and haul system individual septic tanks that once were designed for partial treatment of the combined wastewater flow before discharging it into storm water drains or infiltrating it into the soil may be converted into a holding tank (vault) that receives blackwater and stores it until it is pumped out and hauled to a processing and reuse site (Figure 3). Although similar to septic tanks, vaults have no outlet piping and must be watertight. [5]

(source: [11])

Figure 3. Pumping put of holding tank (left) and close-up of quick coupling for easy emptying of holding tank (right)

If conversion of individual septic tanks to blackwater holding tanks is not feasible (access to tank may be difficult or the tank may be of poor quality) construction of new communal holding tanks may be a suitable solution. [8]

Each holding tank should be equipped with an audible and visible high-water alarm, which alters the resident to the need for pumping and a standpipe and a quick coupling (Figure 3) to which the pumping truck can be directly connected for efficient (minimal spillage) emptying. Release of objectionable odours during tank pumping may cause some discomfort to residents. [5]

As pump and haul collection can became prohibitively expensive when homes are occupied all the time or where the distance from the treatment plant to the home is more than a few miles [5], installation of low-flush urine-separation toilets should be taken into consideration to reduce daily amount of blackwater production and frequency of holding tank emptying.

Holding tanks should be used only where a proper management program is in place and regular services are guaranteed. [5] If not so, then going for a vacuum sewerage system may be an alternative. Using conventional in-house installations, the wastewater from a single house or a number of houses is drained by gravity flow to collection chambers that are connected to a vacuum station for evacuation. When a pre-determined volume of wastewater is collected a pneumatic vacuum valve is opened automatically and the wastewater is evacuated into the vacuum sewer pipe. [6]

(source: Roediger GmbH)

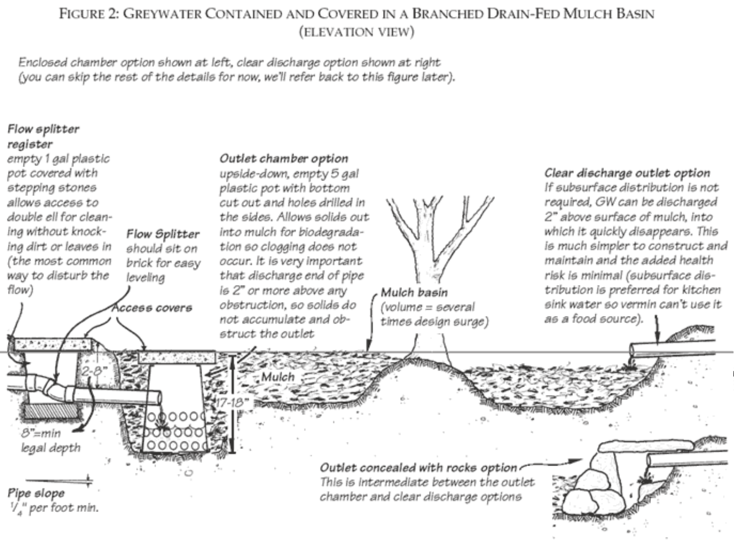
Figure 4. Collection chamber (left) and vacuum station for evacuation (right)

With both systems ("holding tank and haul system" or "vacuum sewerage system") processing of blackwater may be done in a biogas plant for its hygienically safe treatment and recovery of valuable energy in form of biogas.

Collection, treatment and reuse of greywater

Depending upon site conditions, especially in regard to space available, greywater management may be done on-site or off-site in a semi-decentralized multi-stage treatment facility.

Simple greywater management systems that allow direct utilisation of the water, facilitate breakdown of organic compounds and recover nutrients are depicted in Figure 5. If site conditions (e.g.: space available for direct reuse greywater, soil conditions, …) are favourable, the easiest way to apply greywater for subsurface irrigation purposes is to drain it (without any pre-treatment) to swales or trenches, which are filled with mulch material. Distribution and application may be done either sub-mulch or above the surface. Sub-mulch application means that the greywater outlet points are below the surface of the mulch material. If subsurface distribution is not required, greywater can be discharged 2" above the surface of mulch into which it quickly disappears. The latter is much simpler to construct and maintain. [9] The greywater management system shall be designed in such a way that perimeter bunds keep additional surface run-off water from entering the valves or trenches.



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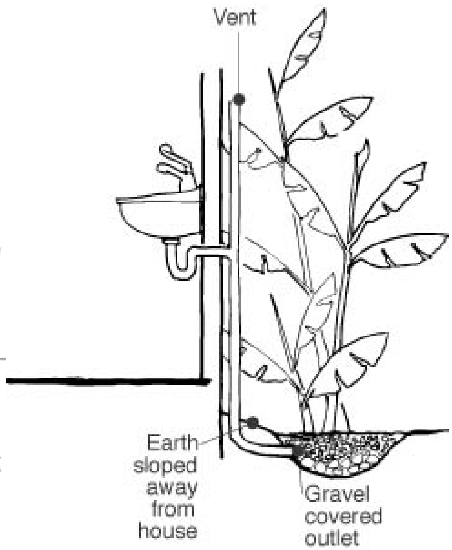

(source: [10])

Figure 5. Examples of simple greywater reuse systems

If, for whatsoever reason, on-site management of greywater is not possible, treatment may be done in a semi-decentralized treatment facility that may comprise a settler for retaining floatable and settleable solids and advanced treatment in a constructed wetland system for the reuse of treated greywater for surface irrigation purposes.

Collection, treatment and reuse of yellow water

Urine from urine-separation toilets and urinals is diverted either to individual collection tanks that are situated outside the houses or to a communal tank that receives urine from a larger number of houses. The accumulated urine is collected by suction trucks for agricultural use or used as raw material for industrial fertilizer nitrogen production. [4]

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