ECOLOGICAL SANITATION PROJECTS FROM AROUND THE WORLD AND THEIR LINKS WITH THE SOLID WASTE SECTOR

S. Rüd and E. v. Münch

Contact: Sören Rüd, Deutsche Gesellschaft für Technische Zusammenarbeit (gtz) GmbH, ecosan Programme, Postfach 5180, 65726 Eschborn, Germany
Tel.: 0049-61 96-79-4219
email: soeren.rued@gtz.de

EXECUTIVE SUMMARY

The paradigm of ecological sanitation (ecosan) regards human excreta and water from households not as a waste but as a resource that should be made available for use. Ecosan does not favour a specific sanitation technology, but is rather a new philosophy in handling substances that have so far been seen simply as wastewater and solid waste for disposal. Ecosan approaches are also ideally suited to contribute to achieving the Millennium Development Goals on sanitation because they are highly flexible and can be implemented at lower cost than centralised disposal-oriented systems.

The solid waste sector already achieved such a paradigm shift, at least in countries such as Germany where this approach is well institutionalised: Over the last decades, solid waste has been seen more and more as a valuable resource for product recycling and product design has been improved to allow for reuse. Hence the “community of ecosan implementers” has much to learn from the solid waste sector.

The overlap between ecological sanitation and solid waste management includes issues in the areas of collection (e.g. separation at the source), transport (particularly in an urban contest, e.g. road-based transport for barrels of urine rather than pipe-based transport), treatment (e.g. composting or biogas systems for treatment of the mixture of blackwater (excreta and flush water) with kitchen waste or manure) and reuse (marketing of compost or digester residue).

In the last decade many successful ecosan programmes have been put into practice in Asia, Africa and Latin America mainly in rural but also in urban areas. A variety of solutions exists that can be recommended for large-scale implementation in accordance with local physical, cultural and socio-economic conditions. This paper explores the common issues that exist in the ecosan field and in the solid waste sector, with regards to collection, transport, treatment and reuse. It describes ecosan pilot and up-scaling projects from the Philippines, India, Germany and Africa, which show in one way or another these common elements (e.g. using composting or anaerobic digestion; road-based transport of urine; marketing of the recycled product to users). Ecosan technologies briefly described in this paper include urine-diversion dehydration (UDD) toilets, composting, biogas systems for brownwater (faeces with flush water) and urine diversion flush toilets for separate collection of urine.

In order to establish ecosan as the commonly agreed design approach for sanitation systems much work remains to be done. A stronger link to solid waste management will help to mainstream ecosan and to improve sustainability of ecological sanitation projects.

1 INTRODUCTION

1.1 The approach of ecological sanitation

Conventional approaches to excreta management generally fall under the category of either waterborne ("flush and forget") or pit-based systems ("drop and store"). In both cases the system design is based on the premise that excreta are a waste, and that waste should be disposed. Experience in developing countries and countries in transition has shown that the long-term sustainability of such purely disposal-oriented systems is often questionable, as is their appropriateness to achieve the Millennium Development Goal for sanitation.

The solid waste sector achieved a rethink, at least in some countries such as Germany: Over the last decades, solid waste has been seen more and more as a valuable resource for product recycling and product design has been improved to allow for reuse. A similar new paradigm now exists for the sanitation / wastewater sector: Ecological sanitation (ecosan) regards human excreta and water from households not as a waste but as a resource that should be made available for use (Werner, 2004). Ecological sanitation strives for an ecologically and economically sustainable resource-oriented wastewater management system tailored to the needs of the users and to the respective local conditions.

Sustainable sanitation has an even broader definition and includes all sanitation systems that are economically viable, socially acceptable, technically and institutionally appropriate and protect the environment and resource base (SuSanA, 2008).

The implementation of an ecosan project requires an interdisciplinary approach which addresses issues such as transport logistics, agricultural use, sociological aspects of acceptance and cultural appropriateness, health and hygiene, town planning, economic and small-enterprise promotion, institutional administration, and so on. In the last ten years ecosan has come a long way from a niche to a mainstream phenomenon. Incorporating knowledge and expertise from the solid waste sector will be beneficial for the process of further "mainstreaming" ecosan.

1.2 Ecosan technologies and ecosan challenges

For cost effective and reliable treatment and recycling options, two principles are very often applied in ecosan systems:

- Firstly, flow streams with different characteristics, such as urine, faeces and greywater, are often (but not always) collected separately. This allows the application of specific treatment processes and optimises reuse.
- Secondly, unnecessary dilution of the flow streams (particularly from toilets) is avoided, for example by using dry or low flush toilets or vacuum piped transport systems. This minimises the consumption of valuable drinking water and opens up other transport options besides conventional sewers.

However, whilst often making treatment easier and less expensive, the separate collection and treatment of the flow streams is not a prerequisite in ecosan systems, and a wide variety of system configurations is possible. An overview of the different available methods for collecting, treating and reusing the different flow streams (solid biowaste, animal manure, faeces, urine, greywater and rainwater) is shown in Figure 1.

As ecological sanitation does not prescribe a particular technical solution, but rather tailors sanitation systems to fit the needs of social, economic and environmental sustainability in a given context, a wide range of technologies can be used. These range from simple low-tech systems to sophisticated high-tech solutions. On the low-tech side, the use of simple dehydration toilets (either with or without urine separation) or composting toilets is common. For such systems, faeces and urine are most often collected and treated on site, with the recycled material being used locally. High-tech components of ecosan systems include vacuum sewers and semi-central biogas plants with heat and electricity generation.

The recovery and agricultural use of the organic matter and nutrients contained in excreta and wastewater improves soil structure and fertility, increasing agricultural productivity and thus contributes to food security – A fact that is very important in the current times of rising fertiliser prices. The recovery of energy through the anaerobic digestion of faeces, organic waste and animal manure provides biogas for cooking, lighting, heating or electricity generation.

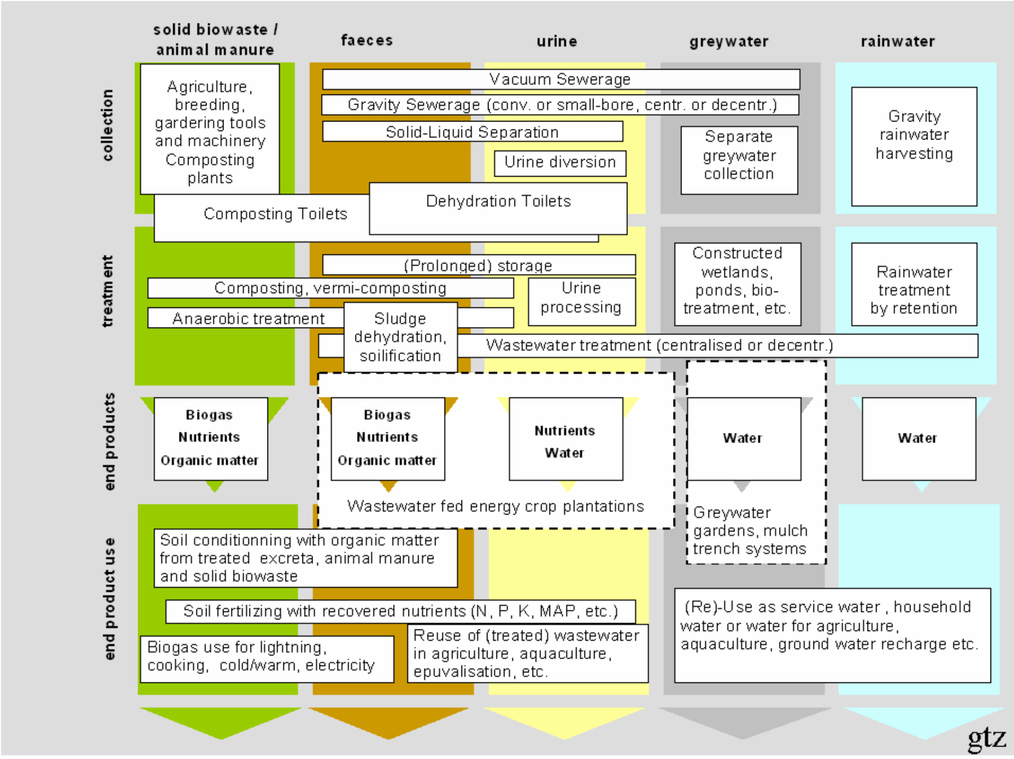

FIGURE 1 **Examples of possible ecosan collection, treatment and reuse elements (note the overlapping technology options for solid organic waste and faeces). Source: www.gtz.de/ecosan**

There are several main challenges which need to be overcome before ecological sanitation systems will be widely adopted not only in rural but also in peri-urban and urban settings:

- General awareness (amongst decision-makers) of the possibilities and options of an ecosan approach has to be increased
- Capacity development at all levels is required
- Reuse needs to be integrated into urban and sanitation planning processes from the very beginning
- Existing cultural constraints towards the usage of treated excreta and wastewater need to be dealt with
- New financing instruments supporting private businesses and households investment are required.

1.3 Links between ecosan and solid waste sector

The term “sanitation” encompasses four broad categories:

1. excreta management
2. greywater management
3. solid waste management
4. stormwater drainage

The term ecological sanitation is often understood to mainly focus on the first two categories on this list, but it also includes a part of the solid waste category – namely the organic fraction of the solid waste, and rainwater harvesting from category 4 (some experts use the term “environmental sanitation” to include all of categories 1-3).

The overlap between ecological sanitation and solid waste management includes issues in the areas of collection, transport, treatment and reuse (the transport steps in the sanitation system are indicated in Figure 2):

Collection:

Many households are nowadays separating their solid waste at source or it is done later by “waste scavengers” or by solid waste workers, e.g. paper, glass, green waste, plastics. Similarly in the ecosan approach one can (in case of urine-diversion systems) segregate at source by keeping urine separate from faeces and water (as is the case for UDD toilets). As shown in Figure 1, greywater may also be kept separately from urine and faeces, and so on.

Transport:

If the chosen toilet for excreta management is not a flush toilets, then the transport problem of the excreta essentially becomes a solid waste problem (i.e. road-based), rather than pipe-based. For example, transport of urine and/or faeces can take place in barrels/containers on a truck from the point of collection / on-site treatment to the point of (secondary) treatment and reuse. The transport of urine barrels can be a major cost factor in such a scheme (see for example von Münch and Mayumbelo (2007)), depending on the travel distances required. A detailed overview of the logistical challenges when transporting urine and faeces by road was provided by Slob (2005).

Treatment:

Since faeces is also an organic solid waste matter, the same processes which are used in the solid waste sector for biological treatment of organic solid waste can also be used for excreta, namely composting (or co-composting) or anaerobic treatment (also called digestion or co-fermentation) of faeces and organic waste from kitchens, gardens, farms. It is interesting to note that in Germany, the legislation does not allow to treat excreta or sewage sludge in biogas plants together with green biowaste from households for fear of contamination with pathogens.

Reuse:

Compost that is produced from organic solid waste and garden waste is quite accepted by most farmers and gardeners who are generally willing to pay for it. The same is not true when excreta were also used as an input material in the composting process. Such acceptance problems in marketing of compost need to be overcome. Similarly, digester residue from biogas plants can be used as fertiliser on farmland, and marketing issues to the farmers need to be taken into consideration here.

Hence, the "ecosan community" has a lot to learn and again from the solid waste sector, where there is already extensive experience in terms of waste segregation, transport logistics, process technology for green biowaste (composting, anaerobic digestion) and marketing of the treated product and public acceptance for reuse. One major difference is that untreated faeces contain pathogens, whereas household kitchen waste does not

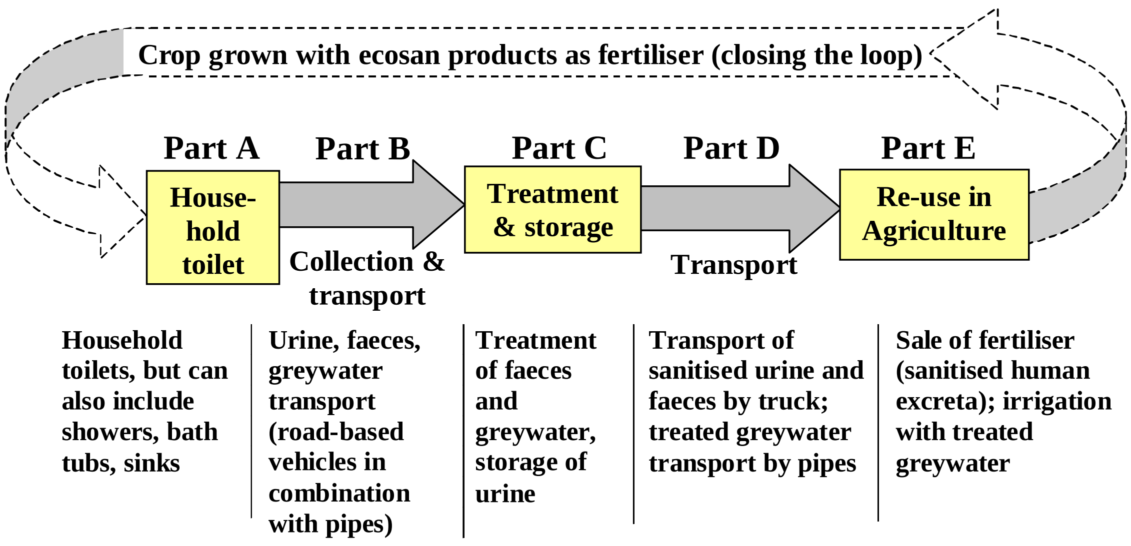

FIGURE 2 **Transport steps (Part B and Part D) as part of the overall sanitation system (von Münch and Mayumbelo, 2007)**

3 EXAMPLE ECOSAN PROJECTS FROM AROUND THE WORLD

Some example ecosan projects which were commissioned in the last few years are briefly explained below. In each case, the linkage with the solid waste sector is described as well.

3.1 The Peri-urban Vegetable Project (PUVeP) in Cagayan d'Oro City, Philippines

The first allotment garden of the Philippines was established in Cagayan de Oro in 2003, as part of a European Union funded project (Holmer et al., 2003). With the assistance of the German Embassy in Manila and several private donors from Germany, this number has now grown to eight self-sustaining gardens located in different urban areas of the city. Each allotment garden has a minimum of eight families as members and currently the eight allotment gardens have almost 70 urban poor families as allotment gardeners who benefited for the legal access to land for food production. This project of Xavier University College of Agriculture in Cagayan de Oro has positive outcomes for farmers and their families securing food security by higher productivity in urban agriculture.

Allotment gardening in Cagayan de Oro has a unique framework compared to other urban and peri-urban gardening systems due to the integration of one particular ecosan technology which is the urine-diverting dehydrating (UDD) toilet inside the garden (see Figure 3). The toilet was the latest technology introduced by the project implementing organization, the Peri-urban Vegetable Project. This type of technology packaged within the allotment gardening is a pioneering venture in the Philippines. The presence of one UDD toilet in each of the eight allotment gardens is also attractive to urban poor farmers because the human excreta collected from the toilet can be integrated as raw material for their compost. The concept of using human excreta as soil conditioner in their garden is highly accepted by the allotment gardeners because instead of buying expensive animal manure (chicken dung) which they used to do before the integration of UDD toilets in the gardens, they can now use human manure as a good organic fertiliser.

FIGURE 3 Double vault urine-diversion dehydration (UDD) toilet in one of the allotment gardens in Cagayan d'Oro. Left: outside view of toilet; right: inside view of toilet, with anal washing area at the front left (source: R. Holmer and http://puvep.xu.edu.ph/ecosan_toilet.htm)

A double vault system is used in the UDD toilet for the separate collection of faeces and urine. Lime is a good covering material for faeces and it is recommended to the allotment gardeners. Ash is used in case no lime is available. The urine is collected in a 200L container and is replaced with an empty container when it is full.

Urine, after six months of storage, is usually added to compost heaps of biodegradable and organic materials. It adds nitrogen to the compost and accelerates the decomposition process. The compost heaps consist of dried leaves, dry grass and other garden wastes as well as household wastes including fruit peels, vegetable peels, coffee grinds, tea bags, egg shells, etc. but bones, meat and fish remains are not included in the compost heaps as they would attract vermin.

Urine is also used as a side-dress fertilizer (second fertilizer application) after diluting it with water before soil application. Faeces stay in the first chamber for twelve months to kill the pathogens while the other chamber is being used. The treated faeces are used as a soil conditioner. They can improve the soil texture and increase the cation exchange capacity (CEC) of the soil. The CEC gives an indication of the soil's potential to hold plant nutrients (the more organic matter the soil has the higher is the CEC).

The existing allotment gardens in Cagayan d'Oro do not only contribute positively to the food security of urban poor but also augmented the awareness of the gardeners for sustainable solid waste management. All allotment gardeners in Cagayan de Oro are informed about the solid waste act (Republic Act 9003) during trainings and seminars conducted by PUVeP. 44% of gardeners learned how to segregate waste in their home and around 25% segregate their waste in the garden because of their intention of using their organic wastes as compost materials for their garden (Miso, 2007).

This project is a best practice example for the incorporation of solid waste management into ecosan as organic solid waste and urine are composted together and the compost is used in urban gardening.

3.2 UDD toilets at primary schools in Gujarat, India

In 2005, the Navsarjan Trust, a NGO based in Ahmedabad which was founded in 1989 to help eliminate discrimination based on caste, established three primary schools in Rayka village (Ahmedabad district), Katariya village (Surendranagar district) and Sami village (Patan district) all of them located in rural areas of Gujarat (India). Each school has a capacity of 210 pupils.

Similar sanitation blocks have been designed for all three schools to provide toilets, showers, washing and laundry facilities to pupils and staff, while allowing the recovery of urine, faeces and water for productive purposes. The toilet block comprises eight single-vault UDD squatting toilets and four waterless urinals for the male pupils and staff members (see Figure 4). The toilets are operated in batches to facilitate the harvest of the dried faeces: Only four toilets are in use at the same time and receive daily deposits until the dehydration chamber below the UD squatting slab is full. The toilet cabins of the closed toilets are then used as showers.

FIGURE 4 UDD toilets at the sanitation facility of the primary school at Rayka village (source: ESF). Left: Faeces dehydration chambers with vent pipes; right: inside view of the toilet: 3-hole UD squatting pan with lowest hole on the photo for anal washing.

The urine from the UDD toilets and waterless urinals is collected in a container and reused as fertiliser. The anal cleansing water from the toilets is infiltrated into a subsurface irrigation of ornamental flowers. Greywater is treated by a vertical flow filter and reused for irrigating the kitchen garden. The alternative use of the cabins as toilet or shower helps to reduce their space requirement and therefore construction costs (GTZ, 2006b).

In contrast to pit latrines no hole has to be dug avoiding on the one hand groundwater pollution from pit leachate and on the other hand making the system more resistant against flooding. Furthermore, food security of the users is improved by providing a natural fertilizer and soil conditioner which can be used in local agriculture (Manjula, 2008).

The new bathrooms, greywater treatment system and school gardens were inaugurated on 10 August 2006. Constant capacity development activities have helped to change the mindsets and prejudices of the staff and the children. Today, the children are very familiar with the ecosan system and act as "ecosan ambassadors": The students from the school won the first prize for the ecosan toilet model showing the collection, treatment and reuse components of the sanitation system at the Ahmedabad school science fair. Initially, the school teachers advised the children to use the UDD toilets without using them themselves as they had pre-conceived notions about the toilets being smelly and unhygienic (as the faeces are not flushed away). The children have subsequently been instrumental in changing the prejudices of their school teachers.

3.3 Ecosan sanitation facilities at a school and college in Badlapur, India

The "Adarsh Vidya Mandir School" is located in Badlapur town, in Maharashtra's Thane district, about 68 kilometres from Mumbai. The school accommodates about 11,000 students attending Primary School, Secondary School and Junior College or the "Adarsh Vidyaprasarak Sanstha's College of Arts & Commerce". The city of Badlapur does not have a sewer system. So far, the school therefore depends on conventional on-site sanitation, consisting mainly of septic tanks followed by soil infiltration.

After several capacity building workshops organised by the Indian Water Works Association in cooperation with GTZ, the Swiss company seecon GmbH and other partners, the city of Badlapur and the Adarsh College have taken the decision to refurbish the sanitation system of the college following an ecosan approach (Wafler and Heeb, 2006).

In August 2007 construction began for a sanitation block for Adarsh College with a total number of about 2600 students. Additionally, the sanitation blocks will be used by visitors of the open area at the centre of the school which is rented out for approximately 20 days per year for special programmes attended by up to 800 people.

The construction comprises a sanitation block with five pour flush toilets (using small buckets for flushing excreta) and 15 waterless urinals for men, 15 pour flush toilets for women and hand washing facilities. The urine from the urinals is collected in two storage tanks and reused as fertiliser. The blackwater from toilets and greywater from handwashing and cleaning purposes are mixed and drained to biogas settlers where the wastewater is subjected to anaerobic decomposition (see Figure 5). The effluent is then drained to anaerobic baffle reactors for further anaerobic treatment. The effluent from the biogas-reactor is then subjected to a horizontal-flow constructed wetland treatment step, and the final effluent is drained into a polishing pond where the water can be stored and reused for landscaping. The biogas produced will be used to showcase the ecosan concept in the nearby ecosan exhibition hall for running gas stoves and gas lamps, while the treated wastewater will help to beautify the green areas around the buildings. The construction of the project is almost complete (July '08), and the sanitation facilities are planned to be inaugurated in September 2008.

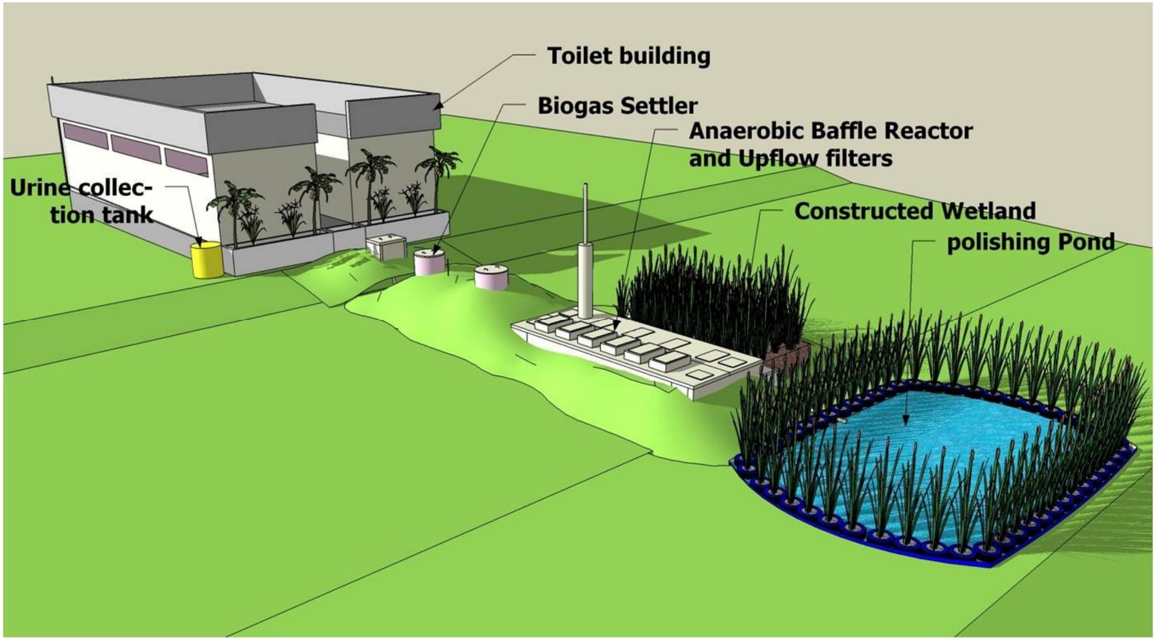

FIGURE 5 Ecosan system for blackwater treatment from pour flush toilets at Adarsh college in Badlapur, India (source: seecon GmbH)

This project is an example of a project where an anaerobic treatment process is used to treat blackwater (mixture of urine, faeces and water).

3.4 Urine diversion at GTZ headquarters main office building in Germany

When it became clear that the GTZ main office building in Eschborn (Germany) had to be renovated, the GTZ ecosan team promoted the implementation of an ecosan demonstration and research project as part of the renovation. The building's renovation work began in 2004 and was finished in 2006.

As part of the project, 56 urine separation flush toilets (model: Roediger NoMix) and 25 waterless urinals (model: Keramag Centaurus) were installed. In addition, four urine tanks with a total capacity of 10 m^3 were built in the cellar of the building. The system started operation in July 2006. Some difficulties during planning and implementation of the innovative concept had to be overcome. For example, the tank overflow had to be shifted as the supplier did not deliver pressure-tested tanks, and the rubber tube odour traps of the waterless urinals had to be changed due to odour problems (GTZ, 2006a).

After these adaptations, the system is fully functional since mid 2007. As German fertiliser law does not yet recognise urine as a fertiliser, the use of urine for laboratory or field research is currently the only option of reusing this urine in Germany. To date, the University of Aachen and the University of Applied Sciences in Giessen have collected urine from these tanks for their research projects. The tanks can be emptied and transported by vacuum trucks, or urine can be evacuated by vacuum trucks, siphoned into storage containers and then transported with conventional trucks to reduce transport costs.

Funding for further research and the implementation of a treatment and reuse system for brownwater has not yet been approved. This project can be used to demonstrate the issue of transporting urine by road (in an urban context).

3.5 Large-scale biogas projects in Africa

Many countries in Sub-Saharan Africa are “off track” for meeting the MDG targets for sanitation (Rockström et al., 2005). Ecosan knowledge transfer from Asia to Africa would be useful to improve the progress: In some densely-populated Asian countries (notably China, India and Nepal), certain supporting factors have led to advances in ecosan implementation. These supporting factors are:

- Higher cultural acceptance for reuse of excreta than e.g. in Arabic or Latin American countries
- High demand for sustainable sanitation systems
- Economic growth

One of the attempts of knowledge transfer is the African initiative “Biogas for better life” launched by the Dutch development cooperation (DGIS and SNV) with support of several international organisations such as the German development cooperation (BMZ, GTZ, KfW), the AfDB (African Development Bank), the UEMOA (Union Economique et Monétaire de l'Ouest Africain), the NGO Practical Action and others. The innovation within this initiative is its market-oriented approach: It will focus on countries and regions in Africa with the best market opportunities. So far, a first batch of more than 20 African countries was set up to start the initiative. In these countries, contacts with local partners were identified and desktop studies are being carried out. Feasibility studies were also started or completed in 13 countries (SNV, 2007). GTZ, in cooperation with SNV and DGIS, conducted 2 feasibility studies (from 50 expected) in Burkina Faso and Tanzania. The main outcome of the feasibility studies is to develop a National Domestic Biogas Programme for each country offering a real potential. The biogas systems under consideration in this project have animal manure as an input, but the option of connecting human waste to the biogas systems is included as well.

With a project budget of 2 billion €, the programme aims at selling two million domestic biogas installations to households. Of this total amount, micro credit, loans and cash contributions are expected to account for 1.2 billion €. A grant provided by donors would supply the remaining 800 million € and will be used to subsidise purchasing costs, promotion, training, quality control, promotion and management. Sustainability should be proven by the objective of having 95% of these installations still in daily operation within ten years. The project is based on experience in Asia, e.g. in China where more than 10 million household biogas plants have already been built and the Nepalese biogas programme supported by SNV (The Netherlands) and KfW (Germany) which is constructing 20,000 biogas systems each year (SNV, 2007). Most of these biogas plants are used to treat animal manure only, but an increasing fraction of households have also connected their toilets to the system.

This project shows how animal waste, human excreta and possibly organic solid waste can be treated together with anaerobic treatment processes in biogas plants for the production of renewable energy and fertilizer.

3.6 Large-scale urine-diversion projects in Africa

After being faced with the problem of emptying pit latrines in very hilly terrain, the eThekwini Municipality in Durban, South Africa, decided to supply its rural and peri-urban population with UDD toilets to replace existing pit latrines. Since 1996 the eThekwini Water and Sanitation Unit has constructed nearly 60,000 UDD toilets and aims at a total number of 140,000 units. According to a recent study, households with a UDD toilet have a 30% reduction in diarrhoeal diseases compared with similar households using pit latrines (Koenig, 2008).

In Burkina Faso, a large ecosan project, mainly funded by the European Commission (74%) within the 6th Framework of its Water Facility, and by CREPA (14%) and GTZ (12%) is being carried out in the peri-urban area of Ouagadougou. With a budget of 1.5 million €, the aim of this 3-year project, which started in June 2006, is to build 1,000 UDD toilets, to (indirectly) reach 300,000 people with the benefits of the ecosan systems, to build capacity of 100 masons and 1,000 small-scale farmers in using ecosan by-products (dried faeces, urine, compost), and to create jobs by supporting 20 small and medium enterprises. About 320 UDD toilets have already been installed in Ouagadougou by July 2007 (ECOSAN-EU 2008).

The project in Burkina Faso is an example of a project with a strong focus on marketing products derived from UDD toilets to small-scale farmers.

4 CONCLUSIONS

In recent years many successful ecosan projects have been implemented in Asia, Africa and Latin America mainly in rural but also in urban areas. A variety of technical options exists that can be recommended for large-scale use in accordance with local physical, cultural and socio-economic conditions. In this paper we have summarised the common elements that exist in the ecosan field and in the solid waste sector, with regards to collection, transport, treatment and reuse of excreta, wastewater or organic solid waste. The given ecosan best practice examples from the Philippines, India, Germany and Africa presented in this paper show in one way or another these common elements (e.g. using composting or anaerobic digestion; road-based transport of urine; marketing of the recycled product to farmers). Ecosan technologies for excreta management briefly described in this paper include urine-diversion dehydration (UDD) toilets, composting, biogas reactors for blackwater treatment or for animal manure and UD flush toilets for separate collection of urine.

It is clear that for non-water based transport systems (e.g. where excreta are collected in UDD toilets) and for the transport of the sanitized end products to the reuse site, the solid waste sector should be involved actively to allow the transfer of knowledge regarding logistics, treatment and reuse issues.

5 ACKNOWLEDGEMENTS

The valuable contributions of the following colleagues from the GTZ ecosan team in Eschborn were highly appreciated: Abdoulaye Fall, Rahul Ingle, Analiza Miso.

References

GTZ (2006a) *Project Datasheet 016 – Urine and brownwater reuse at the main office building of GTZ GmbH, Eschborn, Germany*. Deutsche Gesellschaft für technische Zusammenarbeit (GTZ) GmbH. http://www.gtz.de/de/dokumente/en-ecosan-pds-016-germany-gtz-eschborn-2005.pdf

GTZ (2006b) *Project Datasheet 022 – Urine-Diversion Dehydration Toilet Centres at Navsarjan Boarding Schools, Gujarat, India.* Deutsche Gesellschaft für technische Zusammenarbeit (GTZ) GmbH. http://www.gtz.de/de/dokumente/en-ecosan-pds-022-india-navsarjan-schools-2007.pdf

ECOSAN-EU (2008) Hebdo ECOSAN-EU (project newsletter – in French). http://www.reseaucrepa.org/page/1363

Holmer, R.J., Clavejo, M.T., Dongus, S., and Drescher, A. (2003) *Allotment Gardens for Philippine Cities*. In: Urban Agriculture Magazine, 11, 29-31. http://puvep.xu.edu.ph/publications.htm.

Koenig, R. (2008) *Durban's poor get water services long denied*. In: Science 8, February 2008; pp. 744-745.

Manjula, P. (2008) *Ecosan technologies promoting human rights, Navsarjan's experience*. Navsarjan Trust. Commission of Sustainable Development Review Session (CSD-16), May 14th. New York. http://www.un.org/esa/sustdev/csd/csd16/sideevents/presentations/14may_pradeep.pdf

Miso, A. (2007) *Assessment of the Socio-economic Impact and Environmental Implication of Allotment Gardens in Cagayan de Oro City, Philippine.* MSc Thesis, Hohenheim University, Stuttgart, Germany. Digitally available at: http://puvep.xu.edu.ph/publications.htm.

Rockström, J., Nilsson, G., Falkenmark, M., Lannerstad, M., Rosemarin, A., Caldwell, I., Arvidson, A. and Nordström, M. (2005) *Sustainable Pathways to attain the Millennium Development Goals: Assessing the Key Role of Water, Energy and Sanitation.* Stockholm Environment Institute. Stockholm, Sweden http://www.sei.se/SustMDG31Auglowres.pdf

Slob, M. (2005) Logistic aspects of ecological sanitation in urban areas. Case study in low-income community in Delhi, India. MSc Thesis, University of Twente, The Netherlands and WASTE, Gouda, http://www.waste.nl

SNV (2007) – Biogas for better life, an African initiative: Business Plan 2006-2020. Netherlands Development Cooperation. http://www.biogasafrica.org/Documents/Biogas-for-Better-Life-Business-Plan-2006-2020.pdf

SuSanA (2008) *SuSanA Vision Statement towards more sustainable sanitation solutions.* Sustainable Sanitation Alliance. http://www.susana.org/

von Münch, E., and Mayumbelo, K. M. K. (2007) Methodology to compare costs of sanitation options for low-income peri-urban areas in Lusaka, Zambia. *Water SA*, **33**(5), p. 593-602, http://www.wrc.org.za.

Wafler, M. and Heeb, J. (2006) *Report on Case Studies of ecosan Pilot Projects in India.* Consultancy report for GTZ-ecosan. http://www2.gtz.de/Dokumente/oe44/ecosan/nl/en-ecosan-case-studies-draft-report-iesn-2006.pdf

Werner, C. (2004) *Reasons for and principles of ecological sanitation*. In: Werner et al. (eds). Ecosan – closing the loop. Proceedings of the 2nd international symposium on ecological sanitation, 7th-11th April, Lübeck, Germany, 23–31. http://www.gtz.de/de/dokumente/en-ecosan-symposium-luebeck-opening-session-2004.pdf