

# Overview of world-wide ecological sanitation concepts and strategies

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**Abstract** This paper aims to describe some of the many different approaches and strategies adopted in different contexts around the world to implement ecological sanitation. It is based on the experiences gathered in the course of the GTZ ecosan sector project as well as on experiences gathered by some of our partners, and presents projects that are being, or soon will be, implemented in both developing and industrialized nations – including Botswana, China, Cuba, Germany, India and Lesotho.

**Keywords** ecological sanitation, water, millennium development goals, introduction strategies, demonstration projects

## Introduction

In order to reach the UN Millennium Development Goals and Johannesburg Plan of Implementation to halve the number of people without access to adequate sanitation by 2015, new holistic concepts are needed, focusing on economically feasible, closed-loop ecological sanitation systems rather than on expensive end-of-pipe technologies. Such ecological sanitation systems advance a new philosophy of dealing with what to date has been considered as merely waste and wastewater. They are based on the systematic implementation of the recycling and use of nutrients, organics and water as a hygienically safe, closed-loop, holistic alternative to conventional solutions. Ecosan systems enable the recovery of nutrients from human faeces and urine for the benefit of agriculture, thus helping to preserve soil fertility, assure food security for future generations, minimize water pollution and recover bioenergy. They ensure that water is used economically and is safely recycled to the greatest possible extent for purposes such as irrigation or groundwater recharge, and that other resources are used efficiently, whilst providing sanitary systems that are hygienically safe, economically affordable and culturally acceptable. World-wide over the last few years increasing numbers of pilot and demonstration eco-sanitation projects have been implemented. These have contributed to the further development of a variety of ecosan technologies and operating and reuse options and have provided a large amount of experience with this approach.

In rural and sparsely populated urban areas, a wide variety of proven ecosan technologies and management solutions now exist, ranging from low to high-tech. These have already been adopted for large scale implementation as standard sanitary systems in some countries, in accordance with local physical, cultural and socio-economic conditions.

Further ecosan pilot-projects should be carried out in order to develop a variety of technological, organizational and economically viable solutions for densely populated urban areas and to obtain results concerning the costs and performances of different systems in both industrialized and developing nations. The conversion of existing conventional systems

towards ecosan should, wherever possible, be immediately started, adopting if necessary a step-wise approach.

One of the main focuses of the GTZ's ecosan sectoral project is the design and implementation of ecological demonstration projects, with particular attention being given to urban areas. The potential benefits of these projects are not only limited to developing and emerging countries, and accordingly the GTZ has also chosen to promote ecosan at home, as the examples presented below will show.

### **Project examples**

#### **Botswana – ecological sanitation as an element of sustainable natural resources management**

In many African countries, including Botswana, conventional forms of wastewater disposal have drawbacks for the general population. Most households located outside the major urban centres are not connected to any existing waste management and sanitation system. Droughts and inadequate water resources make an already unsatisfactory situation even worse.

Until 2006, a project supported by the GTZ-ecosan project and devoted to sustainable regional resource management will be co-operating with local authorities, the International Union for the Conservation of Nature (IUCN) and the German Development Service (DED) to develop, test and demonstrate sustainable, decentralized wastewater management and sanitation systems and methods. Initial results of this project indicate that it has to date been extremely successful.

The project began working with 20 households in the villages of Paje (Central District) and East and West Hanahai (Ghanzi district), focusing on ecological sanitation systems with the use of treated urine and dry faecal matter as fertiliser and soil conditioner in gardening and agriculture. Families chose a source separating dry sanitation system, where urine is diverted into a container for collection, and faecal matter is collected separately in a bucket, or sealed chamber (thus protecting groundwater resources). The use of treated excreta as fertiliser and soil conditioner was combined with the composting of organic waste, rainwater harvesting, grey-water use, gardening and the domestication of veld products, and contributes to improving rural livelihoods in a sustainable manner, as well as providing improved sanitation at a lower cost than the traditional pit latrines.

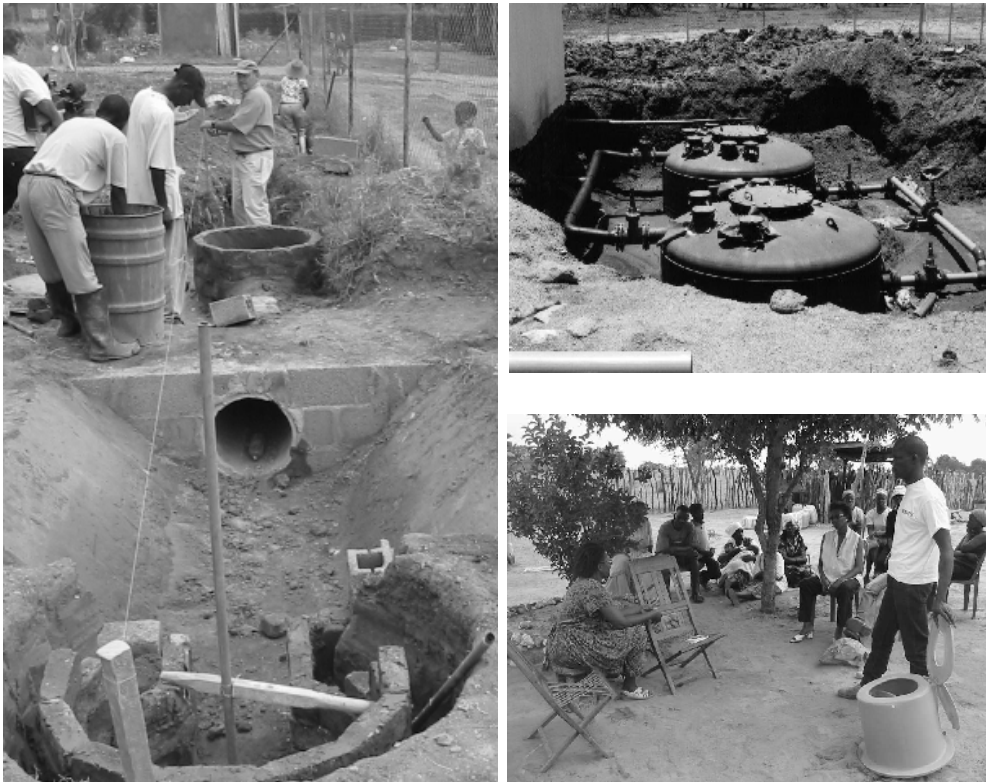
The results have not gone unnoticed in the villages, with around 50 households now directly involved with the project and a further number voluntarily adopting different aspects for their own use. Even production of the urine diversion pedestals is now occurring at a local level.

On a national level, where government policy demands both the protection of groundwater and a prudent and rational utilisation of natural resources, this holistic approach to integrated sanitary provision is also being investigated for large scale implementation. In more densely populated urban areas of Botswana water borne sewage systems are still being installed. However, in the town of Shoshong vacuum systems are being used for the first time in Africa. The project is financed directly by the government with the possibility of the recovery of high-quality products from the wastewater being investigated. Costs for this vacuum sewerage disposal system are estimated at around 75% of the costs of installing a gravity sewer.

Besides cultural taboos initially causing slow acceptance in rural areas the main difficulties faced when introducing ecological sanitation have been in ensuring the financial contribution of households (requested under the self-help approach) and the initial uncertainty of using the end products from the toilet. The lessons learnt show that respecting

the individual needs of the households by adapting processes and systems to suit them can help overcome such difficulties, as can sharing information and learning by seeing with regard to the correct use of the toilet and the application of the products for gardening. Training of households and technicians and a locally based support programme have also contributed to the ongoing success of the project. It has been found that people, once adequately informed, are open to new technologies and recognise the value of the reuse of collected and treated urine and faeces. Households voluntarily accepted to invest in the construction of the superstructure of the toilets and thus moved from a highly subsidised to a self-help system.

On the national level there is now an appreciation by government that adopting ecological sanitation systems can sustainably protect water resources, contribute to agricultural productivity and poverty alleviation, and provide sanitary solutions for both rural and urban areas at a lower cost than conventional systems. The approach is now being promoted on a national level. Appropriate systems for urban areas are being investigated and pilot ecological sanitation systems will shortly come into service in Botswana's capital city Gaborone.



**Figure 1** Above: Lesotho, construction of a biogas septic tank system in Lesotho, right above: Botswana, a community workshop with ecological sanitation being discussed; right below: Botswana, storage tanks of a vacuum sewer system in Shoshong

### **Water-based ecological sanitation in Lesotho**

Lesotho is selling drinking water to South Africa, but in their capital Maseru, high quality drinking water is scarce. Groundwater and surface water pollution within city was measured with pit latrines and septic tank overflows identified as the contaminating source. The rocky underground is impermeable. At the same time, the large urban housing plots could be used more efficiently for gardening and urban agriculture, a need in a land where the arable areas are under pressure. The central sewage treatment system is under loaded, as only a small part of Maseru city is connected and even half these connections do not reach the treatment plant, as the pumping station has not worked for several years, resulting in untreated wastewater being discharged into the border river.

Supported by the GTZ-ecosan project and the German Embassy, the German Development Service (DED) has been carrying out some training and demonstration measures for household-centred, community-based, on-plot reuse of all wastewater and nutrients, driven by a market oriented sanitation approach.

The first system installed consisted of a small bore sewer grid for eight houses (40 persons), a biogas-septic tank unit, an up flow filter based on recycled plastic bottles, a wetland, 800m<sup>2</sup> vegetable and a fruit garden. Two household connections for the biogas to be used as a cooking energy source were installed and have now been in service for more than two years. In addition to this the entire neighbourhood's organic waste is composted in the garden area. The demonstration has shown, that year round gardening is possible, with higher yields and a better quality than when using only rainwater dependent agriculture and much cheaper than the use of piped fresh water for irrigation which then requires the use of additional fertiliser. Driven by a continually increasing private demand and investment, similar systems for individual households and neighbourhoods (3-10 houses) have been installed, with more planned. The sites are also being used for training of private constructors and engineers, from Lesotho and beyond.

Other measures planned include the separation of the grey water and black water streams in order to optimise the system design, reducing the size of the biogas septic-tank unit, and the introduction of urine diversion. However, this last step will only be taken, when the gardening and urban agricultural demand is established and the liquid fertiliser demand is stabilised.

### **India – Co-composting of excreta and waste paper in Bangalore**

In Bangalore, a project aiming to improve the conditions of slum dwellers and Dalits and to stop the pollution of both soil and water, has been in place since 2001. The collaboration between seecon GmbH in Wolhusen, Switzerland, and ACTS ministries in Bangalore, India, has as its objective to develop the implantation of toilets and sanitary arrangements in slum areas and to transform the attitudes of the population dwelling in them.

The ideas behind this project are manifold: to improve the living conditions in the slums and to reduce the risk of spreading diseases by establishing public toilet; to develop and facilitate the commercial production of compost and fertiliser by separately collecting urine and faeces; to generate an income for the development of the slum by selling fertiliser and charging for the use of the toilet; to give slum-dwellers self-responsibility by instructing them how to operate the toilet themselves; and finally to change the attitudes of people and encouraging them to consider human faeces as a valuable resource.

Daily, more than 800 visitors currently use the urine diversion installation in the Rajendra Nagar settlement. The material from the toilet is collected and co-composted with waste paper before being used on the campus of the Rayasandra campus of the Academy for Higher Education ACTS .

Available now is a diploma thesis prepared within the framework of this project by Alexandra Baumeyer and titled "New Toilets for Indian Slums - Nutrients Mass Balance of a Co-Composting Plant in Bangalore, India". The work discusses problems of water content and the transport of faecal matter, presents the results of hygienisation analyses, and documents the composting process and the effect of the compost as a soil improver.

Nasvarjan Trust was established in 1989 to help "eliminate discrimination based on caste, assure equality of status and opportunities and ensure the rule of law, not of castes". Since their inception the organisation has been striving to fulfil this mission through a variety of programs and initiatives. Traditionally, their focus has been on empowering the people at the local level and holding government responsible through legal processes.

Navsarjan Trust is running a centre for Dalit empowerment in the village of Nani Devti. About 150 students are instructed in masonry, steel-work, wood-work, stitching, and production of pre-fabricated concrete parts.

Navsarjan Trust wants to develop socially and culturally acceptable, sustainable and hygienic safe sanitation, treatment and reuse concepts for human excreta. For the Navsrajan Training Campus an ecological sanitation demonstration project shall be developed and implemented.

In close cooperation with students from the Navsrajan Training Campus an ecological sanitation concept, considering low-tech and high-tech sanitation, treatment and reuse solutions, shall be developed and implemented. Experiences in planning, implementing, operating and maintaining sanitation, treatment and reuse facilities and in the production and reuse of recyclates will give students from Navsrajan Training Campus the know-how for generating income from developing, planning, implementing, running or maintaining ecological sanitation facilities and the production and reuse of the recyclates.

### **China – ecological sanitation as a solution for rural and urban areas**

In China there is a long tradition of using animal and human excreta as agricultural fertilisers. This has resulted in a broad acceptance of the use of ecological sanitation systems and led to the current situation where over 685 000 toilets have been installed across 17 provinces, allowing the safe recovery and use of the nutrients in human excreta.

These development has occurred rapidly over the last decade. In Guangxi province, 70 urine diversion dry toilets were installed in the village of Dalu in 1997 as part of an ecosan pilot project funded by Sida and UNICEF. In the following year 10,000 more were built in 200 villages across the province, and by 2002 there were 100,000 urine diversion toilets were in use.

Several factors acting together are seen as having contributed to this widespread adoption of ecosan systems in Guangxi province. The traditional cultural acceptance of reusing nutrients obtained from excreta was supported by a political commitment to integrate ecological sanitation into rural development and poverty reduction plans, with modest subventions being given to support demonstration projects, including the provision of the toilet pan. An active promotion campaign was also carried out with the use of local media, demonstration projects and cross visits to inform people about the system., with the active participation of women and children. Further promoting factors were the relatively low cost of installing the urine diversion toilets, which were up to half the price of a conventional three chamber septic tank system, and the flexibility of the technology used, allowing the toilet to be installed as part of the house, and an easy to handle treated product (for a family of four toilets only need to be emptied every six months).

The ecological sanitation dry system chosen is seen as fitting the Guangxi context perfectly, due to the serious water shortage were flush toilets would be completely

inappropriate. It has also led to increased opportunities for income generation by providing inputs for the year round agriculture, producing a harvest that commands higher price at market, with the creation on a local level of toilet construction teams.

Having implemented ecosan on a large scale, mainly in rural areas, the main challenge now being confronted in Guangxi is how to introduce it to the emerging towns and peri-urban areas in the province. The lessons learnt during the first years in the province will be invaluable in achieving this.

The challenge of providing urban areas with ecosan systems is also being faced in the city of Dong Sheng in Inner Mongolia (Northern China). The city has recently signed an agreement with the Stockholm Environment Institute (EcoSanRes) to build an eco-town in Hei Zao Kui area of Dong Sheng (Erdos municipality) using the principles of ecological sanitation, the first of its kind in China. The Erdos eco-town demonstration project will be built over the next three years with completion in 2007. It will comprise 1500 contained dwellings in 4-, 2- and 1-storey buildings.

This part of China is drought ridden receiving 300-400 mm of precipitation per year. Cities are required to ration water and most residents have no private sanitary services. Conventional solutions to urban sewage collection and treatment are thus inadequate here and alternative methods are necessary.

The eco-town will be set up with modern urine-diverting toilets in each home, with grey water from the kitchen and bath being separately collected and treated using soil filtration and a constructed wetland. Storm water will not be mixed with any of the water coming from the households. An eco-station will be built to collect the various household products to be recycled, i.e. urine, to be used as fertiliser and sterilised faeces, which will be used as a soil conditioner, along with and organic kitchen wastes, which will be composted, and solid wastes which will be source-separated.

Initially the eco-town will serve as a large research and development area to further develop and standardise the various urban ecosan applications. This collaboration between China and Sweden represents a breakthrough that will provide opportunities for many urban centres around the world to learn from.

## **Cuba**

Throughout Cuba, and particularly in urban areas, the wastewater management and sanitation systems lack capacity and are in urgent need of rehabilitation. Most notably in peri-urban areas with considerable agricultural activity, the soil, groundwater and watercourses are heavily polluted. As a result, health conditions and odour-nuisance levels are critical in many places.

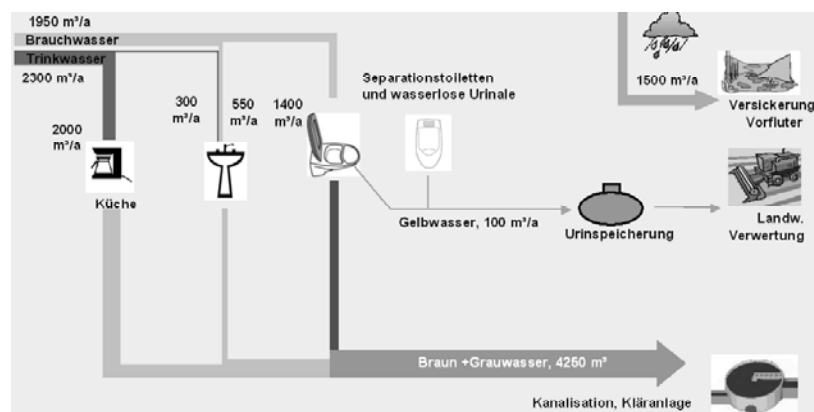
Moreover, many households do not have access to electricity. This forces many people to use ecologically questionable forms of fuel for there everyday needs.

To address the situation, a GTZ-supported ecosan research project is conducting field tests on various household sanitation systems and looking for appropriate-technology solutions that may generate cooking energy. For example, on several city farms in two different project regions, the utilization of household sewage and organic waste is being integrated into the in-house production of fertilizer and cooking energy. In a third region, pre-fabricated components are being designed and developed for diverse decentralized disposal systems, and in a fourth region, different ecosan systems are being implemented in urban centres. The four regions in question are located in different parts of the island to ensure the study of the representative of the island's diverse climatic, structural and social conditions.

### Germany – ecological sanitation systems at the GTZ Headquarters

Recognizing the potential of adopting a closed-loop approach, the decision has been made that in the course of the ongoing renovation of the GTZ main office building in Eschborn near Frankfurt (Germany), the work place of 600 employees, waterless urinals and urine separating toilets will be installed. Urine will be collected in storage tanks with methods of nutrients recovery being investigated during implementation as part of a research and demonstration project. These methods will include direct agricultural application of sanitised urine following different treatment processes, using the process of magnesium ammonium phosphate precipitation, and concentrating the nutrients through evaporation or other processes.

With this, the GTZ will be setting a clear signal of its willingness to use modern, future oriented sanitation concepts in their own building, to demonstrate their feasibility, and the important role they can play in sustainable resources management and in reaching the Millennium Development Goals for water and sanitation. The project planned for the GTZ building will compliment the existing sanitary system at the KfW (Kreditanstalt für Wiederaufbau) banking group headquarters, in Frankfurt. Here, a vacuum sewer has been installed to collect the black water, and grey water is recycled, after mechanical, biological and membrane treatment to flush toilets. With these two demonstration projects, the German development co-operation has increased its credibility when it comes to promoting ecological sanitation concepts in partner countries.



**Figure 3** Flow diagram showing the separate wastewater streams in the systems to be installed in the course of the renovation work at the GTZ

### Germany - Lübeck Flintenbreite

In Lübeck-Flintenbreite, the innovative sanitation system of source separation is realized in an entire housing estate in Germany for the first time. The housing estate, with 350 inhabitants and 3.5 ha, is an example for a densely populated rural area. To reduce consumption the houses are also designed as low energy houses. The construction of the technical equipment and the buildings started in February 1999. By 2002, 28 houses for 95 inhabitants were completed. The project demonstrates the feasibility of the source control system combined with water saving technology as well as fertiliser and energy production.

The area of the housing estate is not connected to the central sewerage system. The main technical equipment is installed in a central community building. All components of the

sanitation concept are in use in different fields of application since many years and therefore well developed. The sanitation system consists mainly of the following components :

- vacuum toilets with vacuum-sewer system and anaerobic digestion with co-treatment of organic waste in a semi-centralised biogas-plant, recycling of digested anaerobic sludge for agriculture with further storage for growth periods. Utilisation of biogas in combined power and heat generator (heating for houses/digester and production of electricity) in addition to natural gas
- decentralised treatment of grey water in vertical flown constructed wetlands (reed-bed filters) with interval feeding
- storm water retention and infiltration in a swale system.

The vacuum toilet system has been running for two years without any technical problems. The flushing system which has been optimised during operation needs only about 0.7 l per flush. Therefore the drinking water consumption is significantly low compared to the German average. The long time drinking water consumption in Lübeck-Flintenbreite is carried out to be only 77 l/(p\*d).

The average amount of blackwater is found to be approximately 6 l/(p\*d). The average amount of greywater is about ten times higher. Regarding the nutrients in these two water flows, the source separation is very effective. Almost 90% of the nitrogen load is found in the blackwater. Accordingly, the blackwater composition shows a high concentration of organic substances and nutrients compared to conventional domestic wastewater.

An evaluation showed that the vacuum toilets are as accepted as the conventional system.

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