Ecological Sanitation: Selected example projects from Sub-Saharan Africa, Asia and Europe

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ABSTRACT
The paradigm of ecological sanitation (ecosan) sees human excreta and wastewater from households as a resource which should be made available for use – after the required treatment steps. Ecosan does not favour a specific sanitation technology, but is rather an approach for handling substances that have so far been seen simply as wastewater and solid waste for disposal.
In the last decade many ecosan projects have been implemented worldwide mainly in rural but also in peri-urban and 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 gives an overview of such recycling-oriented sanitation systems with a focus on the work of the German Development Cooperation (GTZ). It includes up-to-date information of several ecosan pilot and up-scaling projects from Sub-Saharan Africa, the Philippines and Germany. Ecosan technologies briefly described in this paper include urine-diversion dehydration (UDD) toilets, composting, biogas systems for animal manure and toilet waste, and urine diversion flush toilets for separate collection of urine.
The potential to produce fertiliser and soil conditioner from human waste (by implementing "productive sanitation systems") is becoming even more attractive nowadays due to rising food and fertiliser prices and diminishing soil fertility, especially for areas in sub-Saharan Africa where soils have been "mined" for nutrients over the decades (farmers too poor to afford expensive fertiliser).

KEYWORDS
ecosan, Africa, projects, reuse, sanitation

1 INTRODUCTION

Within the last two decades, a new paradigm for the sanitation sector was rediscovered and enhanced: Ecological sanitation (ecosan) sees human excreta and wastewater from households as a resource that should be made available for use - an approach which used to be (or still is) common practice in most agricultural-based societies (Werner, 2004). "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, 2008a). In the last ten years the concepts of "sustainable sanitation" and ecosan have come a long way from a niche to a mainstream phenomenon, a process which the UN International Year of Sanitation (in 2008) and the work of the Sustainable Sanitation Alliance (SuSanA) have helped to foster.

Lessons learnt from projects indicate that the implementation of an ecosan system 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.

Two technology principles are very often applied in ecosan systems:

- Firstly, flow streams with different characteristics, such as urine, faeces and greywater, are often collected separately. This allows the application of adapted treatment processes and optimises reuse.
- Secondly, unnecessary dilution of the flow streams (particularly from toilets) is avoided. This minimises the consumption of valuable drinking water and opens up other transport options for excreta besides conventional sewers or vacuum tankers for faecal sludge.

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. The selection depends on the local requirements, drivers for change, financial capabilities of user, need for fertilizers and many other factors. The technology options range from simple, cheap low-tech systems to sophisticated, more expensive high-tech solutions.

On the low-tech side, urine-diversion dehydration toilets or composting toilets can be used (the most basic option being the “Arborloo” (shallow pit composting toilet without urine diversion) pioneered and promoted by Peter Morgan in Zimbabwe and also widely used in Ethiopia). High-tech components of ecosan systems include for example vacuum sewers and semi-centralised biogas plants. The recovery of energy through the anaerobic digestion of faeces, organic waste and animal manure can provide biogas for cooking, lighting, heating or electricity generation.

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

- General awareness of the possibilities and options of an ecosan approach has to be increased amongst all stakeholders, particularly the decision-makers and the intended users
- Capacity development at all levels (for all stakeholders) is required (SuSanA, 2008b)
- Political will and demand for sanitation has to be increased
- Reuse options need to be integrated into urban planning processes
- Transport logistics (especially for transporting urine) need to be solved, particularly if the distances between production and use are large
- New financing instruments supporting private businesses and household investments are required.

2 NEW DEVELOPMENTS IN ECOSAN PROJECTS FROM AROUND THE WORLD

Some example ecosan projects which were commissioned in the last few years are briefly described below. The agricultural reuse aspects are highlighted for each of the projects. The agricultural use of the organic matter and nutrients contained in excreta and wastewater improves soil structure and fertility, which increases agricultural productivity and thus contributes to food security. This is now becoming increasingly important in times of rising costs of staple foods, rising fertiliser prices and depleting phosphorus reserves (SuSanA, 2008c).

2.1 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. 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 (GTZ and KfW on behalf of the German federal ministry BMZ), the AfDB, the UEMOA, 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 and feasibility studies are being carried out (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 also included.

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 is a good example for South-South knowledge transfer and effective use of organic matter from households and small-scale farming.

2.2 Ecosan Promotion Project in Kenya

Since November 2006, the EcoSan Promotion Project (EPP) which is funded jointly by GTZ, SIDA and the EU is promoting the ecosan approach as a component of the Water Sector Reform Programme (implemented by GTZ) in three pilot areas in the north-west, in the centre near the capital Nairobi and in the east of Kenya near lake Victoria. Two of the pilot areas are located in regions which are seen as sanitation "hot spots" where a number of factors such as low sanitation coverage, frequent cholera outbreaks, high water table, infertile soil and high poverty index require a rapid implementation of sustainable sanitation solutions.

The EPP aims at increasing the sanitation coverage and improving the management of wastewater resources in Kenya. As a core indicator of this project, 10,000 households or 50,000 people are to be reached within the first three years of this project. Several ecosan-related technology components such as urine-diverting dehydrating (UDD) toilets on household and school level, low-flush toilets connected to biogas digesters and constructed wetlands for institutions and public toilet centres for public places and informal settlements have already been implemented or are planned for 2009. As UDD toilets have several advantages over the wide-spread VIP latrines, they are now becoming a "success story" in Kenya (von Bloh, 2008).

Several Kenyan ministries (e.g. the Ministry of Water and Irrigation, the Ministry of Public Health and Sanitation or the Ministry of Education) are taking part in this project. UNICEF, UN-Habitat as well as several Kenyan NGOs, such as KWAHO, ALDEF, UMANDE Trust, are also involved as stakeholders for the pilot phase. Furthermore, financing institutions were won as project partners, marketing schemes of ecosan products have been introduced and the large scale implementation of the technologies is being prepared.

Since 2007, five schools in Kaurine, Butere and Mumias, a prison at Meru, the Naivasha bus park and numerous households in Modogashe, Butere and Mumias have been equipped with either UDD toilets, biogas digesters or constructed wetlands. For 2008 and 2009, it is planned to further spread the dissemination of ecosan technologies in the areas of the sanitation hot spots including also the south-western coastal region (for 20 schools, 14 public toilet centres, 10 informal settlements and more than 500 UDD toilets for households).

This project demonstrates how the implementation of reuse-oriented sanitation methods can spread rapidly from pilot projects to large scale in the African context.

2.3 Large-scale urine-diversion ecosan projects in South Africa and Burkina Faso

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 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 the countries capital, 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. 319 UDD toilets have already been installed in Ouagadougou by July 2008 (ECOSAN_UE 2008).

These projects show how the use of UDD toilets spread in the last years in South Africa and Burkina Faso increasing the awareness for closed-loop approaches for more sustainable sanitation solutions.

2.4 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.

A UDD toilet (see Figure 1) inside the gardens 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.

FIGURE 1 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. The urine is collected in a 200 L container and is added, after six months of storage, to compost heaps of biodegradable and organic materials. It adds nitrogen to the garden compost and accelerates the decomposition process. Urine is also used as a side-dress fertilizer 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. Before this project, the allotment gardeners used to buy expensive animal manure (chicken dung) – now they can use free human manure.

Regarding the agronomic effects of urine, yield increases of 13 % for urine-fertilised sweet corn were recorded compared to non-urine fertilised sweet corn. For non-food crops, earlier and increased flowering was observed for bougainvillea, euphorbia, santan and coppea, resulting in better marketability. Greener leaves and healthier crop stand in general was observed for palms and mango seedlings, a trait being appreciated by the growers and buyers (Guanzon, Y. et al. 2005).

This project shows how urban agriculture and reuse-oriented sanitation can be combined to improve food security (Miso, 2007).

2.5 Urine diversion at GTZ headquarters main office building in Germany

When the GTZ main office building in Eschborn (Germany) was renovated during 2004 to 2006, an ecosan demonstration and research project was included as part of the renovation: 56 urine-separation flush toilets (model: Roediger NoMix) and 25 waterless urinals (model: Keramag Centaurus with rubber tube seal) were installed. In addition, four urine storage tanks with a total capacity of 10 m^3 were built in the cellar of the building. It takes between three to four months to fill these urine storage tanks (i.e. about 34 m^3 of urine collected per year). The system started operation in July 2006.

Some difficulties during planning and implementation of the 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 odour traps of the waterless urinals had to be changed to an improved style due to odour problems (GTZ, 2006).

After these adaptations, the system is functioning quite well since mid 2007. However, experience in mid 2008 has shown that the urine tank ventilation system is too vigorous, so that ammonia escapes from the urine tanks. Furthermore, it was observed that the maintenance staff appears to have neglected the regular cleaning of the urine pipe valves inside of the NoMix toilets with the recommended urine scale remover, a combination of formic and other organic acids. As a result of this, a number of toilets are not achieving the separate collection of urine anymore. These are important lessons to be learnt.

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 - first results from their tests are expected by late 2008.

Funding by the German federal government for Phase 2 of this project for implementation of a urine and brownwater (faeces + flushwater) treatment and reuse system (for demonstration and research purposes) has not yet been approved. This project shows the challenges and opportunities of combining urban sanitation in a modern office building with nutrient recovery from urine.

3 CONCLUSIONS

In recent years many successful ecosan projects have been implemented all over the world 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 given ecosan project examples from Sub-Saharan Africa, the Philippines and Germany with an emphasis on existing or intended reuse practices. Ecosan technologies for excreta management briefly described in this paper include UDD toilets, biogas reactors for animal manure and toilet waste, and UD flush toilets for separate collection of urine.

Including the reuse options of human excreta as fertilizer, soil conditioner, compost or biogas from the beginning in planning sanitation systems opens a wider range of sanitation options and has the potential to generate some income from sanitation projects. Especially for regions with poor soil qualities and where farmers lack money to buy fertilizer, the agricultural reuse of urine, dried faeces or digested sludge is a very valid opportunity - a good reason to tackle the remaining cultural, institutional and technical restraints.

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