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WATER, SANITATION AND HYGIENE:
SUSTAINABLE DEVELOPMENT AND MULTISECTORAL APPROACHES

# Tackling the urban waste and food crises simultaneously and sustainably – examples from the Philippines and Burkina Faso

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*The current urban population of 3.3 billion is expected to reach 5 billion by 2030. This urbanisation of the global population is equally an urbanisation of poverty. Cities concentrate people, huge volumes of excreta and nutrients from vast areas of farmland into a limited area. For the urban poor in particular, these accumulations result in major health problems and a low standard of living. In recent decades sanitation practitioners and researchers have been working on modern sanitation systems that address two related urban problems - the waste and the food production problem. The approaches developed are usually considered under the term ecological sanitation (ecosan) and are based on recognising the value of nutrients as part of a sustainable wastewater management system. Two large-scale projects from the Philippines and Burkina Faso, are presented to illustrate the benefit to the urban poor offered by affordable ecosan alternatives - in terms of sanitation and fertiliser production.*

## Introduction: The urbanising planet

Since mid 2007, for the first time in history, more than half the population of our planet are living in urban areas (Kulikowski, 2007). Whilst ongoing urbanisation is putting rural areas under increasing pressure to produce food, it is expected that the global rural population will not increase significantly in coming years. Urban areas are now the centres of global population growth. The current urban population of 3.3 billion is expected to reach 5 billion by 2030 (60% of the global population), with almost all growth taking place in developing countries (Hinrichsen et al., 2002).

In the developing world rapid urbanisation is happening on an unprecedented scale, and with the urbanisation of the population comes the urbanisation of poverty. Using World Bank 1$-a-day income statistics, 30% of all poor people currently live in urban areas, and this is expected to reach 50% by 2035. But simple, income based criteria fail to reflect the reality of having no access to clean water supplies or sanitation in a densely packed settlement: whilst the rural poor may be able to obtain certain goods and services without cash, in urban areas money is absolutely essential.

## Analysis of two linked crises: sanitation and food production

### Cities accumulate excreta

Whilst the present scale of urbanisation in developing countries is unprecedented, the most acute problems this poses have been encountered (and partly solved) around the world as cities urbanised. One of the most important challenges in urbanising environments is how to manage the waste that is inevitably produced, and how this best be done to protect the most vulnerable and benefit the wider society.

Consider a poor urban area with an extremely high population density of around 250 000 people per km², such as might be found today in Kibera, Nairobi, Kenya, or indeed as existed in parts of Liverpool, England in the mid-19th century. Even if the residents of this area were to do nothing else, they require both food and water to survive. And they need to urinate and defecate. Depending on diet each resident excretes around 1.5

litres of urine and 250 g of faeces per day (Jönsson et al., 2004) - resulting in 375 m³ of urine and 62.5 tonnes of faeces per km² *every single day*, which will simply accumulate if not managed. This gives a graphic idea of the huge “excreta burden” on the community. If not managed properly, this enormous concentration of faeces and people creates the perfect conditions for the entire range of faeco-oral diseases and helminth (intestinal worm) infections to run rampant through the community.

### Cities accumulate plant nutrients and organic matter

The lack of appropriate sanitation systems in urban areas does not only result in a concentration of excreta and disease but also in a concentration of nutrients through the consumption of food: whilst a person grows, plant nutrients in food (mainly nitrogen, phosphorus and potassium) are incorporated into body tissue. However once a person reaches adulthood these plant nutrients generally pass through the body unused and the mass of nutrients ingested equals the mass excreted.

Returning to the example above and considering the nutrient concentrations, we would have around 2 000 kg of plant available N, 350 kg of P and 1 000 kg of K being concentrated in the 1km² every day. Taking a conservative estimate of around 0.1 ha of land to grow the food for one person for one year this results in a concentration of the nutrients from about 250 km² of agricultural land onto this 1 km² of urban land.

Today the flow of nutrients into cities is mainly linear and one-way. This is a clear threat to the sustainability of cities and societies. If nutrients are not replaced in agriculture, these flows represent a nutrient mining of soils which inevitably loose their productivity. In Africa, 85% of arable land is losing an average of 30 kg of nutrients per hectare per year partly as a result of nutrient removal (Morin, 2006). To combat falling soil fertility, farming has turned increasingly to the use of chemical fertilisers, with an estimated 40% of the global population now dependent on the use of chemical fertiliser for food production (Smil, 2001).

In 2007 world fertiliser consumption reached record levels of 163.9 Mt, with projections of 170 Mt for 2008 (Heffer and Prud'homme, 2007). Due to increased demand, high oil prices and limited availability, fertiliser prices have rocketed, with urea (a source of N) doubling in price, and di-ammonium phosphate (DAP – a source of both N and P) increasing by a factor of up to 5 between 2006 and 2008. Fertiliser producers are planning significant increases in output to meet demand, with new nitrogen fertiliser plants and phosphorus and potassium mines (Bradsher and Martin, 2008). This situation is worrying given the finite nature of the world’s phosphate rock reserves - the main source of P. Phosphorus is irreplaceable for plant production. The continued linear transport of agricultural nutrients into cities to dump or destroy them as part of a sanitation system is a “road to nowhere” that is now beginning to show its limitations (SuSanA 2008a).

### The impact on the urban poor

The urban poor are the double losers on this road to nowhere. Firstly, they suffer most from lack of access to sanitation. The accumulation of excreta in poor urban neighbourhoods exposes people to disease and all the social and economic consequences that follow. Often the urban poor live in areas with no legal recognition, denying them “official” services and even space in planning discussions. Also, the congested nature of the settlements makes it difficult for services to access them. They thus often loose out to wealthier areas which can be more easily serviced and prove profitable for service providers. Secondly, the urban poor have been hit hardest by the soaring food prices in 2008 that have resulted from the high price of fertiliser – whilst at the same time agricultural nutrients accumulate around their feet. They are left battling two crises (waste and food production) resulting from the logic of a linear one-way system of sanitation.

## Looking back to move forward

In the past, agricultural societies dealt with the burden of excreta accumulation and nutrient concentration in a pragmatic manner, recognising the nutrient value of excreta through agricultural reuse. This enabled settlements to exist for centuries in closed loop systems, where nutrients and organic matter from liquid and solid household wastes were returned to the soil.

A system of collection, transport and reuse of excreta and wastewater in agriculture was (and is) widely practiced around the world for millennia. In Europe, for example, this was continuing well into the middle of the 19th Century in urban areas, and the marketing of excreta-derived fertiliser was a thriving business (Brown, 2003). In China, where this is still widely practised, soil fertility has been maintained over millennia, despite high population densities. This knowledge however was culturally codified and based on a poor understanding of disease transmission, and as such left those involved in the transport of excreta and the farming population particularly exposed and vulnerable to disease (Bracken et al., 2007).

However, whilst excreta reuse addressed the sanitation problems of settlements and contributed to securing agricultural productivity, it did not become the conventional approach to sanitation we know today from industrialised countries. At the time of its demise in industrialising countries there appear to have been three main driving factors that generally put an end to the reuse of excreta in agriculture in industrialised countries.

Firstly, urban settlements had grown dramatically, but the logistical challenge of removing excreta from densely packed city centres to increasingly distant agricultural areas proved too great. Sanitary conditions in the hearts of major European cities degraded dramatically, as they choked on their own waste. In nineteenth century Britain an average of 26% of children died before the age of 5, in the cities this average was over 50% (Brown, 2003).

Secondly, the arrival of piped domestic water supplies in the 19$^{th}$ century made water flushed sewerage possible. Water flushed systems dramatically transformed the situation, with sewage being flushed away from homes and the hearts of cities into nearby rivers. Water flushing greatly increased the volume of sewage and diluted nutrients, making it impossible for them to be recovered and reused as they were previously.

And thirdly, the nutrient demand of farmland was eventually met by the start of the 20$^{th}$ century for all three major nutrients (N, P and K) using affordable chemical fertilisers, making any efforts to recover and reuse the nutrients and organic material from the large volumes of sewage unnecessary.

At the turn of the 20th century it seemed the urban sanitation problem was solved – at least in the global North. Cities became cleaner, healthier places to live, even for the poor. Farmers had access to affordable chemical fertilisers to feed growing cities and this model was exported around the world. The water-borne sewer system became the standard approach for urban areas of industrialised countries and indeed around the world **-** but it has not benefited the urban poor in the global South.

The conventional sewer systems have tremendously improved public health for people who can afford them, but they drain finances, pollute and squander fresh water resources (as functioning wastewater treatment plants are commonly lacking on a global scale), break nutrient cycles and provide no benefits for soil fertility. They have also had little or no impact on the living conditions of the urban poor in the developing world. The same can be said to a large extent for sanitation systems that end simply at the bottom of a latrine pit (for urban areas where space, and access to soil, is limited).

These sanitation systems were developed to remove dangerous human waste from settlements, whilst their relative costs have often put them beyond the reach of the urban poor. However, according to the FAO, meeting the increasing food demand of a growing population will depend mainly on raising resource use efficiency rather than on improving yields. Currently the biggest single wasted nutrient flow out of agriculture is in the nutrients in human excreta. The FAO therefore see nutrient recovery from human excreta as a key activity in securing crop production (FAO, 2008).

## Examples of urban ecosan systems

### Ecological sanitation overview

In recent decades some sanitation practitioners and researchers have been working on developing modern sanitation systems that address both the sanitary needs of growing populations and the problem of soil fertility. These approaches are usually considered under the term ecological sanitation (ecosan) and are based on an overall view of material flows as part of a sustainable wastewater management system to meet the needs of the users and local conditions. They do not focus on specific technologies, but are rather a way of managing substances that have traditionally been seen simply as wastes, and introduces the concept of sustainability and integrated resources management to sanitation.

The basic principle of ecosan is to close the nutrient loop between sanitation and agriculture and to:

- provide affordable, safe and appropriate sanitation systems
- reduce the health risks related to sanitation, contaminated water and waste
- protect the quality of surface and groundwater
- preserve soil fertility and optimise the management of nutrients

Appropriate treatment and handling throughout the entire process, from collection to reuse, is essential in ecosan systems to ensure a series of barriers against disease transmission are erected, thus providing comprehensive protection of human health. Closing local nutrient cycles is not only important in minimising the energy and resources used in producing mineral fertilisers, but also because it makes agricultural inputs available even to the poorest farmers in developing countries (Werner et al., 2004). To optimise cost efficient, high quality treatment and recycling options, two principles are often applied in ecosan systems:

- Firstly, if appropriate, flow streams with different characteristics, such as faeces, urine and greywater are collected separately. This allows the application of specific treatment processes and to optimise reuse.
- Secondly, unnecessary dilution of the flow streams is avoided, for example by using dry, low flush or vacuum systems. This produces high concentrations of recyclables.

In taking a wider systems view of sanitation, ecosan projects require an interdisciplinary approach that include the technological aspects of excreta and wastewater management, their agricultural use, sociological aspects of acceptance and cultural appropriateness, health and hygiene, town planning, economic and small-enterprise promotion, institutional administration, etc. The involvement of such a wide range of disciplines and the integration of municipal authorities in the process has proven essential to the success of ecosan projects so far, as illustrated in the two examples below.

## Cagayan de Oro City, the Philippines

Functioning sewage treatment plants are uncommon in the Philippines. Most raw wastewater and sewage is discharged into rivers with other household and industrial waste, leading to the spread of diseases and threatening livelihoods. The poor are the most exposed to these health risks; 40 % of all Filipinos live below the poverty line.

Since 2005, GTZ and its Integrated Experts Programme (Centre for International Migration and Development, CIM) have been supporting the implementation of ecosan in the cities of Cagayan de Oro (a city of 554,000 inhabitants, of which 94% live in “urban areas”) and Bayawan (a city of 110,000 inhabitants, of which 22% live in “urban areas”). More than 30 urine diversion dehydration toilets (UDDTs), a constructed wetland for the village of Bayawan and a biogas installation for the treatment of wastewater from an abattoir have been installed, providing sanitation systems to the poor at an affordable price.

Further, allotment gardens have been created in poor neighbourhoods of Cagayan de Oro as part of the project. The UDDTs produce fertiliser which is used in the gardens. Accompanying research by the Philippines’ Xavier University of Agriculture has shown that the nutritional standard of the poor urban families taking part in these activities has considerably improved as these families now grow their own fruit and vegetables (Figure 1). This has not only improved their general health, but has also enabled gardening families to increase their income by up to 20% through the sale of their produce (Holmer and Drescher, 2005; SuSanA 2008b).


**Figure 1. Drip irrigation, school gardens, and UDD toilets are combined in many ecosan projects in Mindanao, Philippines (Photo: A.R. Panesar)**


**Figure 2. Ecosan Training of Trainers workshops contribute to a faster up-scaling and spreading of the approach (Photo: GTZ Philippines)**

A key to this success is that the allotment gardens are part of a city-wide approach, including a waste management concept and tax breaks for land owners who provide land for allotment gardens. Ecosan user groups can incorporate their input into the planning and design of these gardens. The participatory approach increases the acceptance of the systems, ensuring correct operation and this in turn strengthens the interest of the users to maintain the system. Based on these positive results, the administrations in both cities have begun to integrate the ecosan approach into their overall city planning.

Three years after the first UDD toilet was inaugurated in Cagayan de Oro in November 2005, several similar ecosan projects have been implemented on the island, including in the municipalities of Initao (Misamis Oriental), Katipunan (Zamboanga del Norte) and Manolo Fortich (Bukidnon). Thirty UDDTs have been installed within public schools, while several are located next to “barangay halls” (meeting halls of villages or city districts) and project offices where they also serve as demonstration units for the interested public. Three UDDTs are being installed close to chapels in barangays (city districts) Balubal and Taglimao, where they will be used by the church community and one unit will be soon available for the employees of the Philippine Ports Authority in Cagayan de Oro City. In most of the school projects, ecosan systems are combined with school gardens to contribute to school feeding programmes.

Starting the momentum for sustainable sanitation systems has been a joint effort of universities, local authorities and community organisations in poor city districts in collaboration with the activities of GTZ/CIM (SuSanA 2008b).

The holistic approach of ecosan requires planning adapted to the given social and cultural context. GTZ is therefore training local ecosan advisors from local councils and non-governmental organizations in planning their own projects, implementing them and training more trainers (Figure 2). In the Philippines, not only is ecosan leading to hygienic urban sanitation facilities, but it is also contributing to livelihoods on several levels, thereby sustainably improving the health of poor urban families.

### Ouagadougou, Burkina Faso

Until recently sanitation was a low development priority for the landlocked West African nation of Burkina Faso. In the capital, Ouagadougou, 81% of the population of 1.4 million people, had no access to basic sanitation in 2006 (Programme National d’Approvisionnement en Eau Potable et Assainissement, 2006). Several innovative initiatives have been launched to address this problem, but with an annual population growth rate of around 5% they have had difficulty in simply maintaining pace with growth – particularly in poor peripheral areas of the city. Calculations in 2007, before the recent leap in fertiliser prices, showed that the nutrients in the city’s excreta, if collected and reused, would have an annual value of over € 16.5 million.

It was in response to the sanitation challenges in Burkina Faso that the German Technical Cooperation (GTZ), the West African Centre for Low Cost Water Supply and Sanitation (CREPA), and the National Office for Water Supply and Sanitation (ONEA) developed the 3-year project initially titled “ecological sanitation in peripheral neighbourhoods of Ouagadougou”, which is co-financed within the framework of the EU Water Facility and began in July 2006. The aim of the project is to facilitate the access of poor households in poor urban neighbourhoods to sustainable and affordable sanitation systems that protect human health, contribute to food security, and enhance the protection of natural resource and the promotion of the private sector (Bracken and Voudounhessi, 2007).

The sanitation systems currently (November 2008) under construction collect urine and faeces separately in specially designed UDDTs (with provision for anal washing with water), and the use of the treated products contributes to resolving the problems of managing faecal sludge and the need for agricultural inputs in urban agriculture and market gardening. To ensure that the sanitation system meets the needs and expectations of all actors, the project has adopted a participatory and multidisciplinary approach with an appropriate legislative and regulatory framework. The users (and farmers) are the key stakeholders in system design and operation.

The project partners (GTZ, CREPA and ONEA) have identified three major fields of activity. Firstly, ecological sanitation systems are being developed with the users of these systems, responding to their needs and the local context. Secondly, lobby work is being carried out at municipal and governmental level in order to create an enabling environment for ecological sanitation and ensure its inclusion in legislation and future strategic plans. This second field of activity is also serving to create the conditions for the third field, which is to support and promote the involvement of the local private sector in furnishing the infrastructure and logistic services required by the system (Figure 3).


**Figure 3. Donkey cart for the collection of jerry cans with urine from households (Photo: S. Rüd)**


**Figure 4. A cabbage garden fertilised using stored urine (Photo: S. Rüd)**

Through a broad range of activities over the three year project period the project aims to reach up to 300,000 people in Ouagadougou, informing them of the existence and the possibilities of ecosan, and supporting 1,000 households in obtaining appropriate and affordable closed-loop sanitation.

The project began with an intensive first year of dialogue with various stakeholders, from municipal authorities to households and the local private sector, to assess needs and establish the framework within which the system was to be developed. Technical, logistical and organisational proposals were made and validated with the various stakeholders before any work began putting the system in place. So far almost 50 masons have been trained to build four different toilet types, gardeners and farmers have been consulted and trained on the application of treated faeces and urine on their crops (Figure 4), households have been consulted on their preferences, and community-based organisations have been supported in setting up collection and transport businesses. By September 2008, 378 homes were using urine diversion dehydration toilets and 11 public toilets had been built in and around communal structures, and gardeners harvested their second season (ECOSAN_UE, 2008).

Throughout the project a strategy of close cooperation with communal authorities, community based organisations in peri-urban areas and the local private sector has been adopted, with positive results and a high degree of engagement from all actors involved. The project has worked intensively with these actors to increase their capacities to engage in a programme of providing and operating sustainable sanitation systems with the aim of ensuring that activities will be integrated into ongoing work when the project ends.

To date the results have been extremely encouraging at both household level right through to reuse and harvest. The municipal authorities have fully embraced the concept. At ministerial level, the Minister for Agriculture has spoken out in favour of the approach, and the double benefit it is bringing in sanitation and agriculture, noting its compatibility with the national operational strategy for food security, which aims to reduce the number of people suffering from malnutrition in Burkina Faso by 50%. It is seen as having the potential to make an important contribution to reaching several of the Millennium Development Goals at national level, including those outlined in the National Programme for Water Supply and Sanitation and the Strategic Framework for Poverty Reduction. The main financers of the project, the EU, have also expressed their satisfaction and are financing a second ecosan project using a similar approach which is aimed at farming families through a fund earmarked for improving food security through improved soil fertility.

## Conclusions

The conventional approach to urban sanitation as a problem of collecting, treating and disposing of excreta and greywater has let down the urban poor in the global South. It is for the most part based on thinking from over 150 years ago and has resulted in the dominantly linear, one-way sanitation systems. However, at the start of the 21st century this one-way flow of nutrients into rapidly growing cities is becoming unsustainable.

In order to make sanitation systems more sustainable, they need to be:

1. comprehensive – insofar as the entire flow of all waste streams need to be considered;

2. re-use oriented – with the resource value of the different streams recognised and used beneficially whenever possible;
3. appropriate – with a comprehensive suite of technology options being examined to determine the most sustainable, rather than the most typical, solution.
4. people-centred – to address the needs of the users of the facilities and products from productive sanitation systems. Participatory project design integrated into overall town and city plans can contribute greatly to this.

Urban ecological sanitation systems are now being trialled and implemented to improve the living conditions of the urban poor, with considerable potential to address the problems of both, localised excreta accumulation in poor urban areas and high fertiliser costs. The most successful large scale systems thus far have actively sought to ensure interdisciplinary cooperation and multi-stakeholder participation in implementation processes. They have also sought to integrate systems into the work of municipal authorities and embed the innovations in municipal and even national strategies. This strategy has paid off for all involved and should be continued.

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## References

Bracken, P., Wachtler, A., Panesar, A.R., Lange, J., (2007) *The road not taken* **-** *how traditional excreta and greywater management may point the way to a sustainable future*, Water Science & Technology: Water Supply Vol 7 No 1 pp 219–227 Q IWA. Available at: www.iwaponline.com/ws/00701/0219/007010219.pdf (Last accessed 23.09.08)

Bracken, P., and Voudounhessi, A., (2007) *ecosan in Ouagadougou – building capacities to support sustainable systems*, Paper delivered to the UNESCO Symposium "New directions in urban water management", September 2007, Paris, France. Available at: www2.gtz.de/dokumente/oe44/ecosan/nl/en-ecosan-ouagadugo-burkinafaso-2007.pdf (Last accessed 29.09.08)

Bradsher, K and Martin, A., (2008) *Shortages Threaten Farmers' Key Tool: Fertilizer*, New York Times 30.04.08, Available at www.nytimes.com/2008/04/30/business/worldbusiness/ 30fertilizer.html?partner=rssnyt (Last accessed 23.09.08)

Brown, A.D., (2003). *Feed or feedback: agriculture, population dynamics and the state of the planet.* International Books Utrecht, the Netherlands.

ECOSAN_UE (2008) *Hebdo ECOSAN_UE Semaine 29 (project newsletter – in French)*, Centre Régional pour l'Eau Potable et l'Assainissement à faible coût (CREPA). http://www.reseaucrepa.org/page/1363

FAO (2008), *Plant Nutrients: What we know, guess and do not know*, http://www.fao.org/ag/agl/agll/plnu_know.stm

Heffer, P., and Prud'homme, M. (2007) *World Agriculture and Fertilizer Demand, Global Fertilizer Supply and Trade 2007-2008*, Interational Fertilizer Association. http://www.fertilizer.org/ifa/Home-Page/LIBRARY/Publications.html/World-Agriculture-and-Fertilizer-Demand-Global-Fertilizer-Supply-and-Trade-2007-2008.-Summary-Report.html

Hinrichsen, D., Salem, R., and Blackburn, R. (2002) *Meeting the Urban Challenge. Population Reports, Series M, No. 16.* Baltimore, The Johns Hopkins Bloomberg School of Public Health, Population Information Program, Fall 2002. http://www.infoforhealth.org/pr/m16/m16chap1.shtml

Holmer, R. J. and Drescher, A., (2005) *Allotment Gardens of Cagayan de Oro: Their Contribution to Food Security and Urban Environmental Management*, In: Christine Knie (ed.) 2005: Urban and Peri-Urban Developments – Structures, Processes and Solutions. Southeast Asian-German Summer School Prog. 2005 in Cologne/Germany, 16-29 Oct, 2005: 149-155

Jönsson, H., Richert Stinzing, A., Vinnerås, B., and Salomon E. (2004) *Guidelines on the Use of Urine and Faeces in Crop Production*, Stockholm, EcoSanRes Programme, Stockholm Environment Institute, ISBN 91 88714 94 2. http://www.ecosanres.org/pdf_files/ESR_Publications_2004/ ESR2web.pdf

Kulikowski, M., *Mayday 23: World Population Becomes More Urban Than Rural*, NC State University News Service, http://news.ncsu.edu/releases/2007/may/104.html

Morin, H. (2006). *L'Afrique agricole.* LE MONDE Diplomatique 09.06.2006

Programme National d'Approvisionnement en Eau Potable et Assainissement (2006). *Mission: État des lieux, Volume 2: Assainissement.* Ministère de l'agriculture, de l'hydraulique et des ressources halieutiques. Direction générale de l'approvisionnement en eau potable (in French) – National Program for water and sanitation: Task 1: Baseline study, volume 2: sanitation. Ministry of agriculture, hydrology and fishery. Director general of water supply.

Smil,V. (2002), *Nitrogen and Food Production: Proteins for Human Diets*, In: Ambio Vol. 31 No. 2, March 2002, Royal Swedish Academy of Sciences, home.cc.umanitoba.ca/~vsmil/pdf_pubs/ Nitrogen%20and%20Food%20Production.pdf

SuSanA (2008a*) Food Security and Productive Sanitation Systems*. SuSanA Fact Sheet, Version 1.3, May 2008. Sustainable Sanitation Alliance. http://www.susana.org/images/documents/05-working-groups/wg05/en-wg5-factsheet-2008-05-28.pdf

SuSanA (2008b). *Ecological sanitation and reuse in allotment gardens.* Sustainable Sanitation Alliance. http://www.susana.org/images/documents/06-case-studies/en-susana-case-study-cagayan-de-oro-philippines-2008-02-12.pdf

Werner, C., Bracken, P., Mang, H.P., Klingel, F., (2004) *Ecological sanitation – principles and technologies*, Paper presented at the IWA World Water Congress, Marrakech, September 2004. www.gtz.de/en/dokumente/en-ecosan-principles-and-technologies-2004.pdf

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