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Sustainable Water Management in the City of the Future

Integrated Project
Global Change and Ecosystems

D4.1.1- Cross-country assessment of the adoption, operational functioning and performance of urban ecosan systems inside and outside the EU

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SWITCH Deliverable Briefing Note

D4.1.1. Assessing the adoption and operational performance of urban ecosan systems Consisting of two sub-deliverables • D4.1.1.a. Cross-country assessment of the adoption, operational functioning and performance of urban ecosan systems inside and outside the EU • D4.1.1.b. Drivers and barriers for scaling up ecological sanitation
Audience A varied audience who are interested to know more about urban ecosan systems and aspects related to implementation of this approach in practice. This can range from persons and organizations responsible for selecting and implementing sanitation technologies (project development firms, local governments, water and sanitation utilities, NGO) as well as scientists and technologist working on innovating these technologies.
Purpose The purpose of this deliverable is to focus on the issues related to implementing and operating urban ecosan systems. The practical implementation of source-separating sanitation systems in urban and rural settings has shown to be rather complex due to the involvement of many actors, such as project developers or housing corporations, future inhabitants, the local municipality, water authorities and water utility companies. Another important barrier in implementing new sanitation systems is that in most cities, sewer systems already exist and investments in assets have already been made. Development of new sanitation options in most western countries therefore requires a long-term vision. Despite the complexity, a number of demonstration projects based on source-separation have been realized inside and outside the European Union in the past 15 years.
Background Over last 10-15 years various new systems for municipal wastewater management based on separation at source have been developed or are under development. At present these source-separating systems can be divided into two basic approaches. In the first approach grey water (shower-, washing-, and bath water) and black water (toilet water) are separated at household level and treated separately and reused as fertilizer (urine, composted feces) or as second quality water (for toilet flush and irrigation). The treatment is done on decentralised (i.e. neighbourhood) scale or off-site. In the second approach urine is separately collected and treated or used as fertilizer. Urine separation can be implemented in combination with conventional sewerage discharge or in combination with grey and black water separation. In order to assess the potential of source-separating sanitation systems for wide-scale application in the long run, it is important to learn from these practical experiences. One of the outputs of Theme 4 is an investigation into practical experiences with source-separation in urban settings. The first part reports on practical experiences with implementing and operating various source-separation in urban settings in China, Germany, Norway, Sweden and The Netherlands, including urine separation and reuse as fertilizer, vacuum systems for black water removal and grey water reclamation systems. It also reports on the complexity of

ecosan implementation due to the involvement of many actors, such as project developers or housing corporations, future inhabitants, the local municipality, water authorities and water utility companies. Different stakeholders were approached in the different cases and performance assessment were conducted.

The second part provides a summary based on two questionnaire surveys undertaken between August 2007 and March 2008 with experts in the North and South who have been strongly involved in ecological sanitation. Respondents ranged from field workers testing pilot ecological sanitation schemes to researchers working full-time on understanding specific aspects of ecological sanitation. In response to the first questionnaire, champions of ecological sanitation mentioned various reasons why ecological sanitation did or did not work. Responses to the second questionnaire, gave further information on the important factors for scaling up ecological sanitation from:

- The user perspective: driving forces and barriers for implementing and using ecological sanitation
- The Government perspective - creating an enabling environment
- The product user perspective - the end users of excreta and/or urine in agriculture

Potential Impact

The study shows that ecosan, in its various forms, can generally successfully be implemented. In some cases operational problems were identified, however by using innovative solutions found in other projects these could be overcome. It shows that ecosan technologies are becoming mature.

Issues

Grey water reclamation technologies, urine separation, vacuum technology

The study shows that above mentioned ecosan technologies still have higher investment initial costs, compared to conventional technologies. This is a barrier for upscaling. The potential of reuse water and other resources (e.g. nutrients) may provide a pay-back mechanism which might even be very attractive if water is scarce and expensive as was shown in the case of Beijing.

Dry ecosan toilets

From a user perspective, there remains a reluctance to accept dry ecosan toilets as a possible option, mainly because of reluctance to handle the by-products (urine and faeces). In order to find acceptable solutions, it is of critical importance that stakeholders ranging from government personnel to households are more aware of the potential benefits for ecosanIn particular, it needs to be made clear that the end product is no longer faeces, but a nutrient rich derivative that is no longer unsafe or impure.

There is a general lack of support and co-ordination at all governmental levels, national, intermediate and municipal. Several countries lack any general policies and/or regulation focusing on sanitation, let alone consider ecological sanitation as one of a range of options. Consequently, ecosan is often not taken seriously or takes place only in small scale pilot schemes which are not converted into large scale sustainable projects.

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1 Introduction

In last 10-15 years various new systems for municipal wastewater management based on separation at source have been developed or are under development. At present these source-separating systems can be divided into two basic approaches. In the first approach grey water (shower-, washing-, and bath water) and black water (toilet water) are separated at household level and treated separately. The treatment can be done on decentralised (i.e. neighbourhood) scale or off-site. In the second approach urine is separately collected and treated or used as fertilizer. Urine separation can be implemented in combination with conventional sewerage discharge or in combination with grey and black water separation. The potential advantages of source-separating systems over the traditional wastewater system are a.o. i) reduced use and/or recovery of resources (water, nutrients, organic material, energy), ii) reduction of emissions to the environment and iii) more efficient handling of flows due to less dilution.

The practical implementation of source-separating sanitation systems in urban and rural settings has shown to be rather complex due to the involvement of many actors, such as project developers or housing corporations, future inhabitants, the local municipality, water authorities and water utility companies. Another important barrier in implementing new sanitation systems is that in most cities, sewer systems already exist and investments in assets have already been made. Development of new sanitation options in most western countries therefore requires a long-term vision. Despite the complexity, a number of demonstration projects based on source-separation have been realized inside and outside the European Union in the past 15 years.

In order to assess the potential of source-separating sanitation systems for wide-scale application in the long run, it is important to learn from these practical experiences. This deliverable reports on an ongoing investigation into practical experiences with source-separation in urban settings. The deliverable reports on:

- Grey water separation in The Netherlands and urine separation in Sweden (chapter 2)
- Source separated grey wastewater treatment and agricultural reuse in Palestine (chapter 3)
- Decentralised wastewater reclamation systems in Beijing (chapter 4)
- Constructed wetlands for decentralized treatment of grey water in the Netherlands, Germany and Norway
- User acceptance of vacuum toilets and grey water systems in The Netherlands, Norway and Germany

More specifically the research that is described in the three chapters has focussed on:

1. Technology selection - the drivers and barriers that led to establishment of a non-conventional system in a neighbourhood. For this purpose interviews were made with the important stakeholders in these projects in order to gain insight into their main drivers and barriers.
2. Performance - the comparative performance of the source separation systems after they have been established.
3. Operations management - the support systems that make the technologies function,

2 Technology selection and comparative performance of source-separating wastewater management systems in Sweden and The Netherlands

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Abstract
The research described in this paper has evaluated five demonstration projects with source-separating sanitation at neighbourhood scale, 10 years or more after their establishment. It presents results of two systems with local grey water treatment in the Netherlands and three sites with urine separation in Sweden. The study has focussed on i) the drivers and barriers of the stakeholders that were responsible for project implementation and ii) the comparative performance of the source separation systems after their establishment. In the Netherlands the main drivers were water use reduction, combating sewer overflows and reduction of emissions. For the Swedish cases the main drivers of the involved actors were nutrient recycling, emission reduction and an active policy of the local government. The main barriers in all cases were higher investment costs and low experience with new sanitation approaches systems compared to the conventional system. Three of the sites showed a lower performance with respect to public health because effluent monitoring protocols for the grey water treatment systems were not in place or people could have direct contact with feces. Lack of operation and maintenance is a cause of occasional failure for the grey water treatment systems, while the dominant failure reason for the urine separation systems was pipe clogging. The inventory showed that source-separating sanitation systems have a high potential to save or recover resources (water and nutrients).

Keywords
source-separating sanitation, drivers and barriers, performance assessment, demonstration projects

INTRODUCTION

In last 10-15 years various new systems for municipal wastewater management based on separation at source have been developed or are under development. At present these source-separating systems can be divided into two basic approaches. In the first approach grey water (shower-, washing-, and bath water) and black water (toilet water) are separated at household level and treated separately. The treatment can be done on decentralised (i.e. neighbourhood) scale or off-site. In the second approach urine is separately collected and treated or used as fertilizer. Urine separation can be implemented in combination with conventional sewerage discharge or in combination with grey and black water separation. The potential advantages of source-separating systems over the traditional wastewater system are a.o. i) reduced use and/or recovery of resources (water, nutrients, organic material, energy), ii) reduction of emissions to the environment and iii) more efficient handling of flows due to less dilution (Otterpohl et al, 1997; Otterpohl et al, 1999; Lens et al, 2001; Johansson et al, 2001).

The practical implementation of source-separating sanitation systems in urban settings has shown to be rather complex due to the involvement of many actors, such as project developers or housing corporations, future inhabitants, the local municipality, water authorities and water utility companies. Another important barrier in implementing new sanitation systems is that in most European cities, sewer systems already exist and investments in assets have already been made. Development of new sanitation options in most western countries therefore requires a long-term vision. Despite the complexity, some tens of demonstration projects based on source-separation have been realized throughout the European Union in the past 15 years. In The Netherlands e.g., about 5 projects with local grey water treatment are in operation (Mels and Zeeman, 2003), while in Sweden approximately 10 projects in urban neighborhoods with urine separation have been implemented (Aarsrud, 2003). In order to assess the potential of source-separating sanitation systems for wide-scale application in the long run, it is important to learn from these practical experiences. The study that is described in this paper has investigated a number of sites in The Netherlands and Sweden in order to gain more insight into the technology selection process and to collect data on the practical performance of these systems. More specifically the research has focussed on:

- Technology selection - the drivers and barriers that led to establishment of a non-conventional system in a neighbourhood. For this purpose interviews were made with the important stakeholders in these projects in order to gain insight into their main drivers and barriers.
- Performance - the comparative performance of the source separation systems after they have been established. A field performance assessment was made based on five criteria: compliance with primary functions and sub functions, user-perspective and environment. Each criterion had several verifiable indicators.

MATERIALS AND METHODS

Study sites

Within the framework of this investigation 5 sites were studied that were established in the 1990s:

- In the Netherlands: ‘Het Groene Dak’ situated in Utrecht (1993) and ‘Polderdrift’ in Arnhem (1997), both with local grey water treatment and reuse. The black water is discharged to the municipal sewerage;
- In Sweden: ‘Ekoporten’ situated in Norrköping (1995), ‘Understenshöjden’ in Stockholm (1995) and ‘Gebers’ in Stockholm (1998), all three with urine separation. In Ekoporten and Understenshöjden grey and brown water is discharged to the municipal sewerage. In ‘Gebers’ the feces are collected in a dry toilet and composted locally, while the grey water is discharged to the municipal sewerage.

Technology selection process
To gain insight in the technology selection process interviews were made with the stakeholders that were involved during the design and implementation phase of the various projects. The various interviewees were approached by letter or phone call.

Performance assessment
In order to evaluate the performance of the systems, five performance indicators (PIs) were formulated. These PIs and their means of verification are presented in Table 1. Some of the PIs make a comparison with the conventional sanitation system, i.e. transport of wastewater and rain water by sewers to off-site treatment facilities. The information necessary for the PIs was gathered by interviews with system operators and current inhabitants, by review of literature and internet sources, and by site-inspections. Per case 5 randomly selected households were interviewed to find answers for the user perspective questions.

Table 1 Indicators to evaluate the performance of the investigated source-separating systems

Performance indicator	Means of verification
1.Public health protection	• Is there a chance for the house owners / tenants to get in contact with excreta or untreated wastewater? • Is the effluent quality of wastewater flows that are treated in the neighborhood monitored? • If so, does the effluent quality comply with local standards?
2.Sub functions	• Is there a system for rainwater/stormwater management?
3.User perspective	• Are the yearly costs for water supply and wastewater disposal for the house owners/tentants equal/higher/lower compared to the conventional system?[1] • Does the system cause nuisance (vermin, noise, odours)? • What are the operation & maintenance inputs of house owners/tentants?
4. Robustness	• What is the nature and frequence of system failure?
5.Environmental aspects	• Are the emissions to surface water of nutrients and BOD equal/higher/lower compared to the conventional system? • Does the system save or recover resources (water, nutrients, energy, etc.) compared to the conventional system?

[1] The yearly costs were assessed based on the investment and operational costs, including the water and wastewater fees. Investment costs were expressed in yearly costs, by using the annuity method.

RESULTS

Het Groene Dak (1993, Netherlands)
In 1989 the tenants' association 'Het Groene Dak' initiated the design of an ecological neighborhood with a low environmental impact. They cooperated with a public housing corporation and a private developer. The neighborhood was established in 1993 and consists of 66 houses. The area has two clusters of five houses with a special sanitation system based

on separation of grey, black, and rainwater. These two clusters (rental apartments) were subject of this study. Grey water is treated in a process train consisting of sedimentation and a trickling filter. A part of the treated grey water is led into a surface-flow constructed wetland from where it is led into a retention pond; another part is used as irrigation water in a small greenhouse. The black water was at first composted in Clivus Multrum composting toilet systems. However after many problems with smell, flies and a disturbed composting process, these systems were removed and replaced by (low) flush toilets. The black water is currently discharged into the municipal sewer. Rain water of the entire neighborhood is infiltrated. Rain water from the roofs is collected and used in a number of collective laundry machines.

The actors involved in the design and decision-making in the two clusters were the tenants' association and the housing company. Interviews with these actors showed that the drivers for implementing grey and rain water measures were water consumption reduction, reduction of storm water overflows, prevention of drying-out of soils and reduction of pollutant emissions by the conventional wastewater system. The main barrier was the higher investment cost.
The tenants are responsible for the in-house equipment (toilet, pipes, etc.) and take part in the maintenance of the pond system (yearly removal of the plants) and the small greenhouse. The housing company is responsible for the treatment and maintenance of the grey and rainwater system. The effluent quality of the grey water system is not monitored on a regular basis. The interviewed tenants appreciated the system and they indicated that it made them feel environmentally concerned. They managed to reduce their water consumption by approximately 40% compared to the average Dutch water consumption. They reported incidental smell coming from the constructed wetland and the greenhouse. The greenhouse was reported to have occasional flooding problems due to loss of infiltration capacity and the tenants were considering removing it at the time of the interviews (autumn 2005). There were no noise complaints and no vermin problems.

Polderdrift (1997, Netherlands)
Polderdrift, a neighbourhood with 40 houses, was initiated by a housing corporation ('Woningbouwvereniging Gelderland', nowadays 'Portaal') in 1991 and constructed in 1997. Through a series of workshops new tenants could participate in the urban and architectural design and other aspects of their future neighborhood. Reduction of water consumption received a high priority in the final design. Nowadays, Polderdrift has its own local grey water treatment by means of fat removal, sedimentation and a surface-flow constructed wetland. The treated water is discharged into a pond system for storage and from there it is used for toilet flushing. The black water is discharged into the municipal sewer. Rain water of the entire neighborhood is infiltrated. Rain water from the roofs is collected, stored and used in the laundry machines. The resulting water consumption in Polderdrift is approximately 43 % lower compared to the average Dutch water consumption.

The main actors involved in the decision making were the tenants, the housing company and a green architect. The main drivers were to reduce water consumption, to reduce sewage overflows, and to create a nice neighborhood. The main barriers were the high investment cost and low experience with grey water systems.

The tenants are responsible for the in-house equipment (toilet, pipes, etc.) and for the operation and maintenance of the constructed wetland. Maintenance activities include cutting of the reed, regular inspection of the manholes and flushing of the drainage pipes once a year. Operation problems should be reported to the housing company. Two times a year a specialized company removes the settled sludge from the sedimentation tank. The effluent quality of the grey water system is not monitored on a regular basis. Site-inspections and an interview with one of the operating tenants showed that the status of the system at the time of the visit (autumn 2005) was not good. The sedimentation tank was not emptied that year and the frequency of water discharge to the reedbed was too high.

The interviewed tenants appreciated the system and also the required maintenance work. Two people said it made them more environmentally aware. Three out of the 5 interviewed tenants sometimes experienced smell. There were no noise complaints and no vermin problems.

Understenhöjden (1995, Sweden)

The site 'Understenshöjden' in Stockholm includes 44 rental houses. A local tenants' association was the main actor in the design and decision-making. The association cooperated with two project developers with experience in 'tailor-made' housing projects. The tenants implemented several ecological building measures of which one was a source-separating sanitation system. Urine is separated and transported once a year to a location near Lake Bornsjön. This location is owned by Stockholm Vatten and leased to a local farmer. After storage for six months (to remove pathogens) the urine is used to fertilize cereal crops. Grey and brown water was locally treated, but because the effluent standards could not comply with local effluent standards these flows are currently discharged into the municipal sewer system. Rain water from roofs and roads is infiltrated.

According to interviews with representatives of the tenants' association, the interviewed 5 tenants and one of the project developers, the main drivers for a source-separating sanitation system were nutrient reuse and the development of an innovative environmental technology. The role of the tenants in operation and maintenance is limited to the in-house equipment (toilet and pipes). The main operational difficulties encountered so far were problems with clogging of the urine pipes (approximately 2 times per year). Maintenance activities to solve this include flushing the toilet with hot water and soda, and cleaning the pipes with a mechanical snake.

The interviewed tenants appreciated the system and also had no problems with the cloggings and the required maintenance work. Two persons indicated that the system could produce some smell during clogging. There were no noise complaints and no vermin problems. Urine separation recovers nutrients for agricultural use and also potentially reduces nutrient emissions to surface water. According to Jönsson the emissions of N and P to water may decrease by 55 % and 33 %, respectively (Jönsson, 2002). The water saving capacity of the urine separation toilet is, depending on ones habits, approximately 5 – 40 L/p.d (Johansson et al, 2001). Urine transport from Understenshöjden over 33 km to Lake Bornsjön requires 44

MJ/p.y (Jönsson, 2002). However the energy savings for the conventional system and fertilizer production amount respectively 32 MJ/p.y and 75 MJ/p.y (Jönsson, 2002).

Ekoporten (1995, Sweden)
The site ‘Ekoporten’, consisting of 18 apartments, was an initiative of a local housing company to implement the latest technologies on sustainable building. Among other measures also a source-separating sanitation system was implemented. Urine is separated and, since 2002, transported to two local farmers and used on their land. The transport is paid by the housing company. The brown water undergoes a centrifugal liquid/solid separation in a so-called Aquatron system. The separated feces are mixed and composted with organic waste and wood chips. The flush water fraction and the grey water were treated in a three-chamber-sedimentation tank, an ultraviolet (UV) filter for disinfection and a horizontal-flow constructed wetland. In 1999 the UV filter and the horizontal-flow constructed wetland were replaced by a vertical-flow constructed wetland. The reason was a poor functioning UV-filter due to the high suspended solids concentration, leading to high amounts of e-coli in the effluent of the wetland. Also exposure to greywater in the horizontal-flow wetland was an argument to do replace this system. Although the system is now performing well, it is considered to connect the flush water and the grey water to the sewer. The reason is that the constructed wetland discharges on a sensitive river.

The main actors involved in the design and decision making were the housing company and local government. The main drivers were nutrient reuse, the development of an innovative environmental technology and the application of sustainable building measures. The housing company also considered having a green label as a driver. The main barriers were the high investment costs.

The role of the tenants in operation and maintenance is limited to the in-house equipment (toilet and pipes). There is a system manager for operation and maintenance of the constructed wetland. An important operational difficulty encountered in Ekoporten is clogging of the urine pipes. The applied pipe diameters are low and some pipes have angles of 90°. This occasionally leads to complete stoppages. The tenants flush the toilet relatively often in order to remove the sediments and also flush the toilet with soda. Based on the experiences in Ekoporten recommendations were made to use bigger pipes for urine transport (preferably 110 mm instead of 40-50 mm) and to use a slope of 1% for new applications.

Despite the cloggings the inhabitants were generally satisfied with the system. Occasional smell was reported during cloggings. There were no noise complaints and no vermin problems. Due to the installation of urine diverting toilets the water use in the area was lower than average. The urine needs a flush of 0.2 litres and the feces of 4 litres. With the same amount of flushes the toilet saves 25 % water compared to a conventional Swedish toilet (Vinnerås, 2001).

Gebers (1998, Sweden)
In January 1995 the tenant’s organization EKBO (Ecological Collective Housing in Orhem) was founded. The EKBO members initiated the idea to live in the empty building of Gebers. In cooperation with a housing company the building was renovated in 1998. It currently has

32 apartments in which between 60 and 80 people have been living over the years (Boverket, 1998). The appartments have dry toilets with urine separation. The feces are collected by a drop-hole and a 200 mm wide pipe into a plastic bag in a 140 litre (or smaller) bin (Krantz, 2005). The amount of separated feces and toilet paper is approximately 0.22 L/p.d (Palmquist and Jönsson, 2003). When the bin is filled the tenants carry it out of the basement to empty it at the compost site. The urine is collected and transported to the farmer at Lake Bornsjön. Grey water is discharged into the municipal sewer system.

The main drivers of the tentants of EKBO were nutrient reuse, reduction in water consumption and an environmental-friendly neighborhood. The tenants are responsible for all operation and maintenance activities with respect to the feces and urine. In the processing of the feces they can get in contact with the feces. They use protective measures (gloves) while empyting the bin. An important operational problem is the occurrence of flies that are attracted to the feces collection bin. According to Krantz (2005) all 26 respondents had experienced problems with flies at least once. Also clogging of urine pipes was encountered. The air from the feces bins in the basement is ventilated in order to avoid odors. The amount of nutrients recycled is for N, P, and K respectively 9, 1, and 2.2 kg/hh.y (Palmquist and Jönsson, 2003).

TECHNOLOGY SELECTION PROCESS

Table 2 summarizes the drivers and barriers for implementation of source-separating sanitation systems that were mentioned by the local stakeholders in Sweden and The Netherlands. The study showed that a number of the important drivers and barriers of the stakeholders to select certain technologies were different in the Netherlands compared to Sweden. In The Netherlands the interest in reuse of reclaimed wastewater as a measure to reduce the tap water consumption was a relatively important driver. This driver was – on average – rated lower in Sweden. Another noticeable difference was the higher interest in the recycling of nutrients in Sweden due to an active stimulation policy of the Swedish government to recover phosphorous. This formed an important driver for all Swedish actors in contrast with The Netherlands where nutrient recycling was generally not considered important at all. In Sweden also local governments such as Stockholm Vatten stimulated and facilitated the implementation of the studied urine separation systems. The water authorities in The Netherlands only played a passive role. In Sweden the protection of sensitive surface waters also rated higher than for The Netherlands. All actors address both in Sweden and in The Netherlands, rated higher investment costs as an important barrier. The last barriers is that in most urban areas already a conventional sanitation is present, and several actors value the system on its reliability and cost effectiveness.

Table 2 The drivers and barriers that were mentioned by the local stakeholders for implementation of non-conventional sanitation systems and their average score

Drivers	**Sweden**	**The Netherlands**
Reduction in water consumption	No	Yes
Reduction of pollutants' emissions to the environment	Yes	Yes
Recycling of nutrients	Yes	No
Development of innovative technology	Yes	Yes
Active governmental involvement	Yes	No
Discount on (waste)water fees	Yes	No
Barriers		
High costs	Yes	Yes
New technology	Yes	Yes
Presence of a conventional sanitation system	Yes	Yes

PERFORMANCE ASSESSMENT

Table 3 presents the performance evaluation of the various cases based on the assessment protocol that was developed for this project. The performance was assessed in comparison with conventional off-site wastewater transport and treatment.

- PI 1: An important conclusion with respect to PI 1 (public health) is that the two Dutch cases with local grey water treatment had no effluent monitoring systems in place. For the Swedish case Gebers the direct responsibility of inhabitants for emptying feces bins can be considered as a health risk according to our assessment protocol, although the involved people are well instructed and aware how to avoid risks.
- PI 2: All the investigated cases used local rain water infiltration system and sometimes had a rain water use system. This can be considered an improvement compared to the conventional system, because it reduces emission of pollutants through sewer overflows.
- PI 3: The total yearly costs for water supply and wastewater disposal compared to the conventional system were more or less similar for Groene Dak and Understenhöjden. The yearly costs for the inhabitants in Gebers were approximately 30% lower. Due to relatively high investments in equipment, the yearly costs for Polderdrift and Ekoporten were significantly higher. Gebers has a high level of nuisance due to frequent problems with flies. Moreover, this site also has a high O&M requirement by the tenants.
- PI 4: The two Dutch cases with local grey water treatment experienced (partial) system failures due to lack of operation and maintenance. The dominant failure reason for the urine separation systems in Sweden was pipe clogging. Pipe clogging can be controlled by extra maintenance activities of the tenants / house owners. For future cases recommendations for improvement have been made by Swedish experts.
- PI 5: The grey water treatment systems have the potential to significantly reduce water consumption (40%). The urine separation systems have a high potential in reducing emissions and in recovering resources (nutrients).

Table 3 Performance evaluation of the various cases based on the pre-defined performance indicators; +, 0, - indicate better, neutral or worse in comparison with the conventional sanitation system

Performance indicator		Groene Dak	Polderdrift	Understens-höjden	Ekoporten	Gebers
1. Public health protection		-	-	0	0	-
2. Sub functions		+	+	+	+	+
3. User perspective	Costs	0	-	0	-	+
	Nuisances	0	0	0	0	--
	O&M	0-	-	0	0	-
4. Robustness		-	-	-	-	-
5. Environmental aspects	Emission reduction	+	+	+	+	+
	Resource use / recovery	+	+	+	+	+

CONCLUSIONS

- This investigation showed that there were different drivers for the establishment of source-separating sanitation systems in three Swedish and two Dutch cases. For the Swedish cases the main drivers of the involved actors were nutrient recycling, reductions of emissions and an active policy of the local government. In the Netherlands the main drivers were the reduction of water use, reduction of sewer overflows and reduction of emissions. The main barriers in all cases were high investment costs and the small experience with new sanitation approaches systems compared to the conventional system (sewers and off-site treatment).
- The investigation shows that all five demonstration cases were operational and well-functioning after 8 – 12 years of operation and that most people using the systems are satisfied about the performance and use of the systems.
- The two Dutch cases with local grey water treatment illustrate that decentralised grey water treatment systems have a large potential to reduce water consumption (upto 40%). Both systems lack an effluent monitoring system which in the used performance assessment is considered as a risk to public health. Some (partial) system failures have been encountered due to lack of operation and maintenance by inhabitants.
- The three Swedish cases show that urine separation systems have a high potential in reducing emissions and in recovering resources (nutrients). The dominant failure reason for the urine separation systems in Sweden was pipe clogging. Pipe clogging can be controlled by extra maintenance activities of the tenants / house owners. For future cases recommendations for improvement have been made by Swedish experts. One of these sites had frequent problems with flies and a high O&M requirement by the tenants.
- All five cases were characterised by relatively higher investment costs compared to the conventional sanitation system. The yearly costs (capital and operation expenditures) of two cases in Sweden were lower than the conventional system.

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3 Assessment of non-conventional source separated grey wastewater treatment and agricultural reuse in Palestinian rural areas

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Abstract

Source separated of grey and black wastewater streams and house onsite treatment of grey wastewater and reuse of treated effluent for irrigating crops are increasingly perceived acceptance and application in the Palestinian rural developments. The application of those non conventional sanitation systems are steered by NGOs which have constructed so far more than 600 units all over the West Bank rural areas. The main goal of this research was to assess the impact of those systems on the environment, health and socio-economic factors at household level according to the beneficiaries' perception as so far very little is known about those issues. The drivers and barriers of constructing those systems were also assessed. This research was performed mainly by the means of questioners filled in Qebia village where 47 house onsite sanitation systems have been recently implemented. The results of this research showed that the source separated house onsite wastewater collection, treatment and reuse systems have very promising future in Palestine. However, further improvements are still needed to solve the problems of odour emission, and proper system is required to handle the black wastewater in order to reduce the desludging frequency and its potential risk of groundwater pollution. The operational and maintenance requirements of the system are rather limited to routine work like cleaning and desludging, and thus the system is robust, but still the effluent quality compliance with local effluent disposal requirements should be assessed. The biggest incentive for applying this system is the reuse of treated grey wastewater for irrigation purpose which is socially accepted. The application of those systems is limited to the availability of external funds. The main worries people might have over the constructing of those house onsite systems are health risks, flood concerns, and odour emission. Those issues should be given special attention when implementing other projects. Accordingly, the house on site source separated wastewater management systems is very efficient in wastewater treatment and food production.

Keywords: grey wastewater; black wastewater; source separated; house onsite; reuse; perception; Palestine

2 Introduction

The status of wastewater management in Palestine is extremely critical. Of the total Palestinian West Bank population, only about 30% is served by centralized sewerage systems and only about 6% is served with adequate centralized treatment facilities (Mahmoud, 2002;

Mahmoud *et al*., 2003). Wastewater from non-sewered localities is mostly disposed of in cesspits. About 73 percent of the households have cesspit sanitation and almost 3 percent lack any sanitation facilities. The situation even becomes more critical in the rural communities where less than 2 percent of the households are connected to sewerage networks. This is mainly due to lack of financial national funds and inequitable political power (Al-Sa'ed and Mubarak, 2006).

Cesspit is certainly an improper disposal system taking into consideration its negative environmental impact. Liquid in cesspits often percolates into the ground. It is also quite common that cesspits become clogged after a certain period of operation. In such a case the content has to be emptied more frequently by rather expensive tankers. The cost of cesspits desludging may reach fifty US$ per month for a household, representing for some families more than 20% of their monthly income. Currently, the tankers dispose the evacuated septage within the surroundings of the communities, mainly in the nearby open areas, and to a lesser extent in the existing treatment plants which are mostly outdated and overloaded. The infiltration of wastewater into the cesspits surrounding soil and the present practice of septage disposal has seriously impacted the quality of water resources and soil. Over land wastewater seepage from cesspits when become full is a common phenomenon leading to foul odour emission in addition to the imposition environmental pollution and health hazards. The emitted odour is frequent at the time of cesspit emptying, and thus causing occasional disturbances. In order to minimize the regular desludging of cesspits and due to water need and shortage, some families use untreated grey wastewater for irrigating trees in backyards. This in turn causes nuisance due to mosquito breeding, odour emission, aesthetic problems, soil pollution, etc.

Due to the financial and environmental problems experienced with cesspits and the increasing demand for irrigation water, non-conventional house onsite wastewater collection, treatment and disposal systems had been introduced since the late 1990s. So far around 600 house onsite wastewater management systems have been implemented in several Palestinian rural areas by local non-governmental organizations (NGO) as the Palestinian Hydrology Group (PHG) and Palestinian Agricultural Relief Committees (PARC) (e.g. PARC, PHG). Those sanitation projects have been financially supported mainly by international aid agencies (e.g. ACDIVOCA, IDRC, etc). Most of the implemented systems comprised of separate collection and treatment of black and grey wastewater and utilizing treated grey wastewater in irrigated agriculture. The black wastewater is disposed and stored in cesspits, and the grey wastewater is treated in grey wastewater treatment system (GWTS). Most of those rural GWTS consist of anaerobic pre treatment step by the means of septic tank followed by anaerobic upflow gravel filter, namely Septic Tank-Upflow Gravel Filter, and further polished by a post treatment "aerobic" multi layer filter. The effluents are mostly disposed by the means of drip irrigation systems for irrigating the homes' gardens (Burnat and Mahmoud, 2004; 2007).

Al-Sa'ed and Mubarak (2006) reported that the decision of installing a particular onsite treatment system in the Palestinian rural areas is primarily made within the NGOs by non-experienced developers based on principles of low-cost treatment systems and NGOs profitability. Once the onsite systems are installed they are usually rarely checked again or maintained. The authors claimed that in all Palestinian small communities, existing onsite sanitation facilities are inadequately designed, poorly sited, and rarely maintained over their service life cycle.

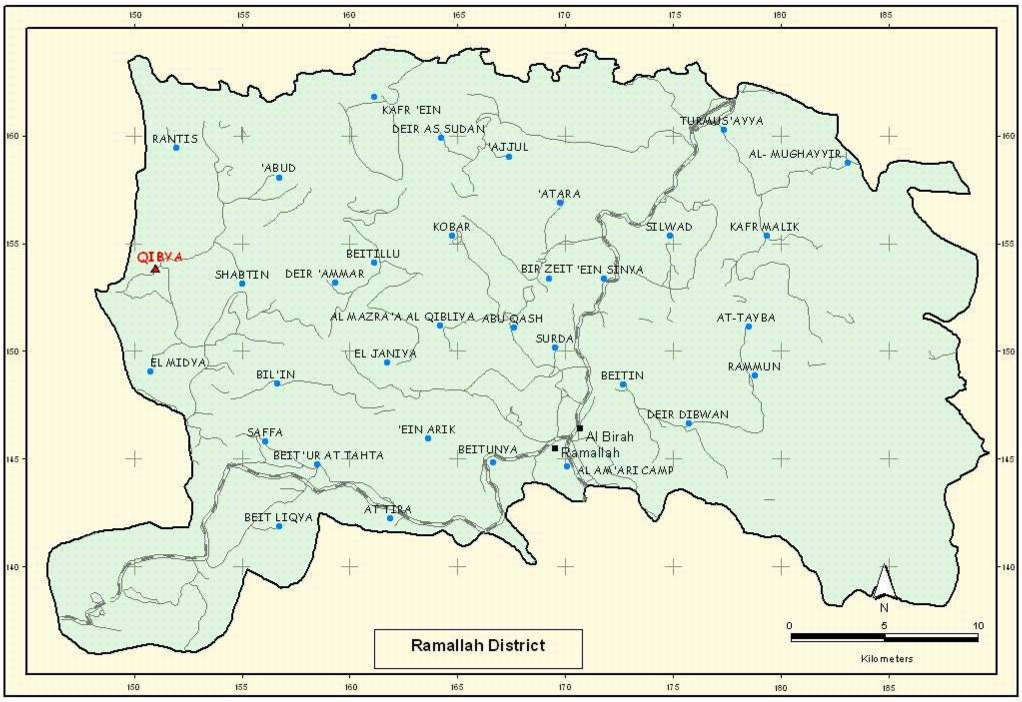
The main goal of this research is to assess the impacts of hose onsite source separated wastewater management systems on environment, health and socio-economic factors at household level according to beneficiaries' perception. The drivers and barriers of implementing those non conventional sanitation systems were assessed. Qebia village in the West Bank was chosen to carry out this study where the most recent house onsite sanitation project was implemented consisting of 47 house onsite grey wastewater treatment and reuse units. The project was implemented during the period september/2005 and June /2006. The investigations were conducted by the means of field survey by distributing questionnaires for all beneficiaries and personal interview with six main decision makers and sanitation experts. Since any sustainable water resource should be environmentally friendly, socially acceptable, and financially viable, those main themes were discussed. It is widely agreed that progress towards sustainable services requires the integration of these three elements into the decision making process so the project might have future.

3 Study area

Qebia is one of the middle income localities living under water stressed environments located in the western parts of Ramallah district (map 1). It has a population of 5,300 inhabitants. This village is one of the Palestinian rural developments that is not expected to be sewered for many years to come. That is due to the national policies which are in favour of providing sanitary services to the main urban centres, and due to political unrest, lack of national funds and the crawling course of the overall development.

The Qebia Women Cooperative (QWC) had initiated and implemented with financial aid from ACDIVOCA 47 house onsite- source separated – grey wastewater treatment and reuse project serving 48 houses in the village. Each of the served families was provided with a one treatment unit except two houses were provided with a one common unit. Each of the grey wastewater treatment units is intended to treat about 0.5 cubic meters per day per family. The treated grey wastewater is being reused for irrigating home gardens plants, fruit trees and vegetables eaten cooked.

The ACDIVOCA and QWC, the main actors of this project, aimed at improving the wastewater management system in Qebia households, and at creating new sources of water to irrigate houses gardens for food production.



Map 1: Location of study area

4 Description of the house onsite wastewater management system used in Qebia

The house plumbing fixtures installations were changed so as to separate the grey and black wastewater streams. The black wastewater (from toilet) is discharged into the existing cesspit and in other cases into modified cesspits which were constructed within the framework of the project. The modified cesspit is built from bricks with a honeycomb structure and surrounded with around 60 cm thick gravel layer in order to enhance water seepage into soil by suspended solids removal (Fig. 1). The grey wastewater (shower, kitchen, sinks and washing machine) is conveyed to a house onsite grey wastewater treatment plant (GWTP).

The GWTP consists of an anaerobic pre-treatment step followed by an 'aerobic' multi-layer filter (sand, coal, gravel). The anaerobic step is comprised of a septic tank followed by a two stage upflow gravel filter. The septic tank receives the grey wastewater from the house through a 2-inch or 4-inches diameter PVC pipe. The raw grey wastewater flows through a screen to the first compartment which is the septic tank by means of a T shaped PVC inlet, with a one end directed upward subjected to the atmospheric pressure and the other goes down to the bottom of the septic tank at a level of about 30 cm from the bottom of the reactor. Accumulation of grease occurs by installing a T-shaped pipe at the outlet at same level of the inlet T. The second and third compartments are upflow graduated gravel filters, and the fourth is a balancing tank for holding the pre-treated effluent where a submersible pump is installed. The pump lifts the water to a multi-layer aerobic filter, and after then effluent is collected in a storage tank from where it is discharged into the irrigation network of the house garden.

The intended design hydraulic retention time of the septic tank is 1.5 to 2 days. The upflow gravel filter is designed as a gravity loaded system, works at maximum flow at day hours and zero flow at night hours. The gravel filter media are mainly hard crushed stones or washed wadi gravel of hard limestone of 3 cm diameter (in the first gravel filter) and 0.7 cm in the second stage gravel filter. The top of the filter was left without concrete cover, and instead was covered with a thin layer of soil and planted with flowers. This is mainly to make the upper part of the filter to function as a biofilter to oxidise the emitted mal odorous compounds. In this line, the headspaces of the septic tank and the balancing tank were connected by a tube to underneath the upper part of the filter to enhance odour removal. Meshes were provided to the tubes going upward and exposed to atmosphere in order to prohibit mosquito entrance to the system and the subsequent growth propagation. The treatment plants have been constructed with concrete or/and bricks. A schematic diagram of the GWTP is presented in Fig 2.

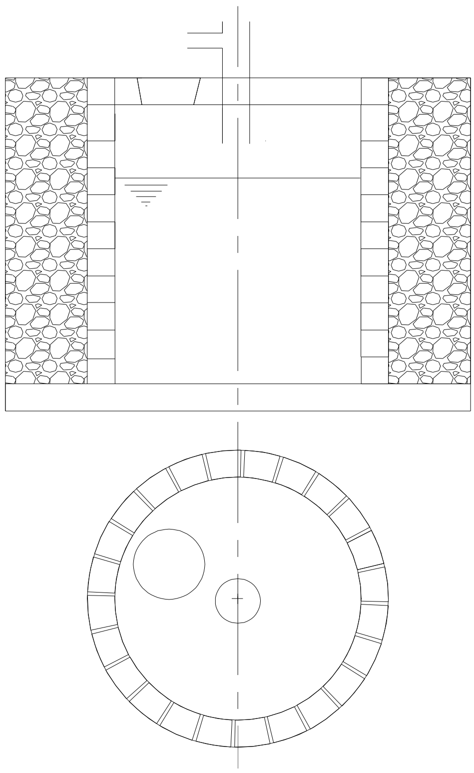


Fig. 1. The modified cesspit for black wastewater disposal

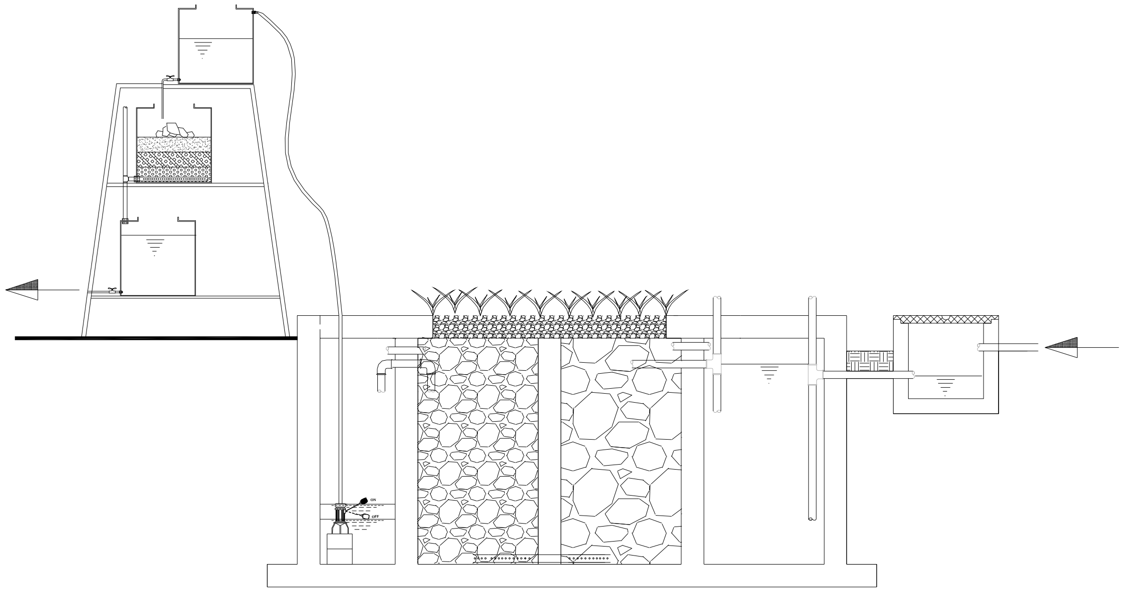


Fig. 2. The Septic tank- Up-flow gravel filter household grey wastewater treatment plant applied for 47 houses in Qebia village/ Palestine

5 Methodology

5-1 Field investigations

Several field technical site visits were conducted to Qebia village where grey wastewater treatment systems had been applied. The wastewater treatment units were visited, observed and checked visually, including all collection and treatment units as well as the irrigation system, the planted crops and the irrigated soil. Beneficiaries were met and various subjects were discussed over the system performance, perception and project history.

5-2 Questionnaire

The applied ecological sanitation systems in Qebia village were assessed by two unified questionnaires formats which were developed and distributed in March 2007. The first questionnaire, which is the core of this study, was designed to the systems owners (beneficiaries) and the other was designed to the decision makers and sanitary experts. The specialized questionnaires were designed according to statistical principles and written in the Arabic language, the mother language of the respondents, and a person from each household was interviewed. The beneficiary’s questionnaires were distributed and filled in by all of the

47 served houses. The questionnaires of the decision makers and sanitary expert interview were limited to around six persons as those key persons are very few, and so data collection from them was based on personal interview and discussion. The questionnaires covered the following issues:

I. System owner interview:
Vast of subjects were discussed with the beneficiaries to understand their perception, attitude and drivers and barriers for applying the house onsite wastewater management system. The questionnaire focused on the following main issues:

- Is the sanitation system socially and culturally accepted?
- Is the system affordable with respect to capital and operational and maintenance costs?
- What benefits have you gained from the sources house onsite separated grey and black wastewaters management systems?
- Are there any problems experienced with the sanitation system?
- Is it safe to have a house onsite wastewater management system?
- Is it convenient to have an onsite sanitation system?
- What are the drivers and barriers for choosing the house onsite source separated sanitation system

The questionnaire consisted of the following main headings:

- Family structure
- Household water uses and infrastructure
- Invisibility and user comfort and acceptance of the ecological sanitation system
- Robustness of the sanitation system: system failures; operation; maintenance; compliance with effluent standards
- Health impact of the sanitation system
- Drivers and barriers: environmental aspects; environmental and public health aspects; separation (social/technical); financial aspects; social and managerial aspects

II. Decision makers and sanitary expert interview
This questionnaire focused mainly on system description and the drivers and barriers of the applied sanitation system.

3-3 Statistical analysis

The data collected from the beneficiaries were analyzed using the SPSS (Statistical Package for Social Science) program for windows- Release 11.0.0, SPSS® Inc. (2001). The data collected from the decision makers and sanitary experts are presented qualitatively.

6 Results and Discussion

6.1 System owner interview

General information on the families and houses

The survey results revealed that the average family size is 9.4 which entail a large family size, a typical characteristic of the developing countries. The families in Qebia are rather poor with average monthly income of around 400 US$ which represents almost 40 US$/person/ month. All houses have rather big gardens with an average area of 1338 m^2 and in the range 200-700 m^2. Of the total 47 surveyed houses, only 13 houses have rainwater harvesting systems constructed from concrete. The rainwater harvesting systems are located at a distance in the range of 8-100 m with an average value of 36.8 m. This indicates that the wastewater management systems might cause pollution of the harvested water as the Palestine Standards Institution (PSI, 2003) impose a minimum distance of 15 m with the cistern located upstream.

Of the all surveyed household gardens, 100%, 91.5%, 14.9% and 100% are planted respectively with fruit trees, vegetables, forestry tress and flowers. The percentage of families that use treated grey wastewater in irrigating the planted crops of fruit trees, vegetables, forestry tress and flowers are respectively 97.9, 91.5, 4.3 and 95.7%. The produced crops are mainly used for household consumption (93.6%) and the other 6.4% sell them. This shows that the application of the source separated house onsite wastewater management system have encouraged the use of treated grey wastewater in agriculture which have consequently resulted in improving the food security.

Invisibility and user comfort

The people satisfaction with the applied sanitation system is very promising as 74.5% of the beneficiaries are very satisfied and 21.3% are satisfied, and only 4.3% are not satisfied. The people satisfaction with the black and the grey wastewater collection/treatment systems expressed as very satisfied, satisfied and unsatisfied are respectively 66, 12.8 and 21.3%, for the black system and 80.9, 10.6 and 8.5% for the grey system. This shows that people are more satisfied with the grey wastewater system as compared with the black one, which points that further improvement of the black system is still needed. The aesthetic impact of the system is very positive as 97.9% of the interviewed people stated that it has a good impact, and 2.1 % find it acceptable but no one perceived it negatively. With respect to odour emission, 42.6% of the interviewed people stated that no odour is emitted from the system, and 12.8% of them sated that there is strong odour emitted and 44.7% stated that there is rather acceptable odour emission. Figure 3 demonstrates that the odour emission from the wastewater management system is mainly noticeable during July, August and September which are rather the hottest period in the year. The raised complains over smell during summer time are expected to be people living more outdoors as compared with the cold period of the year.

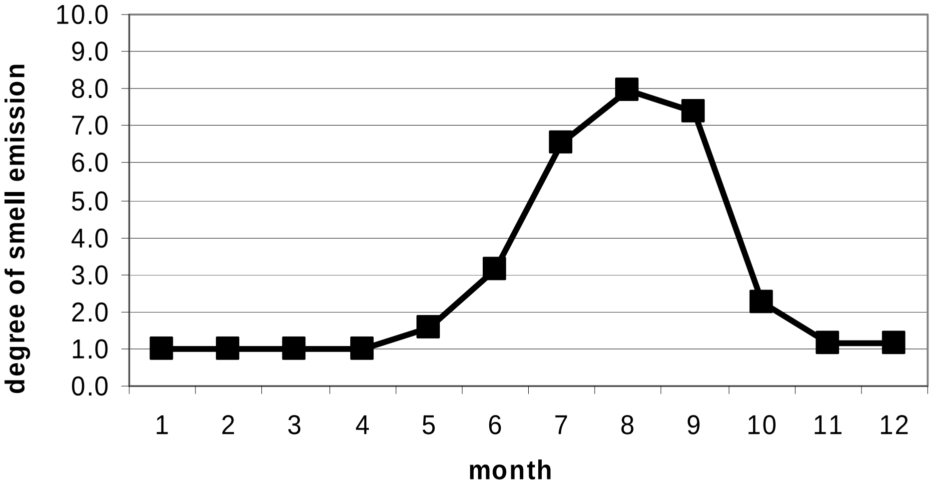


Fig. 3. Degree of smell emission over the year from the grey wastewater treatment plant applied in Qebia village/ Palestine

The produced noise from the system is rather negligible as stated by 97.7 % of the people and 2.1 % sated that it is acceptable. 10.6% of the interviewed people stated that the system is not enhancing mosquito breeding, but 78.7% think that the system slightly enhance mosquito breeding, and 10.6% of the people sated that it enhances remarkably mosquito spreading. The vast majority of the beneficiaries (95.7%) recommend the system to be applied for other non served houses and only 4.3% do not recommend it at all, but no one recommend any modifications in the system as a pre condition for accepting the system. The majority of the people are so satisfied with the onsite sanitation system as 89.4% of them stated that in case the village is served with a centralized sewerage system; they are not going to give up the onsite system because of their need to reuse the treated effluent. The other 10.6% prefer the centralised system because of odour emission from the onsite system which is the most important reason reported by people, and to a lesser extent people complained about the unpleasant seen of the pipes over ground, rejection of reusing treated effluent for all types of crops, frequent desludging of black wastewater and seepage, the up ground positioning of the grey wastewater treatment plant and the close distance of some of those plants from the served houses. Of the total 47 beneficiaries, 16 of them reported 21 complains about there house onsite sanitation system. The complains are compiled in Table 1.

Table 1. Complains reported by 16 beneficiaries out of 47 about experienced troubles with their house onsite grey and back wastewater management systems

Complain	**Black wastewater system**	**Grey wastewater system**
Seepage/ flooding	4	2
Aesthetically unpleasant/ close to house	2	
Odour emission	6	5
Desludging cost	2	
Insects infestation/ close to house	2	
Sub-total	16	7

System robustness

The robustness of the system is described in terms of system failure, operation, maintenance and effluent quality compliance with the effluent standards. The sanitation system as stated by 95.7% of the people had been monitored. The monitoring activities included routine work only such as checking the treatment basins (Fats removal; seepage, etc.), irrigation network, pump, influent manhole, and the maintenance activities included repair and cleaning. No satisfactory data is available on system performance in terms of effluent quality and removal efficiencies. The both grey and black wastewater management systems have hardly any operational problems with an average value of around once per year. The problems encountered with the wastewater management system and the adopted solutions for maintaining the system are presented in Table 2. The results clearly reveal that the system requires minor effort and mostly the activities are rather routine maintenance work of cleaning and desludging the black wastewater collection pit.

Table 2. Problems and solutions that have been experienced with the black and grey wastewater management system and the solutions used by the beneficiaries

		Solution					
	Problem↓	Not exist	dseludging	Fixation	Water pressure	Pipes cleaning	**Subtotal**
Black wastewater management part	Flooding		4				2
	Seepage	3		1			4
	Odour emission						
	Pipes blockage					3	3
	Pipes disconnection						
	Sub-total	3	4	1		3	11
Grey wastewater management part	Flooding						
	Seepage			4			4
	Odour emission	1					1
	Pipes blockage				1	3	4
	Pipes disconnection	1					1
	Sub-total	2		4	1	3	10
All parts	Flooding		4				4
	Seepage	3		5			8
	Odour emission	1					1
	Pipes blockage				1	6	7
	Pipes disconnection	1					1
	Total	5	4	5	1	6	21

The applied wastewater management system requires very little operational and maintenance efforts. The beneficiaries exert 0-200 hours/year for maintenance and operation works with an average value of 41 hours/ year. The sludge production from the system is rather low since the average yearly desludging rate is 1.6 and in the range of 0-12. The desludging cost of the existing wastewater management and the previously used cesspit system is in average 10 US$/time but reached maximum values of around 30 US$/round.

Public health

In terms of people exposure to touching wastewater, the system is rather safe as 38.3% of the beneficiaries stated that family member are never exposed to touching wastewater and 53.2% stated that the incidence of touching wastewater is very rare. Nonetheless, the other 8.5% of the beneficiaries stated that they do touch the wastewater. The majority of the people believe that the introduced wastewater management system reduces diseases, and 10.6% sated that they have no clue, but no one worries that the grey wastewater system might cause diseases. Most of the beneficiaries reported that the system is not causing any physical harm, and 14.9% stated that it is not very likely.

Miscellaneous

The main benefits people gained from the application of wastewater management systems are reusing of treated effluent for irrigation (97.9%), raising the hygienic status (97.9%), reducing the cesspits desludging frequency (63.8%). The major problem experienced with the onsite wastewater management system is the odour emission (stated by 11 beneficiaries), seepage from the back wastewater pits (stated by 6 beneficiaries), and to a lesser extent increased insects infestation (stated by 2 beneficiaries) and the small size of the black wastewater pit (stated by 1 beneficiary). The wide scale implementation of the system is apparently limited to the availability of external funding as 66% of the interviewed people stated that they if external funding was not available, then they would not have constructed the system from there own expenses, but 34% of them stated that they would have done. The people who stated that they would not have constructed the sanitation system on their own expenses attributed that mainly to incapability to afford the system considering the difficult economical situation (stated by 30 beneficiaries), the lack of knowledge about the system (stated by one beneficiary), and the no need for the sanitation system (no need for irrigation water and cesspit is never full). On the other hand, the people who stated that they are willing to construct the system on their own cost attributed that mainly to the need for extra water for irrigation (stated by 9 beneficiaries) and solving the problem of wastewater disposal and treatment (stated by 2 beneficiaries). The desludging frequency has been reduced from 2.2 once/year (the range 0-20) for the previously applied cesspit to 1.6 once /year (the range 0-12) for the new wastewater management system.

Drivers and barriers

Environmental drivers

The environmental aspects of the waste water management system that have been important for the beneficiaries and other actors when were selecting the system are presented in Table 3. All beneficiaries (100%) stated that all of the environmental aspects which are presented in Table 3 were important when they decided to serve their houses with the household onsite sanitation systems, with the exceptions of nutrient recycling, and groundwater and surface water protection. With respect to nutrient recycling, 85% of the people answered it was important aspect and 97% considered groundwater and surface water protection important. All of the envisaged environmental aspects, except recycling of nutrients, have been completely achieved as stated by more than 90% of the interviewed people and 80% of the people stated that the recycling of nutrients had been achieved.

Table 3. Environmental aspects of the wastewater management systems which were important for the beneficiaries and other actors when selecting the source separated house onsite wastewater management system in Qebia village/ Palestine

- Positive feeling about environmental behaviour
- Water saving
- Prevention of drying out of soil
- Reduction of water emissions
- Recycling of water
- Protection surface water
- Protection of ground water
- Recycling of nutrients
- Reduction of energy use
- Quality of neighbourhood landscaping

Environmental and public health barriers

The barriers that stood in the way of incorporating non-conventional elements in the design and planning stage, and the percentage of people who considered those as barriers are presented in Table 4. The results reveal that the main obstacles in implementing the onsite sanitation system are the health concerns, flood risks resulting from effluent disposal and the potential of odour emission. Those issues should be given special attention when implementing other projects.

Table 4. The barriers that stood in the way of incorporating the non-conventional source separated house onsite wastewater management systems in Qebia village/ Palestine, and the percentage of people who considered those as barriers

Health risks (biological)	51.1
Health risks (chemical hazards)	44.7
Flood risks	48.9
Physical injury from householder access to equipment	36.2
Odour emission	46.8
Insects infestation	38.3

Separation (social/technical)

The separation of black and grey wastewater in existing houses might be a problem because of the possible need to destruct the tiles which causes extra cost and annoyance. However, the results are not showing that as 68.1% of the interviewed people are not considering the separation as an obstacle neither incentive, while 31.9% considered the separation as an incentive for accepting the house onsite sanitation system. This is due to the existing household plumbing system which was already separated inside the houses and so additional need for outside separation was possible without too much damage. The intention of reusing treated effluent is the reason for considering the separation as an incentive which is merely due to socio-cultural roots. No body stated that the separation was an obstacle, 18 beneficiaries stated that the separation was a driver because they intend to reuse the grey wastewater (raw or treated) for irrigation but not the black and also the separation will reduce the desludging frequency of the black wastewater cesspit (stated by 3 beneficiaries), and the other beneficiaries stated that the separation has no influence on the decision of implementing the onsite sanitation system because they had already separated the black and grey wastewater pipes in their houses from the far beginning of constructing the houses.

Financial drivers and barriers

The financial considerations that were drivers or barriers of decision to incorporate non-conventional elements in the design are presented in Tables 5 and 6. The results clearly reveal that the availability of external funds is a key issue in implementing the sanitation system. The financial revenues coming out of implementing the sanitation system like reducing water consumption, garden irrigation, and nutrients recirculation were also very important elements for accepting and thus implementing the system. Surprisingly, the separation of black and grey wastewaters was a driver element in the process of implementing the sanitation system, and was never perceived as barrier by any of the beneficiaries. This indicates that the people socio-cultural heritage might be much stronger than the financial aspects of the sanitation system.

Table 5. Financial considerations that were drivers or a barrier of decision to incorporate non-conventional elements in the design

Financial consideration	**Driver**	**Neutral**	**Barrier**
Capital cost as compared with the previously applied conventional cesspit system	12.8	12.8	74.5
Operating cost as compared with the previously applied conventional cesspit system	17	14.9	68.1
Availability of external funds	97.9	2.1	0
Beneficiaries financial contribution to the capital cost	0	76.6	23.4
Reduced drinking water consumption and thus lower bills	97.9	2.1	0
Separation of house internal grey and black wastewater piping systems	70.2	29.8	0
Financial aspects of garden irrigation	97.9	2.1	0
Nutrients availability in monetary terms	74.5	25.5	0

Table 6. Extent of the financial considerations that played a role in the implementation of the non-conventional house onsite wastewater management system

Financial consideration	**Important in accepting the system**	**Big role in hesitation**	**No role**
Capital cost as compared with the previously applied conventional cesspit system	97.9	0	2.1
Operating cost as compared with the previously applied conventional cesspit system	91.5	0	8.5
Availability of external funds	97.9	2.1	0
Beneficiaries financial contribution to the capital cost	44.7	8.5	46.8
Reduced drinking water consumption and thus lower bills	95.7	2.1	2.1
Separation of house internal grey and black wastewater piping systems	70.2	0	29.8
Financial aspects of garden irrigation	95.7	2.1	2.1
Nutrients availability in monetary terms	70.2	19.1	10.6

Social and managerial drivers and barriers

The social aspects of the sanitation system those were important for the beneficiaries and other actors to realise the non-conventional house onsite sanitation system are presented in Table 7. The results clearly show that the people obligations to manage there household wastewater is the most important factor for opting for the emerging sanitation system, followed by the interest to improve the overall living conditions and reducing the nuisance caused to the neighbours by the previously applied sanitation systems and practices.

Table 7. Social aspects of the sanitation system those were important for the beneficiaries and other actors to realise a non-conventional design expressed as percentage of the respondents out of the total beneficiaries

Aspects	**Important (%)**
Intensive contact with neighbours / Collaboration with neighbours	76.6
Involvement in sanitation / Taking responsibility for your household water management system, e.g. water saving, reducing emissions	100
Improves quality of living	97.9
Religion	0

The social and managerial considerations those hampered incorporation of non-conventional elements in the design are presented in Table 8. The results indicate that lack of experience and vision in the system performance and operational requirements were among the most important factors which hampered the implementation of the house onsite sanitation system. This leads to the conclusions that the existence of successful pilot projects is essential for wide acceptance of the house on site sanitation systems. When the beneficiaries were asked if they could do the project again, if they would have done it the same way, they mostly answered yes (37 beneficiary) and the rest complained about the smell and the plant close distance to the houses.

Table 8. The social and managerial considerations those hampered incorporation of non-conventional elements in the design expressed as percentage of the respondents out of the total beneficiaries

Aspects	**Caused hesitation (%)**
Difficult technology as compared with the previously applied system	42.6
Worries about the performance of the newly introduced sanitation system	48.9
Maintenance responsibilities unclear	38.3
Maintenance burden on householders	36.2

Decision makers and sanitary expert interview

The discussion with the decision makers and sanitary experts revealed that the main drivers from implementing the sanitary system depend on the main function of the NGO. The clearly distinguished functions are (1) development of water resources, and (2) agriculture development and food security, and (3) rural and marginal areas development. Based on that, the main drivers for implementing those house onsite sanitary projects including Qebia project varied according to the implemented organization function, as well as the organization financial benefits. Most of them stated that they opt for the house onsite rather than the community onsite because people do not like the community based systems since they worry from the unclear responsibilities for operation and maintenance works and potential conflict over those.

7 Conclusions and recommendations

The results of this research showed that the source separated house onsite wastewater collection, treatment and reuse systems have very promising future in Palestine. However, further improvements are still needed to solve the problems of odour emission, and proper system is required to handle the black wastewater in order to reduce the desludging frequency and its potential risk of groundwater pollution. The operational and maintenance requirements of the system are rather limited to routine work like cleaning and desludging, and thus the system is robust, but still effluent quality compliance with local effluent disposal requirements should be assessed. The biggest incentive for applying this system is the reuse of treated grey wastewater for irrigation purpose which is socially accepted. The application of those systems is limited to the availability of external funds. The main worries people might have over the constructing of those house onsite systems are health risks, flood concerns, and odour emission. Those issues should be given special attention when implementing other projects

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4 Decentralised wastewater reclamation systems in Beijing – adoption and performance under field conditions

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Abstract
To alleviate water-scarcity, Beijing has an integrated strategy on water-recycling involving a mixture of off-site and on-site wastewater reclamation systems. It is estimated that approximately 300 decentralised wastewater reclamation systems are in operation, producing 50,000 – 60,000 m3 / day of second quality water that is used for toilet flushing, landscape irrigation, street cleaning, car washing, etc. The objective of the research described in this paper was to analyze the adoption and technical performance of these systems based on a number of case studies.

Keywords: decentralized wastewater reclamation, water-scarcity, Beijing, China

1. Introduction

Beijing, the capital of China, is located on the northern edge of the North China Plain. The city covers 16,800 square kilometer and includes four urban districts, 10 suburban districts and ten counties. Beijing, like other Chinese cities, has a rapidly increasing population. In 1970 the population counted 8.1 million people, which increased to 14.6 million by the end of 2003 (Bureau of Statistic of Beijing Municipality, 2004). It is expected that the city will count 17.4 million citizens by 2020.

Beijing is one of the driest cities in the world. The per capita fresh water resources are currently about 300 cubic meters per year, i.e. one-30th of the world's average. It is foreseen that the available water resources will not meet the increasing water demand in the near future, due to increasing population and decreasing groundwater resources. Sources at Tsinghua University and the Beijing Municipal Urban Planning Institute predict that the gap between water requirement and natural water supply will be 1.2- 3.0 billion m^3 per year in 2010 (Jia et al, 2005).

In order to alleviate water scarcity, the municipal government of Beijing is encouraging water users in the city to make use of decentralized wastewater re-use systems (DWRSs). In a regulation that was issued in 1987, hotels and public buildings that exceed a certain size are required to construct their own (local) wastewater reclamation systems. The treated wastewater is locally used for toilet flushing, landscape irrigation and urban river revival and road cleaning. The high number of DWRSs is unique in the world and provides valuable insights into the potential and constraints of decentralized wastewater reclamation which could be of use for other water-stressed cities.

Although the regulation requiring the establishment of decentralized wastewater reclamation systems is in force now for almost 20 years, detailed information on the adoption and technical performance of these systems is lacking (Water Saving Office of the Beijing Water Authority, 2006). The objective of the research described in this paper was therefore to analyze the adoption and technical performance of these systems based on a number of case studies. The results described in this paper are part of a larger research that is in progress. The cases were analyzed by:

- Investigating the technologies that were used and their performance (technical, financial, operation & maintenance, effluent quality).
- Assessing the drivers and barriers of the stakeholders that were responsible for implementation of the decentralized wastewater reuse systems.

The paper starts by describing the regulatory framework and than describes the methods that we used for the investigation. Subsequently it provides the results and conclusions.

2. Wastewater reclamation in Beijing

Measures for alleviating water scarcity

In order to alleviate the water scarcity, the Beijing Municipal government has taken various measures (Wei, 2005). Reducing consumption through water saving has a high priority. A savings of 410 million cubic meters is planned for 2010. The Beijing Water Authority makes use of communication campaigns to make the general public aware of the water scarcity and to encourage the implementation of water-saving devices. An increase in the price of water functions as an economic lever to encourage water saving and to encourage the use of recycled water. Also water-saving and water recycling in the industry and in agriculture is receiving much notice.

A measure that gets much international attention is the south-to-north water diversion project that will transport water from the Yangtze River Valleys to the North China Plain. The south-to-north water diversion project will have three water diversion routes, namely the east route, middle route and west route. The middle route transport channel will bridge 1267 km from Danjiangkou to Beijing and will transport 1.2 billion cubic meters annually to the city transport water totals. This channel is planned to be ready in 2007.

A third important point of focus is the exploitation of non-traditional water resources (rain water, wastewater recycling). Various measures are taken to take advantage of flooding and to harvest rainfall, such as the construction of flood detention reservoirs to reduce flood peaks and replenish groundwater supplies and the establishment of small ponds to retain water for local use. Rain water harvesting should provide an additional 150 million cubic meters by 2010.

The recycling (reclamation) of wastewater receives a lot of attention, both at municipal level (Beijing Municipal government) as well as at national level (Ministry of Construction). The areas of recycling are industrial reuse, agricultural irrigation, scenic water reuse and municipal reuse (Jia et al, 2005; Wei, 2005). Municipal reuse includes toilet flushing, landscape irrigation, road cleaning, car washing, fire fighting and the use of water for construction (Ministry of Construction, 2002). According to the environment protection planning of Beijing approved by the state environment protection agency (EPA), 14 wastewater treatment plants with a total capacity of 1.2 billion cubic metres per year are planned for the urban area of the city (Wei, 2005; Wang et al., 2005). Over 20 treatment plant will be built in rural counties and satellite towns. By 2008 90% of the sewage of Beijing is treated before discharge or reuse. There will be 640 million cubic meters of water recycled in 2010.

Wastewater reuse planning
In order to facilitate wastewater reuse, the Beijing Municipal government is locating the treatment works according to their suitability and feasibility for recycling, as is illustrated in Figure 1. The city has set up special pipelines for transporting second quality water from these wastewater treatment plants to the various urban locations. Residential areas that are located in these areas should make use of the reclaimed water transported by the pipe networks.

The construction of pipelines to transport is a costly matter and is especially difficult in existing locations (Water Saving Office 2005, 2006). It is therefore that in large parts of the city, construction companies are required to recycling facilities at residential level. Also large-scale industries and enterprises, hotels, colleges and universities and office buildings are encouraged to set up small reclamation facilities. The Beijing Water Authority (BWA) also makes use of trucks to supply water to e.g. car washing companies that are not connected with the second quality water supply lines. So far, according to interviews with officials of the water saving office of BWA, there are more than 200 car washing companies using second quality water as their main water resource.

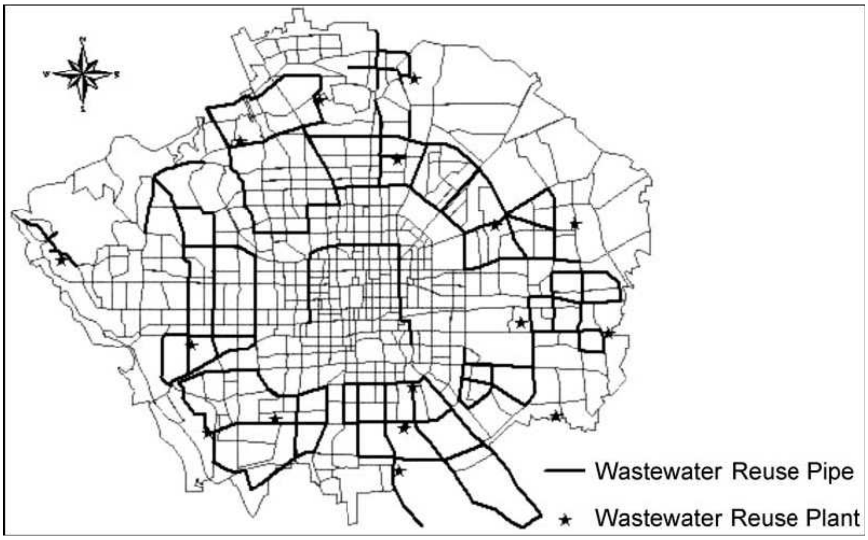

Figure 1. Wastewater reuse planning for the Beijing central region (source: Jia et al., 2005)

Decentralized wastewater reclamation facilities
In 1987, the Beijing Municipal Government issued the 'Management regulation on the construction of wastewater reclamation facilities in Beijing (trial)'. According to this regulation, hotels with construction areas exceeding 20,000 m^2 and all other public buildings

with construction areas exceeding 30,000 m^2 should construct their own wastewater reclamation facilities. Also new residential areas were encouraged to implement wastewater reuse. This last category was detailed in 2001 through a regulation that residential communities required exceeding 50,000 m^2 to build a reclamation facility.

Since 1987, various additional regulations have been enacted at both municipal and national level, encouraging and requiring wastewater reclamation in urban areas. In 2002, the General Administration of Quality Supervision, Inspection and Quarantine published water quality standards for Urban Reuse of recycling water. The reclaimed water quality should comply with the standards given in the following table:

Table 1. Reclaimed water quality standards (source: General Administration of Quality Supervision, Inspection and Quarantine, 2002)

No.	Parameter	Toilet flushing	Road cleaning Fire-fighting	Urban afforestation / landscape irrigation	Car washing	Construction
1	Color ≤			30		
2	pH			6-9		
3	Odor		No unpleasant smell			
3	Turbidity(NTU) ≤	5	10	10	5	20
4	Dissolved Solids (mg/l) ≤	1500	1500	1000	1000	---
5	BOD_5 (mg/l) ≤	10	15	20	10	15
6	Ammonia nitrogen (mg/l) ≤	10	10	20	10	20
7	Anion surfactants (mg/l) ≤	1.0	1.0	1.0	0.5	1.0
8	Fe (mg/l) ≤	0.3	---	---	0.3	---
9	Mn (mg/l) ≤	0.1	---	---	0.1	---
10	Dissolved Oxygen (mg/l)>			1		
11	Free residual chloride (mg/l)			≥ 1.0 after 30 minutes contact ≥ 0.2 at the end of pipes		
12	Coliform Number/L ≤			3		

According to Jia et al. (2005) up to 2002, more than 154 DWRSs had been built in the Beijing central region of which approximately 120 were in operation (Jia et al., 2005). The Water Saving Office of the BWA estimates that at present (2006) approximately 300 DWRSs are in operation and that another 100 are under construction, spread over the city on various scales and with different technologies. According to their estimatons these systems are producing 50,000 - 60,000 cubic meters of second quality water per day or 18 – 22 million cubic meters per year. In 2005 the gross amount of recycled water used by agriculture, industry, community and administration was estimated at 200 million cubic meters per year (WSO, 2005), which indicates that the share of the reused wastewater from the on-site facilities is approximately 10% of the total.

Involved institutional stakeholders

The main institution responsible for the implementation and control of the DWRSs is the Water Saving Office (WSO) which falls under the BWA (Beijing Water Authority). The WSO is responsible for communicating the policies and regulations regarding wastewater reclamation to the relevant stakeholders and the general public. During the development and design phases of construction projects the WSO has an advisory role on the reuse concept and the reclamation technologies and has to approve of the system. After implementation the WSO will test the correct installation of the system. During this phase WSO will usually send an effluent sample to the Environmental Protection Agency to test whether the quality of the water complies with standards.

Since 2005, there is also involvement of the Spatial Planning Committee of Beijing (SPCB) and the Construction Committee of Beijing (CCB). According to new regulations that were established in 2005, wastewater reclamation projects must be approved of by the SPCB before they are built. The CCB is responsible for construction projects in general of which the establishment of a DWRS is a (minor) part.

It is worthwhile mentioning that there is formal monitoring of the water quality of after the systems have been established. The EPA of Beijing offers services to measure the water quality on a voluntary basis. However, no records are kept of these measurements.

Methods

So far, information on 8 DWRSs was collected. The investigated cases were more or less randomly selected, based on our current knowledge and network of contacts. The total installed capacity of these 8 cases was 12,080 m^3/day while the actual treatment was approximately 5,500 m^3/day (it is noteworthy that these figures indicate that the WSO-estimations on the daily water production by DWRSs might be too low). Data were collected by interviewing the stakeholders related to the various DWRSs. Standardized interviews were made with the system owners, the system operators and the users of the reclaimed water.

Results

The investigated cases

This paper will use information of the five cases shown in Table as illustrative examples. The Table includes two universities and one hotel (Beijing Jiaotong University, Beijing Normal University and Xin Bei Wei hotel). All the universities in Beijing (12 in total) and most of the larger hotels have their own wastewater reclamation facilities, following the regulations of 1987. Bobo Garden House and Beiluchun are both examples of residential areas with reclamation facilities.

The approach and techniques implemented at the DWRSs are quite diverse. Two of the shown examples only treat grey water, while the other three treat the total flow of domestic water (grey and black water). Various treatment techniques are used, such as activated sludge, contact oxidation (a type of moving bed reactor) and an aerated ceramic filter (a fixed biofilm process). Jia et al. (2005) found a high variety in approaches. In 2002 they analysed 21 systems for grey water treatment and 12 systems for combined treatment of black and grey wastewater. They found that almost all grey water treatment systems used a contact oxidation system combined with physical and chemical treatment. For treatment of mixed wastewater several kinds of techniques were adopted, including contact oxidation plus physical and chemical treatment and SBR plus physical and chemical treatment.

The final use of the treated water is varying, although toilet flushing and landscape irrigation are dominating. It is remarkable that none of the systems is used at full capacity, which is probably due to the (legal) limitations in the reuse purposes.

Table 2 The five DWRSs that will be discussed in this article

Item	Beijing Jiaotong University	Beiluchun	Beijing Normal University	Xin Bei Wei Hotel	BOBO Garden House
Location type	University	Residential	University	Hotel	Residential
Established in	1993	1999	2001	2002	2003
Influent source	Grey wastewater	Mixed wastewater	Mixed wastewater	Grey wastewater	Mixed wastewater
Main treatment technology	Activated sludge	Aerated Ceramic Filter	Activated sludge	Contact oxidation + disinfection	Contact oxidation + Activated sludge
Maximal reclamation capacity (m^3/day)	200	640	720	120	1,200
Average reclamation (m^3/day)	150	600	400	80	300[1]
Use purposes for the reclaimed water (% of total)					
- toilet flushing	0%	yes[2]	80%	100%	80%
- landscape irrigation	100%	yes	20%	0%	15%
-street cleaning	0%	no	0%	0%	5%
- car washing	0%	yes	0%	0%	0%
- fire water storage	0%	yes	0%	0%	0%

[1] Another 700 m^3 per day are treated and than discharged to the sewer system
[2] Exact distributions not asked for

Technical performance

Table 3 shows some indicators of the technical performance of the five systems. As mentioned earlier, there is no formal monitoring of the effluent quality of the systems after they have been established. However, the EPA of Beijing offers services to measure the quality on a voluntary basis, although no records are kept of these measurements. All the investigated cases made use of the possibility with a monitoring frequency of approximately once per year. According to data that were provided by system owners all systems complied with the quality standards of Table 1. The table also shows the electricity consumption (0.7 tot 1.5 kWh per m^3) and the time input for operation and maintenance.

To investigate the robustness (defined here as chance and frequency of system failure) the reasons for potential system failure were investigated. All the operators except for the one at Xin Bei Wei hotel indicated that power cuts could lead to failure, some also reported pump malfunction as a potential reason. At the hotel a generator is installed that produces electricity. In the last three cases we also specifically asked for the number of system failures. None of the operators reported failures.

Here, it is worth to mention that the performance of the DWRSs is sometimes questioned by the Beijing Municipal government. E.g., Jia et al. (2005) refer to reports that state that small facilities show insufficient operation because of overloading due to peak flows and lack of skilled operating technicians. However, no reports on this were found so far by the authors of this paper.

Table 3 Technical performance and system robustness of the five DWRSs

Question	Beijing Jiaotong University	Beiluchun	Beijing Normal University	Xin Bei Wei Hotel	BOBO Garden House
Is the system being monitored?	yes	yes	yes	yes	yes
Compliance with effluent quality standards?	yes	yes	yes	yes	yes
Electricity consumption (kWh/m^3)?	0.75	0.72	1.00	1.50	1.20
Time input (labour) for operation and maintenance (h / year)	n.a.f.*	n.a.f.*	Approx. 8760	Approx. 1825	Approx. 1095
What could be the reason causing a failure of the DWRS?	Power cut	Power cut	Power cut / pump mal-function	pump mal-function **	Power cut
Any reported failures of the system?	n.a.f.*	n.a.f.*	0	0	0

* n.a.f. – not asked for, in the first interviews we did not include this question

** Back-up generator for electricity supply available

Financial performance

Table 4 shows the financial performance of the five DWRSs. Based on the investment costs, the costs for operation and maintenance and the current tap water price, the pay back time of the systems were calculated. The financial information was provided by the system owners and / or the companies that installed the systems. It is worth mentioning that BWA charges a different in tap water prices for public parties (i.e. 3.7 RMB/m^3 for residents and public offices) and parties from the private sector (i.e. 6.1 RMB/m^3 e.g. hotels). The investment costs only refer to the costs of the DWRS and not to the additional pipelines in the areas and / or buildings that are needed to transport the treated water to the locations of use.

The data that were found in our investigation were compared to the financial information on DWRSs of Jia et al. (2005). It showed that the investment and O&M costs of the cases that were constructed between 2001 and 2003 showed good resemblance financial results of their research. The other two cases (Beijing Jiatong U. and Beiluchun residential area) had relatively low investment costs which probably indicate that the prices of reclamation systems have increased significantly in the past 5-10 years. If we consider the information on the cases that were constructed after 2001 reliable, pay-back times of 8 to 14 years were found for the public stakeholders and 4 to 6.3 years for the parties from the private sector.

Table 4 Financial performance of the five cases

Item	Beijing Jiaotong University	Beiluchun	Beijing Normal University	Xin Bei Wei Hotel	BOBO Garden House
Established in	1993	1999	2001	2002	2003
Investment costs for the treatment system (RMB)	300,000	1,400,000	3,400,000	600,000	3,000,000
Operation and maintenance costs (including labor costs) (RMB/m^3)	0.75	1.08	1.50	1.13	1.72
Current price of the tap water (RMB/m3)	3.7	3.7	3.7	6.1	3.7
Pay back time (years)	1.9	2.4	10.6*	4.1**	13.8*

* pay back times of 5.1 and 6.3 years at a tap water price of 6.1 RMB / m^3
** pay back time of 8.0 years at a tap water price of 3.7 RMB /m^3

Item	Beijing Jiaotong University	Beiluchun	Beijing Normal University	Xin Bei Wei Hotel	BOBO Garden House
Awareness on the use of reclaimed water	0%	--	80%	40%	50%
Wastewater reuse is considered positive (only asked if people were aware(	--	--	yes	yes	yes
Number of Respondents	10	--	14	10	10

Drivers and barriers
This section discusses the drivers and barriers to implement DWRSs. For this purpose we interviewed the system owners of the DWRSs which were the responsible departments at the 2 universities and the manager of the hotel. The ownership (and operation) of the systems at the residential areas (Beiluchun, BOBO Garden House) lies with the real estate companies.

In all cases the drivers to implement the DWRSs were mainly financial. The incentive of the increased tap water prices is high. As already indicated in paragraph 4.3 an investment in wastewater reclamation systems is attractive because of the relatively short pay-back times. Most stakeholders also indicated that they considered the initial investment as rather high. This formed an initial barrier to them. Three of the projects received partial subsidies for the initial investment (Jiatong University, Beiluchun and Xin Bei Wei Hotel). Secondary arguments were (compliance with) the regulatory framework and awareness on the water-scarcity. The regulatory argument was a driver for most cases, however because of the absence of real penalties from the side of the BWA, not as the deciding one. Also raising water-awareness and sustainable living were arguments for all the cases. The universities also consider the DWRSs as a tool to educate students on water issues and had faculties and students design and monitor the facilities. The real estate companies of Beiluchun and BOBO used the facilities in their commercials to sell the houses.

A barrier that was put forward by the real estate companies of Beiluchun and BOBO was the uncertainty about the fees they could raise for the second quality water and the current lack of a policy from the BWA on this. Other barriers that were mentioned were the difficulty of constructing extra pipelines in existing areas for transportation of second quality water.

Conclusions

- Various techniques are in use for decentralized wastewater reclamation (contact oxidation, activated sludge systems, SBR systems). According to our assessment the investigated systems function well without any processing, safety and health problem. However, effluent monitoring is done on voluntary basis and real quality control by an independent party is lacking.
- There is a strong financial driver to implement DWRSs, because of the relatively short pay back times, especially for the private sector. Other drivers are related to the regulations and to awareness on water scarcity issues.
- The implementation of the regulation on DWRSs by the WSO is frustrated by the absence of real penalties. In addition the monitoring of the systems is virtually absent.

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5 Comparative performance of constructed wetlands for decentralized treatment of grey water in the Netherlands, Germany and Norway

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Abstract

In the last decades, attention of both scientists and practitioners for decentralised treatment of gray water in constructed wetlands has increased. It has been shown, that decentralised grey water treatment can have several benefits. It can save costs for centralised sewer systems and may provide a non-conventional source of water for landscape irrigation, toilet flushing, etc. In addition, constructed wetlands in neighbourhood areas may form an attractive element in urban landscaping, especially in water-scarce areas. The objective of the research described in this paper was to analyze the adoption, technical performance and managerial aspects of these systems based on a number of case studies. This study has investigated four of these systems in the Netherlands, two in Norway, and one in Germany built between 1993 and 2000. The investigated constructed wetlands include various designs. These cases showed that the implementation of on-site grey water treatment systems combined with reuse of reclaimed water may lead up to 57% less drinking water consumption. The treatment performance of the wetlands was generally satisfactory, although a number of the studied systems did not monitor properly the systems due to high costs this imply and some operational difficulties with clogging because of inadequate maintenance. People perception of constructed wetlands is positive, health risk is inexistent and different schemes of management and operation can be implemented. Nowadays, there is a big potential for the implementation of these type of systems due to the increasing need to diminish discharges of pollutants into environment, source separation trends and sustainability goals.
Keywords: Grey water, decentralized treatment, constructed wetlands

1. Introduction

Lately, sustainability of conventional sewer systems in Europe have been discussed, parallel to this, disciplines such as urban ecology and resources management have emerged looking for customised integrated solutions for urban settlements. A paradigm shift in water management, from centralised solutions to decentralised systems, has triggered the implementation of decentralised system in urban areas. Among the wastewater treatment technologies, constructed wetlands are a promising low-cost means of treating domestic wastewater.

Constructed wetlands (CWs) are man-made copies of natural wetlands that optimally exploit the biogeochemical cycles that normally occur in theses systems for the purpose of wastewater treatment (Rousseau et al., 2008). Adaptability to different environments and local conditions is a significant advantage, all over the world, different types of constructed wetlands are used to treat a wide variety of wastewaters. The climatic conditions, the size and design of the wetlands, the loading rates and regime, the plant species composition, and the type and composition of the wastewater vary considerably between sites" (Brix, 1994). Besides, CWs not only function as stand-alone treatment plants but also they can be combined with other CWs or with other low-tech or high-tech wastewater system. (Rousseau et al., 2008).

In the last decades, there is increasing attention of both scientists and practitioners for decentralised treatment of grey water in constructed wetlands. Grey water is estimated to be around 70% of the average domestic black water, by addressing decentralised grey water treatment several benefits can be achieved. It can save costs for centralised sewer systems because the amount of water to treat is lower and also because the pollutants are not diluted and in addition may provide a non-conventional source of water of second quality for landscape irrigation, toilet flushing, etc.

Implementation of constructed wetlands in rural areas does not have many barriers, but in urban areas conventional systems are still preferred because of their high degree of convenience for the final users and because the practical implementation of source-separating sanitation systems in urban settings has been shown to be rather complex due to the involvement of many actors, such as project developers or housing corporations, future inhabitants, the local municipality, water authorities and water utility companies." (Mels, 2007). "Another important barrier in implementing new sanitation concepts is that in most European cities, sewer systems already exist and investments in assets have already been made (Mels, 2003). Despite these barriers, some pilot projects have implemented constructed wetlands for domestic grey water treatment in Europe.

Several single cases of constructed wetlands have been studied but comparisons among them are scarce. This study aims to gain insight in the performance of CW in urban areas by comparing seven existing systems in pilot projects, the research was performed between 2005 and 2008. And the relevant aspects for this study were the performance, technical choice and managerial issues.

2. Methods

This study has investigated seven pilot projects, four of these systems in the Netherlands, two in Norway, and one in Germany built between 1993 and 2000. More specifically the research has focussed on:

- Performance - In order to evaluate the performance of the systems, five performance indicators (PIs) were formulated, they are described in the table 1. Data were collected on the field performance at the various sites. Households, promoters and operators were interviewed to investigate their experiences and satisfaction about the systems. Additional information was gathered by review of the literature and Internet sources, and by site inspections.
- Technology choice - the drivers and barriers that led to selection of the systems. Generally, several actors are involved in the design and realization of a new neighbourhood (e.g. governmental organizations, project developers, and the future

inhabitants). In this investigation interviews were made with the important stakeholders in order to gain insight into their main drivers and barriers to implement these systems.

- Institutional aspects & management: Special attention was given to managerial issues, to gain insight in crucial aspects such as involvement during decision making process, ownership and responsibilities. The information was also gathered by means of interviews with the different stakeholders involved in the project.

Table 1 Performance indicators

Performance indicator	Means of verification
1.Public health protection	• Is there a chance for the house owners / tenants to get in contact with untreated wastewater? • Does the system cause nuisance (vermin, noise, odours)?
2. Technical aspects	• Is the configuration flexible and easily adaptable to combine it with other technologies? • What are the operation & maintenance inputs of house owners/tenants? • What is the nature and frequency of system failure?
4.Environmental aspects	• Are the emissions to surface water of nutrients and BOD equal/higher/lower compared to the conventional system? • Does the system save or recover resources (water, nutrients, energy, etc.) compared to the conventional system?
5. Cost	• Are the yearly costs for water supply and wastewater disposal for the house owners/tenants equal/higher/lower compared to the conventional system?

Study sites

Within the framework of this investigation seven sites were studied:

- In The Netherlands: Het Groene Dak , Polderdrift, Drielanden, De Waterspin
- In Sweden: Kaja and Tovertua
- In Germany: Flinterbreite

The general characteristics of the neighborhoods studied are described in the table 2. The cases studied presented different system configuration, different types of toilets, pretreatments and combination with other sources separation systems or conventional sewer. In some cases also rain water collection is harvested, mixed with the wetland effluent and reused.

The constructed wetlands under study were located in settlements that ranged from 24 to 110 houses. In the case study Het Groene Dak, two different systems were implemented for 2 clusters of 5 houses each. Characteristics of the settlements can be observed in the table 1. CWs' designs vary depending on local characteristics and needs, including horizontal and vertical flow. The size of the studied wetlands varied between 22m² and 3000m². The depth of the systems varied between 0.30 m and 1.0 m, while the hydraulic retention also showed important variations between 6-18 days[1]. Detailed description of the wetlands is included in the table 3.

[1] only information of 3 wetlands

Table 2. Systems description

Pilot Project	Het groene dak		Polderdrift	Drielanden	De Waterspin	Kaja	Tovertua	Flinterbreite
Country	**The Netherlands**		**The Netherlands**	**The Netherlands**	**The Netherlands**	**Norway**	**Norway**	**Germany**
City	**Utrecht**		**Arnhem**	**Groningen**	**The Hague**	**As**	**Bergen**	**Lubeck**
Year	1993		1997	1995	1997	1997	1999	2000
type	Houses		Houses	Houses	Houses + business	Student apartment	Houses	26 houses+ 4 apartments
number total	66		40	166	48	24	40	115 houses planned
Number of housing units studied	5	5	40	110	48	24	40	30
people served	6	12	60			48	130	110
Toilet type	Gustavberg toilet	Gustavberg toilet	N/A	Gustavberg toilet	N/A	Vacuum toilet	Vacuum toilet	Vacuum toilet
Type of grey water pretreatment	Large particle filter + aerobic filter with bio-film	N/A	Fat removal + sedimentation tank	Wetland + second filter	Septic tank	Septic tank + aerobic bio-filter	Septic tank + aerobic bio-filter	Sedimentation tank
Pretreatment objectives	Decrease BOD,COD,SS,N total, P-total	Nutrients removal	Nutrients removal	N/A	N/A	Reduces BOD and bacteria	N/A	Heavy particle, oils and fat the suspend to wetland
wetland type	Vertical infiltrating reed bed	Vertical infiltrating greenhouse	Vertical infiltrating reed bed	Horizontal flow reed bed	Vertical reed bed system	Horizontal subsurface CW	N/A	N/A
Grey water-reuse	Combination of treated grey water+ rainwater for toilet and washing machines	N/A	After infiltration water is filtered and reuse for toilet flushing	After reed bed goes to a second filter of the same size. For 2 days	N/A	N/A	N/A	N/A
final discharge of wetland sludge	Remove each 6 months and composted	N/A	Grey + rain 12.5 kg/hh	N/A	Reed bed system	To municipal wastewater treatment	N/A	N/A
final discharge of treated grey water	After to retention pond	After to retention pond	After to retention pond	N/A	Stored in a reservoir and reuse	After rain water sewerage pipe and discharge in a lake	N/A	N/A
Rain water management	Retention pond 50 m2 with overflow to sewer system and reuse	Retention pond 50 m2 with overflow to sewer system and reuse	2 sedimentation tank (2 x 35 m3)	Pond and separate rain water	Is collected from roofs and used to flush the toilets saving 750m3 a year	Rain water sewerage pipe of the municipality	N/A	Rainwater infiltration

N/A: Not available information

Table 3. Wetlands description

Pilot Project	Het groene dak (1)	Het groene dak (2)	Polderdrift	Drielanden	De Waterspin	Kaja	Tovertua	Flinterbreite
Number of house units	5	5	40	110	48	24	40	30
People served	6	12	N/A	N/A	N/A	48	130	110
Wetland type	vertical infiltrating reed bed	vertical infiltrating greenhouse	vertical infiltrating reed bed	horizontal flow reed bed	vertical reed bed system	horizontal subsurface CW	horizontal subsurface CW	Vertical subsurface flow
Total area (m²)	75	22	230	3000	N/A	100	N/A	276
Deep	N/A	N/A	N/A	30 cm	1 m	1m	N/A	N/A
Area / person (m²/p)	12.5	1.8	2.88	6000m2 (total)	N/A	N/A	2	2 or 2.5
Vol. treated grey water	10 m3	N/A	72 lt/ p.d	25 m3/day	N/A	112 lt / p .day	N/A	N/A
Water consumption (Yearly)	32 m3/hh	N/A	50 m3 / hh	N/A	N/A	83 m3 / p	147 m3/hh	24.8 m3/ p
Reuse	yes	yes	yes	N/A	N/A	N/A	N/A	N/A
Energy consumption (Kwh.pe/y)	0.5	N/A	N/A	N/A	N/A	5.67	16.84	2 kwh/ye. Pe
Maintenance required (h/year)	32h/y - External person	N/A	8h/year (tenants)	N/A	N/A	N/A	N/A	N/A

N/A: Not available information

Table 4. Public health and technical parameters

	Het groene dak	Polderdrfit	Drielanden	De Waterspin	Kaja	Tovertua	Flinterbrite
Health risk*	0	0	0	0	0	0	0
Monitoring	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Maintenance	Inadequate	Inadequate	N/A	N/A	N/A	N/A	N/A
Occasional smell in summer or during clogging	Y	Y	Y	Y	N/A	N/A	N/A
Vermin	N	N	N/A	N/A	N/A	N/A	N/A
Clogged (times / year)	0.10	0.12	N/A	N/A	0	N/A	0.12
Other problems	N/A	N/A	delays in the construction work	Different executors caused the delay and no realistic cost in the planning phase	CW were not approved in 1998 in sweden	Collapse of the infrastructure for error during the construction phase	no reuse of grey water (expected at the beginning cause higher costs

N/A: Not available information

3. RESULTS

3.1. Performance assessment

Public health protection
Regarding public health, there is consensus among users and promoters of all the cases that the health risk is really low or inexistent. Householders do not perceive any health risk and there is not evidence of illness due to the operation of the constructed wetlands or reuse of reclaimed water.

Technical aspects
Different systems configuration can be adapted with constructed wetlands systems like different types of toilets, fecal or urine separation or conventional sewer; at the same time, the effluent can be reused, combined with rain water collection, discharged directly into a pond, use as infiltration recharge or connected to the rain water drainage. In all the cases pre-treatment is used in order to remove mainly large particles and fat and to avoid clogging events in the system.

As stated by Rousseau et al (2008), constructed wetlands are known to have a high buffering capacity. Effluent quality is therefore normally quite stable. On the other hand removal percentages are mainly dependent on temperature, hydraulic residence time (HRT) and loading rate, and are highly variable between systems.
Natural treatment systems are too often considered to be a "build and forget" solution not needing attention at all (Rousseau et al., 2008). This was also evidence in these cases, maintenance routines are not performed as planned and inappropriate procedures are followed.

Regular maintenance is not complicated and time allocation is low, besides, some of the inhabitants enjoy doing it, in other cases, a external person is hired. However there is a still a lack of knowledge in the general maintenance, some problems as inadequate soil replacement or no replacement at all can causes a loss of removal capacities, and can cause also blockages affecting system performance.

Vymazal (1998), distinguish two types of operational problems: those resulting from poor maintenance and those associated with parts of the system that were not properly design or built. Within the cases studied the average of failures for the CWs studied is 1 each 10 years, mainly clogging in the wetland due to inappropriate maintenance. This shows high system reliability, due to these failures can be easily avoided by doing proper maintenance.

Vymazal (1998) also mentioned in his research that winter operation of constructed wetlands is often questioned, in some of the cases some measures were taken in advance in order to guarantee system reliability during winter months, in the two cases in Sweden an additional deep was built forecasting a frozen layer, meanwhile, in Drielanden, the wetland is disconnected during winter.

Environmental aspects

Removal properties depend on the typology of the wetland retention time, size, type of soil and vegetation, due to all the cases present a different design a direct comparison can not be done.

Removal rates are also not comparable because of the different qualities of the influents of the wetlands, however, the removal function is satisfactorily combined with the pre-treatment stage and the effluents can be reused for toilets flushing or landscaping functions. The treatment performance of the wetlands was generally satisfactory, although no permanent monitoring is performed. Removal rates can vary a lot from one case to another, because grey water composition also change, for instance in Norway, detergents are phosphate free what modify significantly the influent composition.

These cases showed that the implementation of on-site grey water treatment systems combined with water reclamation and rain water collection may lead up to 57% less water consumption. This type of implementation, minimize sewerage flow and dilution of pollutants, and consequently costs for transport and treatment also decrease. Also energy consumption is relatively low and it is mainly due to recirculation system for water reuse, not properly for the waste water treatment.

An indirect result of wetlands implementation regarding resource use, it is that users have to be aware to the discharge into the grey water system, leading to use of environmental friendly products and controlling pollutant discharges.

Cost

Comparative, the cases studied are more expensive than conventional sewerage for different causes: need of back up systems, errors during implementation, early failures, and unforeseen aspects due to lack of experience. Also the initial investment is higher due to double piping and pumps required to transport the water to the wetland and if needed to re-circulate the effluent. But in the long run, water savings are feasible and reduction of water bills as well, then economic benefits can be obtained. Also in some of the cases, sewer fee reduction was implemented.

3.2. Technology selection process

Different drivers and barriers are experienced by communities when implementing wetlands as wastewater treatment of grey water. Table 5 summarises the main drivers and barriers, also shows in ranking the most and less important factors for the seven cases studied.

Drivers

The perception and opinion of neighborhood dwellers about the systems was generally positive. Most people enjoy the esthetical landscape element of the systems and the presence of water in their surroundings. Most interviewed users feel that these systems contribute positively to environmental awareness. Some of the drivers for the implementation were water saving, reduction of water emissions and protection of surface water.

The fact that the systems generally have low maintenance requirements and low operational costs are also important for the high degree of user satisfaction.

Barriers

The main barriers identified during the decision making process in the pilot cases are decentralize maintenance because of the responsibilities it implies for users, restriction in cleaning products and higher investment cost. In the cases located in Kaja, Tovertua and

Flinterbreite there were no significant barriers during the decision making process. Some barriers have been evidenced during operational stage, such as lack of support by the governmental authorities to reduce the fees.

Table 5. Drivers and barriers during the technology selection process

	Het groene dak	Polderdrift	Drielanden	De Waterspin	Kaja	Tovertua	Flinterbreite	Frequency
Drivers								
Positive feeling about environmental friendly behaviour	1	1	1	1	1	1	1	7
Water saving	1	1	1	1	1	1		6
Quality of neighbourhood landscaping	1	1	1	1		1	1	6
Reduction of water emissions	1		1		1	1	1	5
Protection of surface water			1	1	1	1		4
Taking responsibility for your household water management system			1	1		1	1	4
Improved quality of living	1		1			1	1	4
Reduction of energy use			1			1	1	3
Recycling of water			1	1				2
Intensive contact with neighbours, collaboration with neighbours	1	1						2
Less dilution of black water	1							1
Low maintenance					1			1
Prevention of drying out of soil								0
Total drivers per case	**7**	**4**	**9**	**6**	**5**	**8**	**7**	
Barriers								0
Maintenance	1	1	1					3
Restrictions on products	1		1					2
Economic barriers				1				1
Smell								0
Energy costs (compared to conventional system)								0
Total barriers per case	**2**	**1**	**2**	**1**	**0**	**0**	**0**	

3.3. Managerial aspects

The characteristics such as ownership, management, and responsibilities clearly differ between centralized and decentralized wastewater systems. One of the most important reason is the broad range of stakeholders involve in the management of decentralized systems, often with a diffuse distribution of responsibilities. (Willetts, 2007)

The study showed that there are different management frameworks for ownership and operation & maintenance (O&M). In some cases the systems are owned by a collective of house owners while in others the systems are owned by housing companies. Regarding housing units, houses are owned by the inhabitants, rented or in leasing. O&M is generally performed by specialized companies, but there are also examples were this is a collective responsibility of the neighborhood dwellers. The main problems experienced in the pilot cases are unclear responsibilities for O&M, leading to inadequate maintenance, higher cost than expected and no economical benefits such as reduction of sewerage fee.

Table 6. Stakeholders involvement and responsibilities for each case study.

Stakeholders involved	Het groene dak			Polderdrfit			Drielanden			De Waterspin			Kaja			Tovertua			Flinterbreite		
	Utrecht						Groningen			The Hague									Lubeck		
	D	R	O	D	R	O	D	R	O	D	R	O	D	R	O	D	R	O	D	R	O
Municipality	X						X	X	X				X			X			X		
Consultancy company				X			X			X									X	X	
Users				X	X																
Universities													X	X		X	X				
Construction companies																		X			
Association of users	X									X	X	X	X	X			X				
Housing company	X	X	X	X	X		X			X										X	
Project developer	X			X															X		
Water board		X																			

D: Decision making
R: Responsibilities
O: Ownership

4. DISCUSSION

Grey water should be regarded as a valuable resource and not as waste. Reuse of on-site treated grey water leads up to saving of almost 60%, this evidence should promote this type of system configuration to tackle water scarcity and for improve sources management in urban areas. Grey water reclamation is an effective measure for saving water and minimization of emissions into the environment.

Some of the most remarkable qualities of the constructed wetlands are the choice to have different system configuration, multiple options for design (vertical or horizontal flow), different plants, soil typologies, size and constant or intermittent flow. Also they are able to treat raw wastewater or grey water. It is a flexible technology able to clean different volume and quality of water, maintenance and costs are relatively low and other benefits can be achieved.

When people compare new sanitation systems with conventional systems reliability is an important barrier. Improvement on reliability has to be done and it is important to monitor and identify the cause of the failure in order to make improvements in future implementations. By overcoming the problems of lack of knowledge during construction and maintenance, the systems will be reliable. This research also found maintenance as a key issue for a good system performance.

Barrier for the implementation of constructed wetlands are limitations of cleaning products to preserve reeds and initial investment, they are more expensive than conventional for different causes like: back up systems, mistakes during implementation, early failures, and unforeseen aspects due to lack of experience. The higher costs compared with the conventional are made due to more pipes, pumps to transport the water from pretreatment to red bed, reed bed construction, and consultants and experts on these systems. No health risk is present neither in pond nor in the reuse activities.

No one system is the unique solution for the treatment of domestic grey water. Integrated systems are optimal for specific local conditions. However improvements are needed and knowledge exchange is required. By having a good insight of system performance, potential problems can be addressed in different ways, while in Drieladen, during winter, they disconnect the wetland, because of the efficiency reduction due to the low temperature, in Kaja and Tovertua, within the design phase are contemplate 30cm extra of deep, foreseen the freezing of the upper layer of the wetland during winter time.

Although, at the beginning decentralized maintenance was rated as a barrier for some of the inhabitants, the fact that the systems generally have a low maintenance requirement and low operational costs are also important for the high degree of satisfaction. The main problems experienced in the pilot cases are unclear responsibilities for O&M, leading to inadequate maintenance, higher cost than expected, a bit of smell in some seasons.

It is necessary synergy among the different stakeholders, in order to achieve a successful operation system. It is needed to define clear responsibilities for ownership, operation and maintenance, and also involvement of municipalities or authorities to achieve benefits regarding fees exception, or subsidies. It will also to facilitate to establish a legal framework to regulate them.

5. CONCLUSSIONS

If properly designed, constructed and maintained constructed wetlands represent a potential for decentralized grey water treatment. They promote source separation and improve urban landscape. They are also “drivers” to change, and increase user awareness; people feel attachment to the system and they are more carefully with the discharges into grey water, because there are some limitations, otherwise the filters or the plants can be significantly affected. Better maintenance and monitoring activities should be implemented to guarantee a successful performance of the systems.

People perception is positive, and the additional benefits are strong drivers for their implementation. No evidence of health risk has been evidence. In conclusion there are ecological and aesthetic drivers but economical barriers. The same health risk than conventional system this is due to no handling of feces. There is still lack of legislation and economical benefits in terms of fees reduction, to stimulate further implementations.

Managerial aspects can vary significantly in each case, the distribution of responsibilities can be arranged in different schemes, however is important to clearly define those responsibilities since the decision making process.

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6 User acceptance of vacuum toilets and grey water systems in The Netherlands, Norway and Germany

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Abstract

User acceptance is a key issue in implementing new forms of sanitation, because users are confronted with new types of toilets and equipment in their homes and neighbourhood. This paper reports research on the user acceptance of vacuum toilets and grey water systems in 5 neighbourhoods in The Netherlands, Norway and Germany. Interviews with households in the various cases showed a high appreciation of grey water treatment systems (marks between 7.1 and 8.0) and an average lower satisfaction level for vacuum toilets compared to conventional water flush toilets. Despite of the lower satisfaction, the appreciation of vacuum toilets was generally high, due to the water saving aspect of vacuum toilets (marks between 7.1 and 8.0 for the cases without operational problems compared to 7.1 for the conventional toilets). The flushing sound of vacuum toilets was considered to be unpleasant by 40-65% of the respondents compared to 25% of a control group with conventional water flush toilets. Subsequent sound level measurements showed that the maximal sound level of an average vacuum toilet is 12 dB higher than an average conventional toilet. The measurements indicated that there are various options for sound reduction, such as optimisation of the pipe diameters, sound reducing backplates and silencers.

Keywords

Grey water treatment, new sanitation systems, sound level, user acceptance, vacuum toilets, ,

Introduction

Throughout Europe there is increasing interest in innovative sanitation systems that separate household flows at source and provide for separate treatment and, if appropriate, reuse. The use of new forms of wastewater collection and treatment also involves changes in households. Users are confronted with toilets based on a different working principle and with equipment for grey water treatment in their neighbourhood. User acceptance is therefore a key issue in implementing new forms of sanitation.

One innovative approach is based on separation of black and grey water. Within this approach black water is often collected by using vacuum toilets in order to prevent dilution and facilitate for simpler treatment. This article presents research results into the user acceptance of vacuum toilets and decentralized grey water treatment systems in 5 projects in The Netherlands, Norway and Germany. The investigated projects are shown in Table 1. In a subsequent part of the research sound level measurements were performed with different types of vacuum toilets for possible improvements as the sound of a vacuum toilet. The noise level during flushing was one of the main disadvantages that was mentioned during the user acceptance investigations.

Table 1. Overview of the projects that were part of the research

Project (year of realization)	Short description
Kaja – Ås, Norway (1996)	24 student apartments equipped with a vacuum toilet system and a local grey water treatment system (biofilter + constructed wetland).
Torvetua – Bergen, Norway (1997)	40 single houses equipped with a vacuum toilet system and two local grey water treatment systems (biofilter + constructed wetland).
Wohnen & Arbeiten - Freiburg, Germany (1999)	14 apartments and 4 offices equipped with a vacuum toilet system and a membrane filter system for grey water treatment
Flintenbreite – Lübeck, Germany (2000)	30 houses equipped with a vacuum toilet system and two local grey water treatment systems (constructed wetlands).
Casa Vita – Deventer, The Netherlands (2007)	32 new apartments equipped with a vacuum toilet system

Methods

Interviews

To investigate the user acceptance standardized interviews were made with households in the five cases in the period October 2005- December 2007. For each case 20 households were interviewed, except for Wohnen & Arbeiten (only 11 interviews). The interviews were divided into several aspects, i.e. household descriptors, invisibility, user comfort and system robustness. For the latter three aspects different questions were asked referring to the grey water treatment system and the vacuum toilet system. The interview for the project Casa Vita was limited to the vacuum toilet system. In order to have a zero measurement (benchmark) twenty households with conventional water flush toilets connected to a gravity-based sewer system in the city of Wageningen were interviewed.

Sound level measurements

The sound level measurements were performed in the project Casa Vita in Deventer and at project Lemmerweg-Oost in Sneek, The Netherlands. The project Lemmerweg-Oost is the first project in The Netherlands were vacuum technology is applied at neighbourhood scale, but it was not part of the earlier research. The installed vacuum toilets in Deventer are supplied by the manufacturer Jets en the vacuum toilets in Sneek are supplied by the manufacturer Roediger. Besides the Roediger toilet also three other vacuum toilets are installed in Sneek for testing, namely:

- a Jets vacuum toilet (same type as in Deventer)
- an Evac vacuum toilet
- a Roediger vacuum toilet with a silencer

The sound level of the vacuum toilet was measured with the toilet lid closed and also with the toilet lid open. The Jets vacuum toilet was measured twice (once in Deventer and once in Sneek). This was done on purpose to establish if there is a sound difference due to another piping system and other pipe dimensions. For comparison two conventional toilets were also measured (one standard toilet and one shelf toilet, also known as a Dutch toilet).

The vacuum toilets are measured for their maximum sound production (L_{Amax}) in decibels (dB). The sound is measured at a distance of 60 cm from the front part of the toilet at an angle of 45 degrees. The uncorrected L_{Amax} is calculated based on an half sphere geometrical distribution of the sound, where a sound decline over the distance r $10\log(4*pi*r^2)$ applies.
The corrected L_{Amax} is calculated by correcting the sound production for the reflections in the area with the help of a power noise generator/artificial source. The corrected decibel production (L_{Wmax}) is obtained after the correction for the reflections with the law from Sabine via $L_{Amaxp} = L_{Amaxw} + 10*\log\{4*(1-\alpha)/A\}$, where A is the total adsorption surface defined via the sound level measurements and L_{Amaxp} is the measured L_{Amax} in the reflection zone. Table 2 presents the used measuring equipment.

Table 2 Measuring equipment

	Manufacturer	**Type**
Real time analyzer (investigator)	Brüel & Kjær	2260
Microphone for Brüel & Kjær type 2260	Brüel & Kjær	4189
Sound Level Meter	RION	NA-27
Microphone for RION NA-27	RION	NH-20
Calibrator	Brüel & Kjær	4231
Power noise generator/artificial source	Decabel	50FTM

For a realistic sound production 300 ml of water was added to the vacuum toilets which represents an average toilet visit.

Results and discussion

Interviews
Figure 1 shows the level of satisfaction of the interviewed households with vacuum toilets. The control group with a conventional toilet system in Wageningen shows a high satisfaction level, 85% of the inhabitants are (very) satisfied with their toilet. The satisfaction level (very satisfied and satisfied) in the projects with vacuum toilets is 91% for Wohnen & Arbeiten , 75% in Kaja, 68% in Casa Vita , 55% in Flintenbreite and 50% in Torvetua.

The outcomes showed a good relation between the amount of problems with the vacuum toilet system and the level of user satisfaction. In the projects where the inhabitants have been confronted with a lot of operational problems with malfunctioning (Flintenbreite and Torvetua especially) there was a much lower level of satisfaction compared to projects where less problems occurred (Wohnen & Arbeiten , Kaja and Casa Vita).

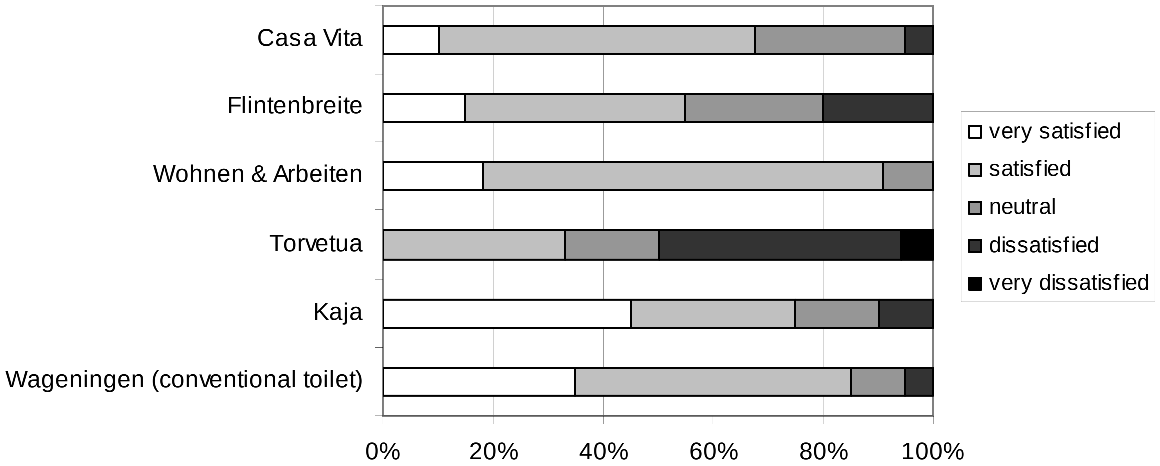

Figure 1. Level of satisfaction of households with their vacuum toilet systems compared to a control group with conventional toilets (Wageningen)

The inhabitants were also asked to give a mark for the implemented systems in their households and neighbourhoods, rated on a 1-10 scale (where 1 is the lowest and 10 the highest mark). These marks included the toilets and / or the grey water systems, depending on the situation.

As for the toilets, the control group in Wageningen gave an average mark of 7.1. The households with vacuum toilets showed a large variation in marks, i.e. 7.8 in Wohnen &Arbeiten , 7.2 in Casa Vita, 7.1 in Kaja, 6.6 in Flintenbreite and 4.4 in Torvetua. This rating also showed a similar relation between operational problems in two cases (Flintenbreite and Torvetua) and a low mark. It is remarkable that for the other projects the marks were similar or higher than for the conventional toilet, despite a lower level of satisfaction. In follow-up questioning we found that many of the inhabitants feel very positive about the principle of the toilet system because of the low water consumption.

The marks for the grey water treatment systems were generally high and varied between 7.1 for Torvetua to 8.0 for Kaja. The mark for the system at Flintenbreite (7.5) was given for the combined sanitation system instead of the grey water system alone. The research showed that people generally feel very positive about these systems. About 65% of the respondents would also recommend their grey water system to others. In the cases of constructed wetlands a number of people made remarks regarding some smell that arose from the systems.

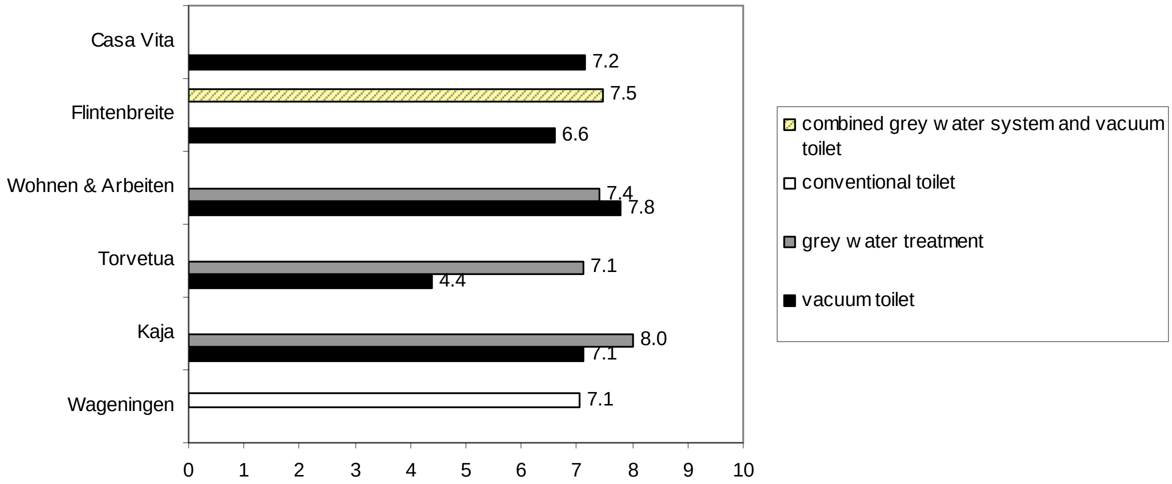

Figure 2. Average marks given by the households for the vacuum toilets and / or grey water systems in the various projects

For the vacuum toilets we also did research into the opinion of the users about the sound level of the system during flushing. We asked whether the users found the sound 'unpleasant' (defined as 'annoying' and 'loud'). The results shown in Figure 3, were compared to the control group with conventional toilets. The data show that 40-65% of the respondents with vacuum toilets consider the sound during flushing unpleasant, compared to 25% of the control group. Noise nuisance is also one of the most commonly mentioned disadvantages of the vacuum toilet system during the interviews, although it was also frequently mentioned that respondents got used to it.

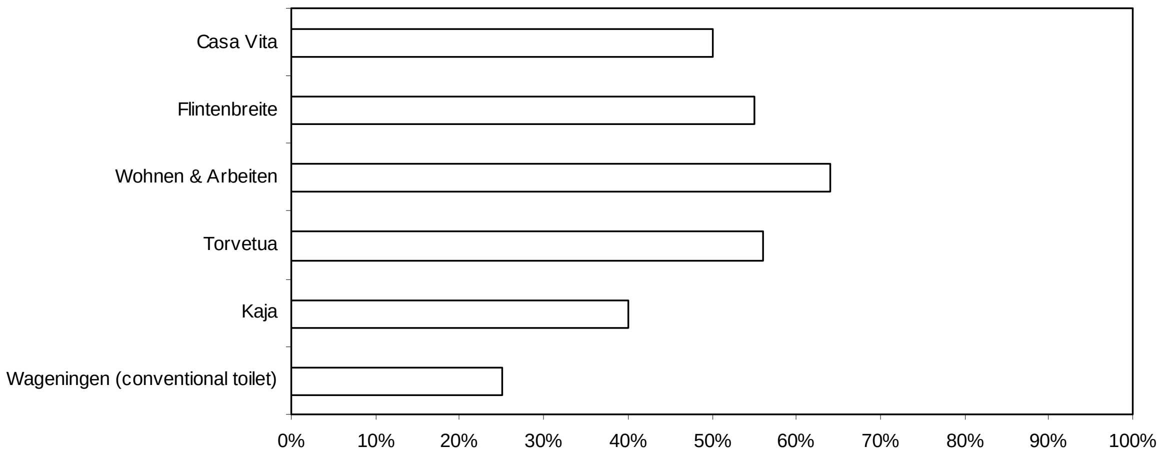

Figure 3. Percentage of interviewed households that considers the flushing sound of their toilet unpleasant

Sound level measurements

Table 3 presents the results of the sound level measurements.

Table 3 Results sound level measurements

Results in dB(A)	**Lid**	**Maximal decibel production after correction for the reflections**
Deventer (Casa Vita), Jets	closed open	91 95
Sneek, Roediger	closed open	102 104
Sneek, Evac	closed open	93 97
Sneek, Jets	closed open	95 99
Sneek, Roediger + silencer	closed open	89 93
Conventional Dutch toilet	closed open	80 87
Conventional toilet	closed open	83 85
Average results	**Average decibel production after correction for the reflections**	
Vacuum toilet: average with standard deviation	96 +/- 5	
Conventional toilet: average with standard deviation	84 +/- 3	

The average maximal sound production of the vacuum toilets is 12 dB louder than the average sound production of the conventional toilets. It has to be mentioned here that the results show the maximum decibel production during the flushing of the various toilets. If an average decibel production in time is measured the difference would be smaller, because the sound production of a vacuum toilet is only 2-3 seconds while the sound production of a conventional toilet lasts for about 30 to 40 seconds.

The average sound level of the vacuum toilet is significantly increased by the standard Roediger vacuum toilet with a sound production over a 100 dB. If the sound level measurement of the Roediger vacuum toilet is excluded from the average decibel production, the average sound level lowers from 96 to 94 dB. The closing of the lid of the vacuum toilets reduces the sound production with 4 dB. An interesting finding was that a 4 dB less sound production was measured for the same Jets vacuum toilet when it is installed in Deventer (Casa Vita) in comparison with installation in Sneek. This difference is probably caused by different isolation around the backplate of the vacuum toilet, the length of the piping system and/or the use of different pipe dimensions. The measurements also showed that the silencer of the manufacturer Roediger is functioning well and reduces the sound level with 11 tot 13 dB lower, depending on whether the lid is opened or closed.

One striking observation is that the 'standard' Jets vacuum toilet in Deventer is only 2 dB louder than the Roediger vacuum toilet with a silencer. This shows good perspectives for development of vacuum toilets. The installation of a silencer on the 'standard' Jets vacuum toilet will most likely decrease the amount of dB further, which will result in a comparable sound level for this vacuum toilet in comparison with a conventional water flush toilet. Some other possible improvements are the optimisation of the pipe dimensions and/or piping of the system. The pipe dimensions probably influence the sound production because of different amounts of air that are replaced during the flushing. The amount of air flowing through the vacuum toilets' valves are an important factor and should be optimised (searching for the boundary between a well functioning system and the lowest sound level possible).

Conclusions

- The user acceptance interviews showed a high appreciation of grey water treatment systems (marks between 7.1 and 8.0).
- The interviews showed an average lower satisfaction level for vacuum toilets compared to conventional toilets. These results can partially be explained by operational problems in two of the studied locations. Despite of the lower satisfaction, the appreciation was generally high, due to the water saving aspect of vacuum toilets (marks between 7.1 and 8.0 for the cases without operational problems compared to 7.1 for the conventional toilets).
- A large part of the respondents with vacuum toilets, i.e. 40-65% of the respondents considers the sound of the flushing unpleasant, compared to 25% of the control group. Noise nuisance is also one of the most commonly mentioned disadvantages of the vacuum toilet system during the interviews.
- The maximal sound level of an average vacuum toilet is 12 dB louder than an average conventional toilet (the quietest vacuum toilet has a difference of 10 dB) and is experienced as disturbing by the larger part of the households.
- To make the vacuum toilet more acceptable to users the maximal sound production has to be reduced. Based on this investigation various options for reduction appear to be available, such as optimisation of the pipe diameters and sound reducing backplates. The combination of a silencer with a Jets vacuum toilet could result in a vacuum toilet with a maximal sound level that equals the sound of a conventional toilet.

Outlook

The results have been communicated with the various vacuum toilet suppliers that are mentioned in this article. The maximal sound level appears to be getting more attention of the manufacturers. The manufacturer Evac will e.g. introduce a new type in 2008 which claims to have a maximal sound level of 86 dB. This is more or less equal with a conventional toilet.

The results in user acceptance and operational functioning of vacuum toilets and grey water systems will be continued by Wageningen University and the company Tauw. To obtain more insight in the energy use and system robustness of the vacuum system Tauw has installed energy meters at the project in Deventer and logs the amount of blockages/failures.

Acknowledgement

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Part 2 DRIVERS AND BARRIERS FOR SCALING UP ECOLOGICAL SANITATION

Executive summary

The World Summit on Sustainable Development (WSSD) estimates that 2.4 billion people lack adequate sanitation, most of them living in developing countries.Progress towards meeting the Millennium Development Goal (MDG) ***sanitation target*** is the slowest of all MDGs, with an enormous gap between intended coverage and today's reality. New approaches are needed to meet the demands of sanitation for all, to prevent environmental degradation and to make long-term sound investments. To achieve the sanitation MDG, demands more attention and better allocation of resources. The amount of resources needed is inevitably strongly dependent on the choice of technology. Ecological sanitation provides a promising approach to contributing towards achieving the MDG target of halving by 2015 the proportion of people without sustainable access to improved sanitation.

Ecological sanitation(ecosan) is an approach that respects ecological integrity, conserves and protects freshwater, promotes dignified and healthy living and recycles nutrients from human excreta for use in agriculture. There are various types of ecological sanitation, but this study focuses on on-site toilets that combine urine diversion and dehydration or composting of organic matter. The key research question that has been analyzed in the study is what prevents ecological sanitation from going to scale?

The paper reports on two questionnaire surveys undertaken between August 2007 and March 2008 with experts in the North and South who have been strongly involved in ecological sanitation. Respondents ranged from field workers testing pilot ecological sanitation schemes to researchers working full-time on understanding specific aspects of ecological sanitation. In response to the first questionnaire, champions of ecological sanitation mentioned various reasons why ecological sanitation did or did not work. Responses to the second questionnaire, gave further information on the important factors for scaling up ecological sanitation from:

- The user perspective: Driving forces and barriers for implementing and using ecological sanitation
- The Government perspective - creating an enabling environment
- The product user perspective - the end users of excreta and/or urine in agriculture

From a user perspective, there remains a reluctance to accept ecological sanitation as a possible option, mainly because of reluctance to handle the by-products (urine and faeces). Although a number of the champions in ecosan would argue that these social barriers are being overcome (or will be shortly), the overall results from the two questionnaires are more pessimistic. In order to find acceptable solutions, it is of critical importance that stakeholders ranging from government personnel to households are more aware of the potential benefits for ecosan. Promoting ecosan requires advocacy for the benefits and also requires people's concerns to be directly addressed. In particular, it needs to be made clear that the end product is no longer faeces, but a nutrient rich derivative that is no longer unsafe or impure.

There is a general lack of support and co-ordination at all governmental levels, national, intermediate and municipal. Several countries lack any general policies and/or regulation focusing on sanitation, let alone consider ecological sanitation as one of a range of options.

Consequently, ecosan is often not taken seriously or takes place only in small scale pilot schemes which are not converted into large-scale sustainable projects.

One of the other constraints is that the initial investment costs tend to be slightly higher for ecological sanitation than for other on-site sanitation options such as VIPs. Some ecosan governmental programmes place strong reliance on government subsidies or external donors to make access affordable. Such programmes however prove *not* to be sustainable in the long run. Governments will need a long term vision to invest in ecosan to stimulate a range of services which include funds for capacity development and the actually implementation of ecosan facilities.

Ecological sanitation clearly has a niche because it provides the final users with nutrient rich products from urine and faeces for agriculture use. Ecological sanitation can also be useful in certain difficult geographical circumstances (high ground water table, rocky ground). These niches should be developed further and can provide the key to making ecological sanitation successful.

1 Introduction

The central philosophy of ecological sanitation is based on protecting the environment by using ecologically friendly toilet systems that not only save water and reduce pollution, but also are designed or equipped to processed excreta in such a way that makes it safe enough and suitable to use in agriculture. By these means, food production can be increased using an inexhaustible resource.

Ecological sanitation, at its best, is able to link the two disciplines of sanitation and agriculture, thus achieving what Steven Esrey (1998) called “closing the loop”, and this aim should ideally lie at the core of such developments. The reality is that many ecological sanitation projects fail due to concentrating only on promoting the toilet itself, with too little emphasis on how to recycle processed excreta to enhance food production.

This report

This study examines a number of issues related to ecological sanitation focusing on institutional, financial and social issues. A number of best-case ecological sanitation schemes are reviewed from Africa (Burkina Faso, Kenya, Malawi), Asia (Philippines, Nepal, India) and Latin America (Mexico, Peru). Issues involved in scaling up ecological sanitation are reviewed with a focus on governance and policy issues, institutional issues, financial and social issues. Finally, the paper reflects on what has made some ecological sanitation schemes successful, while others are unsuccessful, and thereby searching for evidence on how the approach can be taken to scale beyond pilot phases.

The key research question analyzed in this study is ‘what prevents ecological sanitation from going to scale?’ There are a variety of different types of ecological sanitation, but this study focuses on dealing with on-site toilets which combine urine diversion and dehydration or composting of organic matter. This is because these are the most commonly used ecological sanitation facility in developing countries.

Methodology

A literature review was conducted to examine the advantages and disadvantages of ecological sanitation, and three case studies each from Africa, Asia and Latin America were identified and reviewed.

Two questionnaires were given to a list of people in the North and South who have been strongly involved in the area of ecological sanitation. They range from field workers testing pilot ecosan schemes to researchers whose sole work revolves around understanding aspects of ecosan. The list of these ecosan “champions” can be found in Annex 1.

The first questionnaire, undertaken between August and November 2007, simply asked these champions about the issues they considered were stimulating or creating barriers towards the scaling up of ecological sanitation. A total of 25 questionnaires were sent out, of which 19 were returned. The case studies and this initial questionnaire together gave an initial idea of the most relevant issues that help or hinder scaling up ecological sanitation. For a comparison of issues in selected ecological sanitation schemes from the first questionnaire, refer to Annex 2.

A second questionnaire was then developed to gain deeper insights into the barriers in scaling up ecosan. Between December 2007 and March 2008, this was answered by 22 of the 25 experts to whom it was sent. This second questionnaire focused on the user perspective, the role of national government, the role of local government at intermediate, municipal and community level, the role of international, national and community organizations; and the role of the final users of ecosan products. The questionnaire can be found at Annex 3. It summarised the issues that had been revealed in the first questionnaire and asked the experts to rate them in order of significance

To achieve this range, the second questionnaire was divided into three sections:

- Level 1: User perspective– Driving forces and barriers for implementing and using ecological sanitation.
- Level 2: Government perspective– the importance of creating an enabling environment. Local (and/or national) government can play an active role in sanitation planning, although they often do not do so for various reasons. National government sets the rules (through laws and a policy framework) under which sanitation services are provided. Local government can create an enabling environment for consumers to choose ecological sanitation systems. The key discussion point is the role of government at various levels in ecological sanitation and what instruments they have to stimulate ecological sanitationand thereby create the enabling environment.
- Level 3: Final users' perspective– the end users of excreta and/or urine products in agriculture. The use of excreta is some culture is more prevalent than in others for agriculture use. However, the management of excreta can be a strong barrier for ecological sanitation. There are also logistical issues, such as finding safe and low cost ways to transport excreta and/or urine products to where they are needed.

Questionnaires were administered by e-mail, with reminders and encouragement by telephone. Some open discussions with ecosan champions also took place at the Sustainable Sanitation Alliance meeting in August 2007 in Stockholm, Sweden.

In retrospect, it may have been more useful if the second questionnaire had asked the experts to rate the issues in a scale manner ranging from good to bad, rather than numbering them by priority. However many of the champions added their own comments in the open space box provided with each question. This gave additional useful information and thereby a better insight into the real issues.

2 Background

What is ecological sanitation?

Ecological sanitation is based on three fundamental principles: preventing pollution rather than attempting to control it after we pollute; sanitizing the urine and the faeces; and using the safe products for agricultural purposes. This approach can be characterised as "sanitize-and-recycle".

This approach is a cycle- a sustainable, closed-loop system. It treats human excreta as a resource. Urine and faeces are stored and processed on site and then, if necessary, further processed off site until they are free of disease organisms. The nutrients contained in the excreta are then recycled by using them in agriculture (Winblad and Simpson-Hebert, 2004).

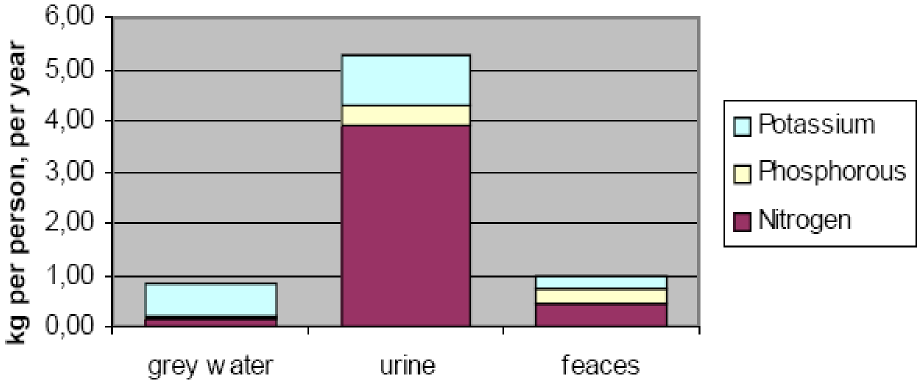
The concept of ecological sanitation is based on the idea that urine, faeces and grey (sullage) water contain resources that form part of the ecological cycle. The nutrients in human excreta and grey water are valuable and should be regarded as such. Hygienic use, instead of hygienic washing away is one of the key principles. Use of nutrients in human excreta and grey water is only possible when the complete sanitation system is taken into account, from source to final disposal. This contrasts with end-of-pipe solutions. Ecological sanitation does not just promote hygienic use of human excreta and grey water after they have been produced; one of its main objectives is to recover and reuse them as precious resources.

In some respects, daily practice is ahead of scientific progress and interest. While scientists and engineers still debate the wisdom of reusing municipal and industrial wastewater and sludge for agricultural purposes, farmers in the peri-urban areas of Africa and Asia have widely adopted this practice out of sheer necessity. As the International Water Management Institute (IWMI) says on its web page on wastewater reuse: "In rural and peri-urban areas of most developing countries, the use of sewage and wastewater for irrigation is a common practice. Wastewater is often the only source of water for irrigation in these areas. Even in areas where other water sources exist, small farmers often prefer wastewater because its high nutrient content reduces or even eliminates the need for expensive chemical fertilizers." IWMI goes on to point out that research is needed on the impact on human health, wealth and nutrition (as well as soil-fertility) of using wastewater and excreta for agricultural production to generate practical advice for farmers and information for consumers, to limit risks and maximise benefits.

An average human being produces annually 500 litres of urine and 50 litres of faeces, which contain enough nitrogen, phosphorous and potassium (NPK) to produce the equivalent of 230kg of cereal/year. This human fertiliser can partly replace the demand for artificial fertiliser. The need to conserve phosphorous, a mineral resource used to produce artificial fertilisers, is urgent. The most important causes of phosphorous depletion are inefficiencies in agricultural practices and the dispersal in sewage and solid waste of phosphorous contained in food and phosphate-based detergents. Recycling from sanitation and solid waste can be a partial solution.

Keeping urine separate opens ways for more effective treatment in both dry and existing wet systems. Urine contains the largest amount of nutrients in wastewater. Compared with faeces, urine contains about 70% of all nutrients available in excreta (urine and faeces). So, if urine is kept separate, wastewater treatment plants would require less energy.

Figure 1: Nutrient content of grey water, urine and faeces (after Gajurel and Otterpohl, *2003)*



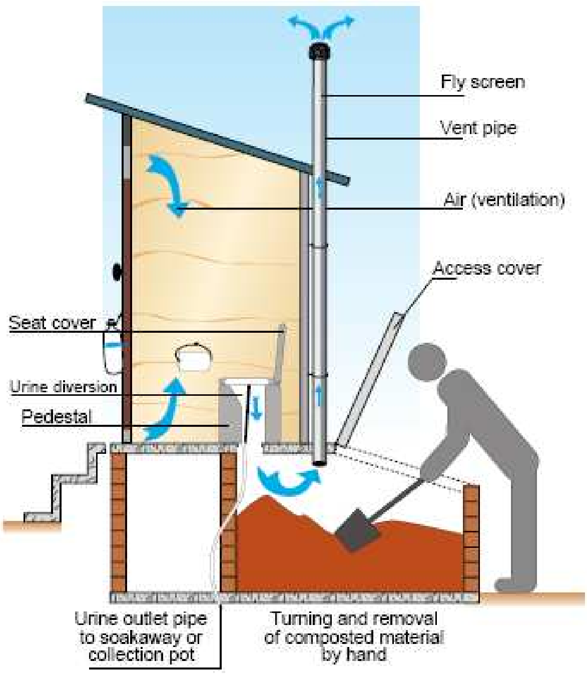
An additional advantage of dry urine diversion sanitation options is the optimisation of pathogen destruction. Research and practice have demonstrated that pathogens die quicker in circumstances with:

- High pH rate (adding sawdust, ash, etc.)
- Increased oxygen supply (ventilation)
- Low moisture (urine diversion, dehydration)
- Higher temperature (solar / artificial heating)
- Increased retention time (storage)

These conditions prevail in dry climates. Adding water to excreta creates precisely the opposite situation. Another advantage of diversion of urine (either in dry or wet sanitation systems) is the reduction of bad odour in comparison with systems such as pit latrines or composting toilets. Mixing faeces with urine creates a septic situation with the familiar unpleasant smell.

Urine diversion toilets depend on regular manual removal of urine and less frequent removal of dried faeces. In many ways this requires a shift in attitude towards sanitation for many stakeholders and a danger that the system will depend on the poor for excreta collection. This is a general problem facing the waste sector: bad image and unhealthy jobs for the poor (Bruijne, G, Geurts, M., Appleton, B., Snel, M. 2007).

Figure 2: Composting urine diversion (UD) toilet



What are the arguments for and against ecological sanitation?

The ecological sanitation concept can be summarised and divided into three main steps: separation/collection, treatment and utilisation. Each step can be implemented through different technologies, processes and components as shown below:

Table 1: Types of Ecological sanitation facilities

Step	Solution/Modules
1. Separated "in-house/on-site" collection (faeces/urine/grey water/organic solid waste)	"High-tech" (waterborne) • Double or triple sewer system in households • Vacuum toilets/urine-separation toilets "Low-tech" (dry) • Appropriate on site latrine systems (with faeces chamber and urine diversion)
2. Treatment	• Anaerobic digestion (faeces/organic waste) • Drying (faeces/urine) • Storage (liquid urine) • Composting (faeces/organic waste) • Constructed wetlands/sand and gravel filtration; membrane filtration (grey water)/maturation pons • UV treatment
3. Utilisation	• Fertiliser in agriculture (faeces/organic waste) • Irrigation (grey water) • Groundwater recharge (purified grey water, rainwater)

Source: GTZ and IUCN, 2003.

Ecological sanitation is most strongly linked to the promotion of urine diverting toilets which separate urine from faeces at the source. Using this method the urine can be tapped separately, and since it contains most of the nutrients, particularly nitrogen, it has the potential to be used either diluted or undiluted with water to enhance growth of vegetables, maize and trees, etc. The solid faecal matter collects in vaults, which may be single or double (alternating).

Ecological sanitation therefore implies the separation of waste streams, saving water and energy, nutrient recycling, cost efficiency and the integration of technology to environmental, organisational and social conditions. Ecological sanitation systems are often locally managed with, hopefully, low transport costs, minor requirements for water and reuse of nutrients. In other words, ecological sanitation to a larger extent utilises local resources.

So what are the strongest points on the advantages but also the disadvantages for Ecological sanitation? For the sake of clarity, the following table summaries these issues.

Table 2: Advantages and disadvantages to ecological sanitation

Advantages	**Disadvantages**
Affordable options for all This entails that this is an option that can be used by both the poor and the wealth with sustainable sanitary systems at affordable costs.	Existing legislation in many developing countries remain in favour of conventional, centralised sanitation systems would need to be re-visited in terms of encompassing ecological sanitation .
Flexible systems. This refer to the fact that ecological sanitation can be either centralised or decentralised (e.g. high-tech with low-tec), small or at a large scale.	Water closet and centralised sewers are perceived as the ultimate solution. However the fact is that poor people cannot achieve their aspirations. This inevitably increases the gap between rich and poor in developing countries.
Increasing health and dignity On the health front this type of system can eliminate large quantities of excreta which carry diseases	People's cultural, religious and social views can affect their willingness to use excreta-based fertilisers. Discussions should address psycho-social, religious and gender issues.
Quality of life and enhances dignity especially among the poor	
Enables use in an environmental friendly manner-compost and urine. This means a reduction in expenditure on chemical fertilizers and pollution caused by them. In addition soil fertility is higher and uses an environmental friendly manner.	
Technology points	
Does not use water as a carrier to dispose of human waste and hence conserves precious water	
No need for de-slugging or pumping out black water as in the case of septic tanks	
Ecological sanitation systems can be managed on household or community level and hence is less expensive and do not require investment in large-scale infrastructure as is the case with centralized underground drainage.	
No flies or foul smell; no mosquito breeding as there is no water stagnation	

Sources: Jenssen, et al, 2004; Winblad and Hébert, 2004; Jackson and Knapp, 2005; Morgen, 1999 & 2002.

Based on the literature, one might argue that there are more advantages than disadvantages in respect to the potential resources produced. However, as will become clear from the case studies and the questionnaires, political/institutional frameworks must also be in place to adequately support sustainable ecological sanitation in the long term.

In order to focus on the potential barriers for scaling up, one first needs to understand the role of local governance in general. As cited by De la Harpe (2008), local governance is the set of policy frameworks, structures, relationships and decision making that takes place at the local level to deliver a service or achieve an objective. Within the context of decentralised service provision we understand the term 'local' to apply both to the local governance level (the district or municipality for example) and the community level. How local governance works in practice varies from country to country depending on how government is structured and on the policy and legislative framework. This also applies to the implementation of ecological sanitation within the context of local governance.

Figure 3: Requirements for good local governance

Within the diagram above, we can see that it is simply not only a question of the implementation of ecological sanitation scheme at, for example, community or district level but about the linkages to a number of factors within the local government context which make ecological sanitation sustainable in the long term.

Similarly, we need understand what is meant by scaling up. In order for a project to "go to scale", it needs a number of factors, namely:

- a consistent vision and consistent values
- a core group for learning and action in which all stakeholders are represented;
- a motor- public, private or semi-private- to push the process of change;
- highest level political support and commitment
- different strategies for different local contexts;
- different promotion mechanisms for different services: water, sanitation and hygiene.

Government/policy issues

All countries have national policy and legislation to guide the provision of water and sanitation services. However not all local governments have developed local policies and by-laws for the local provision of services within the national framework. Policies and by-laws create an enabling environment for the provision of WASH services. These are the 'rules of the game' that provide the framework within which services are regulated. By-laws cover the standard of services, technical conditions of supply, how tariffs are determined and structured, the payment and collection of funds for services, conditions under which services will be discontinued (for example if a customer does not pay), how the services will be installed, operated, protected and inspected (De la Harpe, 2008),

In terms of ecological sanitation, policies, legislation and/or by-laws remain nearly non-existent. Only a few exceptional countries such as Sweden and Finland, have come further down the road towards promoting ecological sanitation and have some form of mandatory legislation in place.

If existing legislation for sanitation is in place it needs to be modified and new regulations will be required with a specific focus on ecological sanitation. Without political backing, no project, let alone ecological sanitation has any long term sustainability.

Institutional issues

Water and sanitation services, which may include the provision of ecological sanitation facilities, need to be planned for as part of an integrated development. The planning process must assist stakeholders and their representatives to make informed decisions about, for example, the various types of ecological sanitation facilities available. Planning should include data collection and analysis, stakeholder participation, strategic decision making, project identification and prioritisation, and allocation of resources to implement any such plans (De la Harpe, 2008).

If ecosan systems are implemented, some new institutional arrangements may be required. For example, ecosan system in cities (or peri-urban towns) may wish to create a new department separate from the water and sewerage authority. It may even wish to create an institution that links the ecosan products with urban and rural end users.

Financial issues

Ecosan systems does initially require some more investment for its infrastructure which may be a bit higher than other on-site sanitation options, such as VIPs (ventilated improved pit latrines). In addition, ecosan systems do involve initial costs for information, training, monitoring and follow-up that are greater than corresponding costs for conventional sanitation systems. However, from a long-term financial perspective, it should be cited that ecosan – like other on-site options - does not require water for flushing, no pipelines for the transport of sewage and no treatment plants and arrangements for the disposal of toxic sludge.

Psychology issues

Whether we like it or not, culture plays a very strong role in the acceptance (or not) of ecological sanitation. In Africa, as well as in many countries in Asia, there are taboos against the handling of faeces and its possible reuse. Even if the toilet may be heavily subsidized, these cultural issues will remain. As well as our instinctive repulsion towards excreta, culture inevitably does influence our attitudes towards handling (William, 2005; Manandhar, et al, 2004).

Box 1: Psychological issues

"The psychological aspects of treating human excrement are not well known. Although there is a universal consensus that body waste are sordid, our elimination behaviour and our feeling about it are all learned from our experiences, and evolve and change over time (Kira, 1995). As a result, there is no absolute right or wrong behaviour or attitude, except within a cultural context. In Western cultures, for example, the scale of excrement treatment stimulates different public reactions. Mention a pit privy or ecological sanitation toilet, and the giggle-factor often creeps into the expression. Mention a central sewage system or the health-related statistics and the general response is far from humorous!

In concept, the bridge between attitude and behaviour appears obvious. In reality, the relationship is complex and somewhat unpredictable. For example, McCarthy and Shrum (1994) found that personal values about recycling solid waste did not have a direct relationship with recycling behaviour. Values did, however, influence attitudes; and attitudes about the inconveniences of recycling influenced recycling behaviour. These findings by McCarthy and Shrum (1994) did not however include excrement in their attitude-behaviour study.

Even if the relationship between attitude and behaviour were known, one could not draw universal conclusion about man's reaction to a new toilet or waste treatment system. Psychological investigations follow scientific principles of fair sampling, which implies the results from a study pertain only to the sample population. One cannot deduce, therefore, that a Western attitude would be valid in an Eastern culture. Likewise, one cannot expect Western behaviour in the East.

Therefore if one applies these psychological considerations to the subject of alternative waste treatment, one can understand the general scepticism toward ecological sanitation toilets. To begin with, potential users are often unfamiliar with alternative disposal systems. Probably the most unfamiliar aspect of these sanitation options is that treatment requires some handling at the household level, of the products. But these attitudes are not fixed. Experts in ecological sanitation note that when people see for themselves how a well-managed system works, most of their reservations about handling human waste disappear (Winblad, 1998).

Source: Direct citation from William, 2005[1].

Religious issues

Religions vary considerably in addressing excreta. The Koran, for example has strict procedures to limit contact with faecal material, including its use in agriculture, because excrement is considered impure. As those of Islamic faith use water after defecation, this is an issue as ecological sanitation requires only very little water to be used. The principle Hindu text gives a detailed code of conduct for rituals, the Artha Veda, which clearly specifies the use of water for personal hygiene. In the bible, the act of elimination is mentioned only once, and there is no reference to the use of excreta for agricultural purposes. Similarly in Buddhism, there is no mention of excrement although there is a reference to the harmonious concept of recycling life's treasures (Jenssen, et al, 2004). In discussing such issues it is important to make a distinction between excrement (which in a raw state is indeed impure) and faecal products which have been transformed through the composting process.

Box 2: The role of religion

"Aside from some of the above cited religions, there are countless others that influence waste treatment behaviour. In some cultures, religion is not a separate element of society, rather an *integr*al focal point. It is, therefore, difficult to determine if a particular behaviour is the result of religious doctrine or merely a learned behaviour! For example, the burying of faeces is widely practiced to ward off evil spirits; separate facilities are sometimes provided for particular social groups; and contact with faecal matter is often unacceptable to certain individuals in society (Franceys, et al, 1992).

Source: Direct citation from William, 2005.

Gender and age issues

Gender and age also play a critical role; women need privacy and space and ways of dealing with waste items especially related to menstruation, which could have a big impact on potential re-use. In addition, for the very old special provisions are needed for using such a facility (Jackson and Knapp, 2005).

Ecological sanitation however can also provide a new positive understanding in terms of gender roles. It is significant that ecological sanitation toilets can improve health, generate fertiliser, and consequently increase family income. It is often the women in a family who take care of health and cleanliness and it is likely that in many situations women will be responsible for the effective functioning of an ecosan toilet. Ecological sanitation could in this respect actually potentially increase women's power to control their own lives in the sense that instead of a producer of water, she becomes a producer of resources, which can benefit herself and her family (Jenssen, et al, 2004).

In the following section, a number of pilot schemes which some of the champions are responsible for are described. This is to give the reader an idea of scale of the ecosan schemes, the type of facilities and organization(s) involved.

3 Selected case studies on ecological sanitation

The following section provides an overview of ecosan case studies from the various continents. These case studies give an idea of some of the types of ecosan facilities that exist and the types of issues they are facing. The sources for these case studies came from specific individuals working within these organizations. The reader may either read all of the case studies or dip into specific case studies. The table below (Table 3) gives an umbrella view regarding the type of facilities, the year the scheme was started (and possible finished) and the number of ecological sanitation facilities built (or to be built). The last column provides the level of external financing (in the form of subsidies).

Table 3: Overview of case studies

Country	Organization involved	Type of facilities	Years of the work	Number of ecosan facilities	Level of subsidy
ASIA					
Philippines	Center for Advanced Philippines Studies (CAPS)	-Household toilets -School toilets -Local Gov't buildings/projects	2004-onward	265 household toilets 3 school toilets 463 local government toilets	50% 50% 0%
Nepal	Environment and Public Health Organization (ENPHO)-	- Double-vault, urine diverting dehydrating toilets	2003-onward	200 toilets in 6 areas	70% and 80% subsidy for ultra poor. For other households, they bear between 20-30% of the total cost which includes provision of unskilled labour and construction of superstructure, the rest being borne by UN-HABITAT and WaterAid.
India	SCOPE	- Double-vault, urine diversion toilets	2003-onward	700	70% from either UNICEF, GTZ (Germany), FIN (France), SEI (Sweden) plus under the Total Sanitation Programme and 30% households pay themselves
AFRICA					
Burkina Faso	CREPA-	Dry UD toilets	2006-2009	1000 targeted by 2009 (construction will start in the coming months)	About 100€ per unit
Kenya	ECOTACT	Urine harvesting facilities at public toilets	2007- on ward	40 public facilities in bus stops, markets and CBD areas	Ashoka Award ($30,000) with a request for US$600,000 from ACUMEN Fund
Malawi	CCODE-	Urine diverting system	2005- on ward	Urine diverting 570 Alter Farsena 200	Zero
LATIN AMERICA					
Mexico	CEDICAR	Urine diversion toilets	2003- on ward	130 ecosan systems	Zero
Peru	CENCA	Urine diversion toilets	1998- on ward	12 ecological toilets (where treated grey water is used to irrigate trees) 43 ecological toilets (where the grey water can't be used for irrigation due to geography of the area)	Zero
Costa Rico	ACEPESA	Low flush toilets and urinals	**3 years**	37	80%

Philippines: Demonstrating the viability of ecological sanitation principles (CAPS)

The Center for Advanced Philippines Studies (CAPS) developed a partnership with the City of San Fernando, La Union for the implementation of Ecological sanitation pilot projects in1993. A focus was placed on two areas, namely two barangays of the City: Barangay San Agustin, a peri-urban settlement located along the coast; and Barangays Nagyubuyuban, a rural upland agricultural community. Ecological sanitation pilot projects were also implemented in various institutions such as Don Mariano Marcos Memorial State University (DMMMSU) - North La Union Campus, selected public schools in San Fernando City, plus the Botanical Garden and Science Centrum.

The objective of the ecosan project was to demonstrate the viability of Ecological sanitation principles and systems in the Philippines through pilot projects in the City of San Fernando, La Union. Beginning in 2004, there have been a number of activities undertaken which included the building of demonstration Ecological sanitation toilet facilities in at least two pilot communities, assisting city authorities with the formulation of an Integrated Sustainable Waste Management system on Ecological sanitation that takes into consideration excreta generation, urine-faeces separation, treatment, collection, reuse and recycling; and creating an enabling environment within and around the City with an end view of institutionalizing Ecological sanitation principles and systems in the City health, sanitation and environment policies, plans and programmes.

In 2004, a Consortium was formed to manage the Ecological sanitation projects. This included the City Government San Fernando, CAPS and there other NGOs. In 2005, the construction of at least 200 Ecological sanitation toilets began, i.e., in Barangays San Agustin and Nagyubuyuban; Don Mariano Marcos Memorial State University (DMMMSU). The Botanical Garden of San Fernando City, the Science Centrum and selected public schools were also selected as ecosan sites. As part of the strengthening of ecosan, CAPS worked with national government agencies and the donor community to establish a national network to promote Ecological sanitation concepts in order to influence national policies on sanitation. In 2005, the Philippines Ecological sanitation Network was formed.

CAPS is promoting the urine-diverting dehydrating kind of Ecological sanitation toilet. The main challenge however is that people are not used to handling human excreta. The “flush and forget” method remains ingrained in people’s mind.

Although important efforts have been made via the Ecological Sanitation Network, ecological sanitation however is not mentioned in the Philippines sanitation code. A new law, the Clean Water Act of 2004 is heavily oriented towards sewerage management. In addition, national authorities and a majority of local decision makers are still wary of Ecological sanitation and have concerns about its viability. As such, it is difficult to institutionalize ecological sanitation in most cities and municipalities.

In addition, there is still no culture of sanitation planning in most local governments. This is not to say that CAPS have failed to introduce Ecological sanitation in the Philippines but the task to scale up is daunting. There are a handful of local governments who have now adopted and implemented ecological sanitation and the number is increasing. There are currently about 500 ecological sanitation toilets in San Fernando City and another 500 in other cities. In addition, the Philippine Ecological sanitation Network (PEN)[2] has been able to lobby and insert in the Implementing Rules and Regulation of the Clean Water Act a small provision allowing Ecological sanitation as an accepted sanitation option.

In terms of specific challenges on the issue of policy, local authorities, specially the local chief executives, are still unclear regarding the principles behind Ecological sanitation. As described by one of the key workers at CAPS "Ecological sanitation needs champions for it to be popularized, understood and institutionalized in terms of clear policies, develop sanitation plans with budget and committed implementation."

On the institutional front, sanitation in general and Ecological sanitation in particular, do not have any dedicated staff or unit with a mandate within the local government structure. Currently, sanitation is a loosely coordinated task among various departments, e.g., health, environment, engineering, solid waste management departments. Primary responsibility for sanitation is often unclear among the departments because sanitation issues cut across health, environment and infrastructure. In other words, there is a need for better inter-sectoral co-operation between the various departments in government.

On the financial side, there is still no culture of sanitation planning, it follows that sanitation issues, much less Ecological sanitation, receive no or very minimal budget from the government. For this specific scheme however 50% of the cost is subsidies by local government.

From a cultural perspective, people are not comfortable physically managing their waste, preferring the "flush and forget" system. The way CAPs promotes Ecological sanitation is in the context of poverty alleviation under the UN MDGs. CAPs targets the very poor families without toilets. They are easier to convince than those with existing pour flush toilets.

In summary, based on the experiences of CAPS, there are a number of factors which have influenced the gap in getting ecological sanitation beyond a pilot stage. According to CAPS these are: a) lack of social acceptability at the household, community and city levels; b) Ecological sanitation projects that are heavily subsidized tend to be not sustainable. Loca l demand must be created; c) lack of political will on the part of local authorities; d) the change in local leadership (through elections, for example) wherein Ecological sanitation projects and policies are not sustained, replicated or scaled up. An enabling environment in the Philippines must be created for Ecological sanitation so that it can move forward.

Nepal: Peri-urban ecological sanitation (ENPHO)

The peri-urban areas in the Kathmandu Valley are inhabited by poor farming communities. Water supply and sanitation coverage in most of these areas is in adequate. Even though some areas have access to piped drinking water, service delivery is poor and water is usually microbially contaminated. The water quality of traditional water sources like ponds, dug wells and wells is highly degraded. A majority of the population still practise open defecation and

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[2] PEN has defined Ecological sanitation as an approach that applies the principles of 1) resource conservation, 2) pollution prevention, 3) reuse, 4) minimization of energy and water use and 5) proper/safe human excreta management.

the small percentage of people having access to sanitation facilities use either pits or septic tanks. Due to improper design and the high groundwater table, pits and septic tanks fill up fast creating unhygienic conditions and leading to either unhygienic emptying or abandonment in addition to groundwater pollution.

In the past, people have used raw human excreta on their agricultural fields. Over time, use of this resource dwindled with the introduction of chemical fertilizers that replaced the need for this local nutrient resource. For example, farmers of the Kathmandu Valley have been practising the use of night soil in the agricultural fields for decades. However, with the introduction of the sewer system in the city areas and of chemical fertilisers, this practise is now limited to small numbers of farmers who rely on the resources produced in their households. Farmers however do still realise the importance of human excreta in agriculture.

In this regard, the ecological sanitation project set up by ENPHO was nothing new. The concept of ecological sanitation was introduced to Nepal when a water and sanitation professional from ENPHO attended the training course provided by the Swedish International Development Agency (SIDA) in Sweden in 2001. ENPHO organized the first talk programme in January 2002 to sensitize stakeholders working in water and sanitation sector about the concept of ecological sanitation. After the programme, many organizations were motivated to initiate the ecosan programme in the peri-urban communities of the Kathmandu Valley.

A pilot demonstration project with construction of 10 double-vault, urine diverting dehydrating toilets was initiated in 2003 in a peri-urban area (Khokana) with financial assistance of WaterAid Nepal (WAN). The project was implemented in association with partner organisation in the community. WAN has since then been funding ecological sanitation construction in other peri-urban areas as well. In the second phase, 30 toilets were constructed in Khokana and 18 in two other communities. WAN and UN-HABITAT are now implementing ecological sanitation in Siddhipur which is another peri-urban area. There, 80 toilets are already under operation and about 44 are under construction.

Table 4: Number of ecological sanitation latrines in different areas (source: ENPHO)

Year	Locations						
	Khokana	Lubhu	Siddhipur	Tigani	Imadol	Siddhikali	Duwakot
2003	10						
2003/04	30	6			12		
2004/05			24	6	1	4	
2005/06	25		56 (+44)				10
Total	65	6	124	6	13	4	10

The most favourable aspect for up-scaling of the initial programmes has been the *social acceptance* of this system in the farming communities. The other aspect is the very poor sanitation situation in the peri-urban areas. In a situation where the pits and septic tanks fail and where there are no sewer systems, ecological sanitation for this specific area is viewed as the best alternative sanitation option.

In terms of finances, unit cost during the pilot phase was US$ 270. It has however not been possible to bring down the cost substantially as the present unit cost is still US$ 230. Due to the high cost, people in poor communities cannot construct these toilets without outside funding.

Currently, each household bears 30% of the total cost which includes provision of unskilled labour and construction of superstructure, the rest being borne by UN-HABITAT and WaterAid.

So far operation and maintenance costs have not been analysed in detail. The products are used by the households themselves and the treatment is also done in-house therefore there is no cost incurred in treatment and reuse.

Households themselves are responsible for the operation and maintenance of the toilets. Experience shows that if the users are motivated and also trained well, then the operation of the toilets is simple. However, there are still some constraints in the proper operation mainly due to the reason that the toilet users were either used to open defecation or pour flush toilets, making it difficult to get used to the procedure of the ecological sanitation toilet.

Maintenance requirements are negligible where the structure itself is strongly built. Some small flaws in the initial structures are maintained either by the user alone or jointly by the project and the user depending upon the type of maintenance required. Apart from the design aspect, other regular maintenance like cleaning the toilet or the timely emptying of the vaults is done by the users.

It is found that the community and the potential users must be well trained and provided with adequate knowledge on the concepts of ecological sanitation for the proper use and maintenance of the toilets. The users have been found to be very enthusiastic on reuse of products and are happy with the yields. They cite that crop yields are better compared with the chemical fertilisers.

India- SCOPE- Starting an ecosan movement

SCOPE is an NGO based in Tiruchi, Tamil Nadu (India) established in 1986 to support the empowerment of marginalized women in rural and peri-urban areas. One of the basic problems in the area was a lack of adequate latrines. SCOPE with the help of the State Government under the Total Sanitation Campaign built over 15,000 pit latrines during the period 1995.

However over the years it was found that in several of the villages along the banks of the river Cauvery and irrigation canals, where the water table was high, pit latrines collapsed and people were forced to again resort to open defecation. After discussing this issue with various experts, SCOPE designed an ecological sanitation compost toilet at its training center at Thanneerpandal, Tamil Nadu that would not be affected by high water tables. For the first time in the region, 18 ecosan latrines were constructed at Kaliyapalayam village, Tamil Nadu with the assistance of the District Rural Development Agency (DRDA) and SCOPE in 2004. After these first tests of ecosan toilets showed the toilet to function well, residents of Kaliyapalayam and later Sevanthilingapuram, started to build these types of toilets for 10 households. SCOPE has given training to masons in construction of ecosan, starting from the selection of site, materials needed, until the superstructure is constructed. In general the training programme lasts around three days.

With support form UNICEF, an additional 63 individual household compost latrines where developed in the first phase (2004-2005) and another 75 in the second phase (2006-2007). By November 2006, Sevanthilingapuram village became the first ecosan peri-urban area in the country with ecosan latrines in all 204 houses. In Musiri, an area close to Sevanthilingapuram, another 300 household ecosan latrines have been constructed with the assistance of WASTE (The Netherlands).

Due to the tsunami in December 2005 which hit Kameshwaram village- a coastal town in Tamil Nadu, a total of 100 ecosan latrines where built by SCOPE and this time with the support of UNICEF, DRDA and FIN-France as part of the reconstruction and improving living standards of the people in the area. In the Tsunami hit Nagapattinam, Villupuram and Cuddalore coast, around 100 ecosan latrines were also built. SCOPE has built over 150 ecosan latrines in Kameshwaram, Akkaraipatti and nearby villages of Nagapattinam district. Around 20 masons in the area have undergone training in the construction of ecosan latrines.

The ecosan movement in this region of India is starting to spread into other areas with the strong advocacy support of UNICEF especially in problem areas like rocky, area as well as Tsunami hit coastal belt. The staff and masons of MYRADA, another NGO in the region, for example have visited Kaliyapalayam and Musiri on exposure visits and have had a number of their masons trained at the training centre of SCOPE. As a result, MYRADA has built 100 ecosan latrines in Talavadi, Erode district. The first ecosan community latrines were opened in April of 2006. They received financial support form WASTE (the Netherlands) and the Musiri Town Panchayat. This community latrine has two blocks, one for men and the other for women with seven cubicles in each block. The urine from the latrines is collected in a tank. Each community latrine consists of two chambers. When the first chamber is filled up it is sealed and the second one is used. So far over 400 litres of urine has been collected and used for irrigating 40 banana plants and other plants in the community latrine campus after proper dilution.

Overall similar to the case study in Nepal, there are a number of constrains mainly in terms of the acceptance of using ecosan facilities. The proposal is now is to take the urine for cultivation of paddy, sugarcane and bananas in nearby farms. However this will require some time as community members need to be more educated on how to build these types of latrines and safely use urine for cultivation.

Burkina Faso:Working towards scaling up ecosan (CREPA)

In recent decades sanitation has remained a low development priority for the landlocked West African nation of Burkina Faso. Countrywide, of the population of more than 13,900,000, 89% have no access to basic sanitation services. In rural areas this applies to 90% of the population, and in urban areas to 85%.

In the capital, Ouagadougou, around 1,130,000 of the population of 1,390,000, have no access to basic sanitation - a coverage estimated at around 19%. Several innovative initiatives were launched to address this problem, however with a population growth rate of around 5% per year these initiatives have had great difficulty in simply maintaining pace with growth –

particularly in peripheral areas of the city. In order to achieve a coverage of 59%, the Millennium Development Goal for sanitation in Ouagadougou, a further 1,050,000 people need to gain access to basic sanitation. This would require over 300 households a week investing in sanitation, every week for the next seven years, and would still leave 900,000 people without access to sanitation facilities. In addition to this, the city would be producing around 2,200 m^3 of faecal sludge a day (an assumed accumulation rate of 1l/cap/day for faecal sludge), currently with no clear concept as to how this should be managed. Even at today's prices the nutrients in the city's excreta, if collected and reused, would have an annual value of over 16.5 million euro.

It was in response to these significant sanitation challenges 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 project "ecological sanitation in peripheral neighbourhoods of Ouagadougou". The aim of the project is to facilitate the access of households in peripheral neighbourhoods to sustainable, safe and affordable sanitation systems that protect human health, contribute to food security, and enhance the protection of natural resource and the promotion of small and medium sized businesses. The project is co-financed within the framework of the European Union ACP Water Facility, and unites the experience of the GTZ, and CREPA in the design and development of ecological sanitation systems, based on demand oriented sanitation provision in Ouagadougou.
The sanitation systems envisaged for these areas aim to close the nutrient loop and thus contribute to resolving the serious problems of managing faecal sludge in the urban environment and the need for agricultural inputs in urban agriculture and market gardening. In order to ensure that sanitation system complies with the needs and expectations of all actors, the project has adopted a participatory and multidisciplinary approach, based on the Household Centred Environmental Sanitation (HCES) approach, and the premise that the users themselves are the key stakeholders in system design and operation, and that they must be supported in this process by an appropriate legislative and regulatory framework.

To achieve the project objective, the partners have 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 to ensure its inclusion in legislation and future strategic plans for sanitation, with particular attention being paid to the multi-disciplinary approach required for Ecological sanitation. This second phase is also serving to create the conditions for the third phase, which is to support and promote the involvement of the local private sector in furnishing the infrastructure and if necessary the logistic services required by the system.

The project began in July 2006 and will run for a period until 2009. Through a broad range of activities over this three year period the project aims to reach up to 300,000 people in Ouagadougou, informing them of the existence and the possibilities Ecological sanitation has to offer, and providing them with safe, appropriate, affordable closed-loop sanitation.

One major lessons learnt so far from the project experience is the importance in *creating a network of enabled actors* to work towards real collaboration at national, regional and district level. In the project however, time is a precious commodity. With financing secured for only three years via the EU Water Facility, there is considerable pressure to produce concrete results with little regard for the particularities of implementation. There is therefore a tension between taking the time needed to bring all actors with the project and the demands of the main financers.

A second major lesson that can be drawn is that capacity development has proven key to all project activities and that these have proven most effective when built on *existing capacities and knowledge* (such as including the community based organisations in awareness raising activities).

The project is now entering its second year of implementation in which Ecological sanitation systems will be installed and enter operation. The capacities of the stakeholders will be built upon in the coming months to ensure they are able to operate and maintain the chosen system. At the same time, one of the critical factors currently being focused on is improving the legislative environment for ecological sanitation in Burkina Faso, which entails lobbying across all administrative levels. With the full support of the municipalities, ecological sanitation will then be included as part of strategic sanitation plans across the country.

Kenya- ECOTACT- Ecosan Public facilities

In Kenya, sanitation services, especially in the urban centres, fall below 30% coverage. This poses a great danger in terms of public health as well as urban decay. For the last 20 years, the population in Kenya's urban centres have continuously grown at over 7%, with no corresponding growth of the infrastructure, with the last round of investments in the public sanitation sector occurred in early 1980s. This has led to unprecedented urban decay from the central business district, the public parks, public markets, and residential areas. In Nakuru for instance, there are four public convenience facilities that were put up in 1970s when the city had approximately 50,000 people. Today the city has grown tenfold but still retains the four facilities which are in a pathetic hygienic state and poorly maintained. In Nairobi all the 28 public conveniences had deteriorated to a point where they were being used by street families for shelter plus drug dealers, to conduct their illicit trade. In 2000, the Nairobi Central Business District Association (NCBDA) sought permission to renovate and manage these facilities. So far they have rehabilitated 18 facilities, which have markedly improved sanitation conditions, despite their inadequacy to serve the numbers of people in the city. This initiative has been extended to the slum areas of Nairobi through grants and subsidies by NGOs and UN agencies, where communities pay KShs 3 per use of toilet facilities or a monthly fee of KShs 200 per family.

In many developing nations, there are no (or a minimal) a regulatory framework to support development of sanitation. In Kenya, the sanitation policy was launched three days ago (e-mail dated 30-10-2007)! Despite the massive cry, and clear need to address issues like Kibera slums, it has taken more than 40 years since independence to get to this stage. The next step is follow-up and implementation of these policy frameworks, which in most cases are left on the shelves, this is coupled with a lack of capacity within the relevant agencies to understand and appreciate the emerging ecological sanitation concepts, and thus relying on the traditional engineering practice. Although there has been a lot of external pressure and financial support to access water in developing nations, this has not been seen on sanitation and thus the sanitation agenda has not been a priority.

Interventions especially in the informal settlements or slums have been complicated by lack of planning regulations to support basic service delivery and thus impacting on the budgetary allocations. Yet these are the places that most need the help.

Regarding ecological sanitation, the main challenges in Kenya lies on perceptions and approaches especially between the *advocates of ecological sanitation and the intended recipients.* This is coupled with lack of appropriate and accessible infrastructure to the consumers and the deliberate lack of appropriate policy frameworks focusing on sanitation developments.

Ecotact is a small private company founded in Kenya in 2006 with the sole objective of developing innovative social investments in environmental sanitation in Kenya. The company is developing different flagship social initiatives that include the innovative IKO toilet concept[3] "thinking beyond a toilet" an idea that has been awarded the Ashoka Award on Public Innovation for 2007. The IKO village for social housing models that optimizes ecological sanitation to its full potential, and the municipal waste management initiative that explore investing in women waste pickers into viable and vibrant economic ventures.

Ecotact aims to develop at least 200 facilities in all major urban centres in Kenya, developed in to three phases. Phase 1, which is currently taking place (2007-2008) is targeting 10 municipalities[4] with a total of 40 facilities distributed in bus stops, markets and CBD areas at a cost of US$ 1M. Ecotact has contacted and engaged Care Enterprise Partners for a co financing loan and is expecting an approval of US$200,000 that will take care of the construction costs of 10 units. The concept has scoped 2007 Ashoka Award which will support on further development of the innovation approx. US$ 30,000; and is requesting US$600,000 from ACUMEN FUND for the completion of the first phase with construction of 30 facilities.

So far, IKO toilet has developed a urine harvesting facility for public use in Nakuru Municipality- which has been operational now for the last 7 months with an average usage rate of 600 persons per day. It has caused a lot of excitement both at municipal and central government level. The urine is being utilised for municipal organic composting by a community cooperative. In addition, Ecotact is focusing on scaling up with request from the government and respective municipalities and with funding from Acumen Fund and Care Enterprise Partners-Canada, and planning to construct 40 facilities –urine harvesting systems in 10 municipalities in Kenya.

Malawi- CCODE- Ecological sanitation in urban slum areas

CCODE, a registered Non Governmental Organization based in Lilongwe, Malawi, and working in alliance with the Malawi Homeless People's Federation, focuses on the inclusion of the poor in development programs, that is, to enable them to develop their own initiatives at the

[3] IKO toilet concept is an idea that transcends sanitation into a sustainable development unit that supports private sector involvement in delivery of basic municipal sanitation services, strengthening urban hygiene, generating employment opportunities and increasing access to the services. The idea supports an integration of social linkages, environmental sustainability and local entrepreneurship to promote a public good.

[4] Nakuru, Naivasha, Mavoko,,Nyeri, Karatina, Meru. Chuka, Embu, Thika and Kiambu

level of concrete interventions. Such an approach brings out the civic involvement of the poor. Women are central in this process, and they are given an opportunity to articulate their problems and design options that they then negotiate with state officials and other resource holding agencies to develop solutions to their problems.

Due to the fact that most slum areas are in marginal lands where water tables are high, and due to limited space in cities, CCODE decided to adopt ecological sanitation technology in urban slums. After trials with several Ecological sanitation technologies in 2005, the community members settled for the skyloos[5]. This is because the skyloo was found to be "cleaner", requires little or no digging, and has the added value of producing manure. So far, 250 skyloos have been constructed in Lilongwe City and 200 in Blantyre City; 87 have been constructed in Mzuzu City[6]. CCODE plans to connect the skyloos to biogas digesters that will provide households with energy for cooking and lighting, among other uses. The manure from the skyloos is to be collected by the Solid Waste Management Teams established by the Federation.

CCODE has been involved in ecological sanitation for the past two year through the delivery of low cost housing programmes. So far, 770 houses have been constructed in three cities. All these houses use ecological type of sanitation. CCODE has also been involved in the construction of 'alter fossena' toilets, but people seem to like the skyloos better because they are considered better than the pit latrines. The human waste in skyloos also dry and compost faster since they have a urine diversion system. The objective of CCODE is to eventually develop ecological sanitation facilities for 5000 person in 4 urban cities in the next 5 years.

This type of ecological sanitation is part of a low cost housing initiatives CCODE which is implemented for the urban poor of Malawi. The housing projects began in 2005 when communities had been exposed to Ecological sanitation through Water Aid and given plot sizes to try out Ecological sanitation rather than the traditional pit latrines. After the first batch of the Ecological sanitation alter farsena, people felt the sky loos were more user friendly and nicer and an improvement to the very traditional latrines. The ecosan facilities have been implemented in the three cities of Blantyre, Lilongwe and Mzuzu. As they are part of the housing projects that have a loan (all the costs have to be repaid at an interest of 12% per annum the current prevailing rate is 20% per annum).

Ecological sanitation has been successful in the programme because it has come as a total package together with housing and the people have thus been able to learn and come up with designs that suit (their needs) and this has led to huge levels of acceptability. The role of local government was found to be critical as they gave communities the space to learn and experiment on technologies that work for them and have thus made it possible to adapt to new ecosan technologies.

Mexico- TepozEco- Retrofitting a small town

[5] Skyloos are urine diversion toilets. However there are a few steps to climb up in order to get to the toilet, which is above ground level, hence the name "skyloo".

[6] The figure is expected to reach 600 skyloos in Mzuzu by end-2007 and 460 in Blantyre by the end of 2007.

TepozEco is one of three urban ecological sanitation pilot projects supported by Ecological sanitation Res[7] (along with China and South Africa) and shares research experiences with other ventures in Africa, Asia, Scandinavia and Eastern Europe. These local actions are designed to implement and demonstrate alternatives (or complementary approaches) to conventional sanitation practices. As such, there is a strong emphasis on research and development to adapt technologies to local conditions.

TepozEco is unique in that, unlike other Ecological sanitation pilot projects, which are primarily developing new systems, this project works in an established settlement. It must, therefore, compete against conventional systems and face the obstacles of dwellings that were not conceived with Ecological sanitation in mind. TepozEco has thus been described as a "retrofitting a small town". The challenge is partly technical: to design and refine Ecological sanitation systems for management and treatment of separate domestic and community "waste" flows – human excreta from UD ecotoilets, greywater, and organic solid waste. However, the Project is also confronted with the *more difficult task of establishing an appropriate framework for Ecological sanitation to be considered in policy, planning and budget allotments*, while most government decisions and programs are geared towards often unsustainable waterborne solutions.

Since its outset, the TepozEco project has pioneered the links between sanitation and urban agriculture. Decreasing soil fertility, escalating prices of chemical fertilizers, and contamination of water bodies– due to leaching and runoff of agrochemicals– highlight the need to develop alternatives that recover the valuable nutrients found in human excreta for agricultural purposes. Adequately stored urine is sterile and most nutrients in human excreta are found therein– in forms ideal for plant uptake. Aside from its direct use in agriculture, urine can improve composting processes, both as an activator and accelerator. Compost may then be used as a soil conditioner.

Public collection of urine is feasible and could provide a significant source of nutrients for urban agriculture. Nevertheless, given present agricultural practices, the total potential amount of urine in the municipality would be insufficient to substitute for all commercial fertilizers. Rather, to fertilize large-scale crop production, it will be advisable to combine urine application with other sustainable, organic agricultural practices. Urban urine harvesting (UH) can also have significant impact on water conservation, resulting in environmental, health and economic benefits. Finally, the project has demonstrated that local population – at least in Tepoztlán– can quickly overcome initial cultural rejections through demonstration and education.

Urban and periurban collection services for surplus Ecological sanitation domestic by-products are subsidized in the initial phase, just as wastewater treatment plants have been. The advantage, however, is that a neighborhood or community eco-station and composting facility would ensure proper treatment while encouraging the adoption of sustainable sanitation practices. Lobbying for the inclusion of *UH within existing state and municipal legislation* remains crucial to allow and encourage activities for closing the nutrient loop, while

[7] The Swedish Ecological sanitation Res Project coordinated by the Stockholm Environment Institute (SEI) has provided core funds for the TepozEco Project. Since the program is conceived mainly as technical support, most of these funds have been applied to salaries and fees, as well as administrative costs, for a multidisciplinary team of part-time and full-time Ecological sanitation experts and local counterpart staff (e.g. architect, biologists, agronomists, environmental and water management engineers and social scientist).

maintaining environmental and health risk standards. The WHO guidelines for the safe use of urine in agriculture, proposed by Ecological sanitation Res, are a major step in that direction.

Whereas the solutions will be context-specific, the basic approach can be readily applied to most of Latin America and other regions. This, according to TapozEco, is already happening through enriching south-south – as well as north-south and south-north – partnerships and exchange of Ecological sanitation technologies. Inspiring, training, and supporting others are an essential part of the Sarar/TepozEco mission. During the next phase, activities will intensify the delivery of technical support and capacity building services to community groups, NGOs, private entrepreneurs – such as housing developers– and the general public. One of the most important by-products of the process has been the consolidation of a skilled, experienced and committed team of Ecological sanitation professionals who will share their unique knowledge and capacity.

Perhaps the key achievement of the Project has been satisfied local "customers", which has, in turn, generated increased demand for ecotoilets in San Juan. The Project has demonstrated that by providing an aesthetically appealing, functional and affordable ecotoilet system, it is possible to overcome the stigma of the "dry toilet" as the inferior, temporary solution. Lessons from the field reveal the need to put more attention to design elements to stimulate demand, financial and credit mechanisms to increase access, and improved service delivery and maintenance support to assure user satisfaction and sustainability. All of these, together with an *appropriate regulatory and institutional environment*, will be critical for institutionalizing Ecological sanitation in Tepoztlán –and beyond.

Peru- CENCA- Closing the loop in ecological sanitation

CENCA, the Urban Development Institute, started to work with ecological sanitation in 1998 when a pilot project was implemented in the district of San Juan de Lurigancho, one of the most populated districts of Lima (more than 800,000 inhabitants), which included 36 ecological toilets in the houses and an irrigation system for 700 square meters of green area. Since then, two more additional projects have been developed at the east of Lima, one in Casa Huerta La Campilla of Cajamarquilla implementing 12 ecological toilets where the treated grey water is used to irrigate trees, and other one in Los Topacios of Nievería including 43 ecological toilets where the grey water can't be used for irrigation due to the geography of the area. CENCA has also been consulted by other groups who have implemented ecological toilets at institutions and households outside of Lima, for example in the mountains of Peru[8].

CENCA together with a number of other organitations, have currently constituted the National Work Group of Ecological sanitation entitled ECOLOGICAL SANITATION PERU, which is made up of 30 institutions including: 3 universities, 2 local governments and non-governmental institutions and organizations. Their objective is to promote and spread the Ecological sanitation in Peru by developing experiences that generate policy proposals in the agriculture and sanitation sectors (i.e. propose laws that promote the advantages of using of organic nutrients of urines and treated sewage for agriculture, re-using treated grey water for the

[8] The pilot project was selected by the program APGEP SENREM/USAID from more than 150 projects to be executed. Its successful execution has demonstrated a viable alternative for development of a worthy, healthy and sustainable environmental and economic habitat. In 2002 this ecosan project was recognized and awarded the VI edition of the ECO-Efficiency Prize by the Pontifícia Universidad Particular Católica of Peru and COCA COLA.

irrigation of green areas, constructing ecological toilets and implementing alternative sanitation programs which will make urban areas healthier and more ecologically sustainable).

A number of surveys have taken place in each of the project areas regarding the use of ecological sanitation in the communities (for further information on the detailed results of the survey refer to Smet and Snel, 2006). However in spite of all the good intentions, there is still the dilemma of government regulations. The fundamental question remains how to include ecological sanitation systems in the national policy and thereby prove that the system works and is safe for human health and plants.

4 Further insights into the barriers described by the champions in ecological sanitation

This section of the paper provides some of the key findings based on both questionnaires. For an overview of the questionnaire refer to Annex 3 and for a detailed overview of tables refer to Annex 4. It is important to note that the scores add to 100% which entails that respondents could only select one issue.

User perspective- driving forces and barriers for implementing and using ecological sanitation

- One of the greatest barriers towards scaling up ecological sanitation is considered religious constraints in handling excreta and/or urine followed closely followed by socio-cultural constraints in handling excreta/urine. In total around 45% found religious and socio-cultural issues the key hinderers from the user perspective. This rose to 59% when simple reluctance to handle excreta is included and to 73% if the technology not being seen as user-friendly is included.
- Users' perspective also focused on the issue of affordability of eco-san facilities which respondents stated play a vital role in terms of acceptance of ecological sanitation.

Government perspective- creating an enabling environment

The following are key issues cited by the "champion" respondents, namely:

- Lack of policy supporting sanitation in general and ecological sanitation specifically. The second issue of priority cited was both the lack of co-ordination between sectors and actors to support ecological sanitation and the lack of adequate financing for supporting ecological.
- At the intermediate level, the lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc) was considered the main barrier. This was followed by lack of sanitation planning at the intermediate level. The least priority issue (but closely following lack of sanitation planning) was the support by local government through backstopping.
- At the municipal level, the results show that both a lack of support in co-ordination between actual users and potential final users and the lack of support by local governments through backstopping are the critical issues. However looking at the

overall score, all three issues are quite evenly distributed which indicates that all of these issues are considered important.

- At the community level the issues of lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc) and the lack of adequate financing for supporting ecological sanitation are nearly evenly scored. This reflects that the champions consider both of these issues as nearly equally important.
- The role of international organizations, as cited by the "champions", clearly reflect that the lack of institutional/organizational support to other partners involved in ecological sanitation is the critical factor which prevents eco-san from scaling up.
- The role of national organizations, according to the "champions" suggest first, the lack of adequate financing for supporting eco-san, then followed (with only a one point difference!) by the lack of institutional/organizational support to other partners involved in ecological sanitation indicating that both issues are of importance.

Final users' perspective- end users of excreta and/or urine products

- The lack of support in co-ordination between actual users and potential final users is once again considered the most critical element is creating a barrier in the scaling up of ecological sanitation at the community level. This is followed by the lack of adequate financing for supporting eco-san.
- Although the issues of religious and socio-cultural factors are cited as the most critical barriers, other issues such as the lack of information, demand, and creating a favourable legislative, financial, institutional, organizational environment were considered secondary issues by the champions. This could entail that although religious and socio-cultural issues are citied at the greatest barrier towards the scaling up of eco-san, the champions clear acknowledge the other underlining issues facing eco-san from the final user perspective.

5 Conclusion: Key drivers, barriers and recommendations

Some of the key issues emerge as the main drivers and barriers towards scaling up ecological sanitation based on the narrative case studies of Phase I and the questionnaires from Phase I and Phase II are cited below.

The users' perspective
From a social perspective, religious and socio-cultural issues are seen as the greatest barrier towards scaling up ecological sanitation. These two issues in total summed up to 60%. If the related issues of handling excreta and urine and technology not being user friendly are also added in, then these user perception issues were together seen as the top priorities by 73% of the respondents.

However, pockets of ecosan schemes around the world, as cited in this paper, are slowly becoming more acceptable and finding ways to reduce cultural/social prejudices. In order to do this, more scientific but also cultural/social research on resistance to change needs to be undertaken. However, this research undeniably shows that:

- People are not comfortable physically managing their waste, preferring the "flush and forget" system.
- There is a lack of social preparation at the household, community and city levels for the implementation of ecological sanitation.

Religious constraints in handling excreta and/or urine also play a role in terms of user unwillingness to handle excreta and/or urine products.

Although a number of the champions in ecosan would argue that social barriers are being overcome (or will be shortly), the overall results from the questionnaire surveys do not reflect this finding. It is of critical importance that stakeholders, from government to households, become aware of the potential for ecosan. Religious and cultural acceptance can be changed especially if knowledge is shared. Lack of information and know-how currently remain the real barriers towards the possible development of ecosan at any scale of development.

The enabling environment
There is a lack of support and co-ordination at all governmental levels ranging from national, intermediate and municipal level. In many countries there is a lack of any general policies and/or regulation focusing on sanitation, let alone is ecological sanitation is considered as one of a range of options. Consequently, ecosan is often not taken seriously, and only takes place in small-scale pilot schemes and does not break out to large scale sustainable projects.

At the local government level:

- There is no culture of sanitation planning in most local governments.
- Local municipal and district level authories in many countries are still unclear of the principles behind ecological sanitation and national authorities and the majority of local decision makers are still wary of the viability of ecological sanitation. This leads to a lack of political will on the part of local authorities, so that the sanitation agenda is not prioritized.
- There is often **no** dedicated staff or unit within local government with a mandate for sanitation, let alone ecological sanitation. Sanitation is dealt with through a loosely organized assignment of tasks among various departments, including health, environment, engineering and solid waste management. Primary responsibility for sanitation, is often unclear because sanitation issues cut across health, environment and infrastructure.
- There is also a lack of capacity within the relevant agencies to understand and appreciate emerging ecological sanitation concepts, and they continue to rely on their traditional engineering practice.

Legal aspects
Ecological sanitation is not mentioned in most sanitation codes. For example, the new Clean Water Act in the Philippines deals with sewerage management but does not specifically mention ecological sanitation.

Financial aspects
One key constraint is that initial investment costs are somewhat higher for ecological sanitation than a number of other on-site sanitation options. This inevitably results in ecological sanitation being a less attractive option. Due to the initial higher cost for this type of facility, people from poor communities often cannot construct their latrines without outside funding. As a result, some ecosan governmental programme strongly relies on government subsidies or

external donors. These however prove *not* be sustainable in the long run in many cases, as shown, for example in the Burkina Faso case study. Financing is often secured for a limited time in projects, and there is considerable pressure to produce concrete results with little regard for the true costs of implementation, particularly after the physical implementation is completed. There is often a lack of adequate finance to supporting ecosan over a sufficient period of time.
Government therefore needs to adopt a long term vision and funding to match, including funds for capacity development and for the actual implementation of ecosan facilities.

End users of sanitation products
In terms of the end users of the ecosan products, the main challenge in many countries lies in squaring differences in perception and approaches between the advocates of ecological sanitation and the intended recipients. This is enhanced by a lack of appropriate policy frameworks in many developing nations that do not stimulate ecosan.

The potential for ecosan
Ecological sanitation clearly does have a niche as end-users of sanitation products, usually living in the nearby vicinity, are provided with nutrient rich urine and faeces products for agriculture use. In addition, ecological sanitation can have a niche in, for example, difficult geographical circumstances (high ground water table, rock ground). These niche markets should be developed and can provide the key to making ecological sanitation successful in efforts towards scaling up. Unfortunately, there is currently no research into this specific area, and it should definitely become a focus for any further ecological sanitation studies.

The fact is that many ecological sanitation schemes have only delivered on tens or hundreds (rarely thousands) of toilets in use in a particular place, usually with some form of public or private subsidies. Scaling up is obviously difficult so long as governments do not provide effective policy support for sanitation, with ecological sanitation as an option. Dealing with sanitation-related issues is often the task of a number of local government departments. Sanitation, should in this sense, get a “home” within one of the government departments at all levels.

In reality, research has proven that the use of extensive and unsustainable subsidies does not produce long term effective or affordable solutions. As reflected in the case studies, it seems difficult to scale up these facilities. Designing small pilot schemes with sustainable approaches focused on social marketing (in other words, creating demand) and can potentially encourage more long term solutions for ecological sanitation (Jackson and Knapp, 2005). This potential is reflected in some of the case studies.

At a global level, there is a wealth of data and experience from ecological schemes around the world, but there is a need to compile and share this information and knowledge at a more consistent pace over a period of time, to create a basis to develop new design guidelines for ecological sanitation (Jenssen, et al, 2004).

In summary, it is fair to conclude that the barriers towards scaling up ecological sanitation comes from:

- Social-cultural constraints towards the handling of urine and excreta.
- Institutional, financial and political constraints at local governance level.

Peter Morgen, the champion of champions in the area of ecological sanitation , states: "*Ecological sanitation is not going to solve the problems of the sanitary world, but it will surely help to provide solutions to many problems. Thus it must be seen as an additional method with specific application rather than a solution. Existing systems like the flush toilet have been supremely successful and have made modern life possible. Condemnation of such systems, which has been the practice within the ecological sanitation elite, leads to increased doubt for those who are uncertain. Ecological sanitation should prove itself on its own merit." (Interview with P.Morgen- August 2007)*

For ecosan to be able to "prove itself on its own merit" will require a much greater focused effort to overcome the barriers cited above. Some suggested recommendations include the following:

- There is a need for advocacy lobby work at municipal and governmental level in order to create an *enabling environment* for ecological sanitation and to ensure its inclusion in legislation and future strategic plans for sanitation, with particular attention being paid to the multi-disciplinary approach required for ecological sanitation.
- There is a need for better *inter-sectoral co-operation* between governmental departments dealing with sanitation and potentially, ecological sanitation.
- Local government should provide the *time and space* for communities to learn and experiment on technologies that work for them and thus make it possible to adapt to new ecological sanitation technologies. For example, most slum areas are in marginal lands where water tables are high and are a barrier toward proper sanitation facilities. Ecological sanitation could be one of the better options for situations with high water tables[9].
- Ecological sanitation needs *champions* for it to be popularized, understood and institutionalized in terms of clear policies which are backed up with developed sanitation plans, budget and committed implementation.
- There is a need to build onto *existing capacities and knowledge*, for example by including community based organizations in activities such as awareness raising.
- Users need to understand the *functionality* of ecological sanitation facilities including proper use and storage.

It is hoped that this paper has brought to light the reality of the developments in ecological sanitation and the main challenges that need to be tackled to scale it up. Although, various "converts" in the area of sanitation, believe that ecosan is the solution to existing sanitation problems, it will not work without the support and backing of local government. If this is not the case, the likelihood of scaling up will remain very slim indeed.

[9] Over the years it was found that in several villages in India, on the banks of the river Cauvery and irrigation canals, where the water table was high, pit latrines collapsed and people were forced to resort to open defecation. After discussing this issue with various experts, the NGO-SCOPE designed an ecological sanitation compost toilet in its training center at Thanneerpandal, Tamil Nadu which can withstand high water table levels.

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Annex 1: Champions in ecological sanitation

Name	Country
Generalists	
1. Christine Werner	Germany
2. Hakan Jönsson	Sweden
3. Peter Morgen	Zimbabwe
4. Anna Richert Stintzing	Sweden
5. Elizabeth Kvarnstrom	Sweden
6. Oscar Josefssan	Sweden
7. Mats Johansoon	Sweden
8. Barry Jackson	South Africa
9. Dr. Helvi Heinonen-Tanski	Finland
10. Franziska Meinzinger	Germany
11. Ralf Otterpohol	Germany
12. Elisabeth von Munch	Germany
13. Gert de Bruijn	The Netherlands
In the field	
13. Dan Lapid	Philippines
14. Dr. Subburaman	India
15. Madhab Nayak	India
16. Anselm Rosario	India
17. Ron Sawyer	Mexico
18. Victoria Rudin	Costa Rico
19. David Kuria	Kenya
20. Anselme Vodounhessi	Burkina Faso
21. Modibo Keita	Mali
22. Seydou Diakitie	Mali
23. Siku Nikhoma	Malawi
24. Edmund John	Tanzania

Annex 2: Comparison of issues in selected ecological sanitation schemes- Phase 1

The table below provides an accumulative overview of the issues that came out of the first survey which took place between August and November 2007. It is a tabulation of comments that came about of the questionnaire in the first phase.

ASIA

	Philippines[10]	India[11]
Governance/policy issues	- Local authorities, specially the local chief executives, need to understand the principles behind ecological sanitation . Ecological sanitation needs Champions for it to be institutionalized, in terms of clear policies, develop sanitation plans with budget and committed implementation.	- Policy frameworks are towards zero-open defecation which is supportive in a sense where particular technology is (put in place). Therefore, within (the) broad framework of environmental sanitation, all ecosan points are put in. Pollution guidelines and policy (refer) to ground water/river pollution which all relate to the control of water pollution.
Institutional issues	- Needs to be assigned to a dedicated staff or unit with mandate within the local government.	- Ecosan toilets are highlighted until now more than any other issues. Regional institutions must be involved and exchange their knowledge. Government organisations/NGOs/CBOs and business organisations must be involved so that holistic approaches can be developed and talked about. (Ecosan) must have scope of flexibility and regular exchange of skills, knowledge and personnel.
Financial issues	- There is still no culture of sanitation planning, it follows that sanitation issues, much less ecological sanitation , receive no or very minimal budget from the government.	- No comment
Social issues	- People are uncomfortable physically managing their waste, preferring the flush and forget system. The way we promote ecological sanitation is in the context of the MDGs. We target the very poor families without toilets. They are easier to	- Social acceptability must be explored region wise. - Create community leadership at community level to represent each community

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[11] Marachi Subburaman- SCOPE India Society for Community
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	convince than those with existing pour flush toilets.	
Hindering scaling up efforts	- One is lack of social preparation at the household, community and city levels. Two is ecological sanitation projects which are heavily subsidized tend to be not sustainable. Local demand must be created. Three is the lack of political will on the part of local authorities. Four is the change in local leadership (through elections, for example) wherein ecological sanitation projects and policies are not sustained, replicated or scaled up. To repeat, an enabling environment must be created for ecological sanitation to go beyond pilot phase.	(i) people participation is very weak (ii) It is supply driven (iii) Acceptability is poor (iv) Monitoring of pilot projects is not strong (v) Institutions are not integrated (vi) (Ecosan) is known to project people, conceived elsewhere and implemented somewhere (else). (vii) Project officials are more interested in good documentation instead of giving right-information/constraints (viii) We should know more (about) the failures (of ecosan) than (only the) successes.

	Peru	Mexico[12]	Costa Rico[13]
Governance/policy issues	- To establish a framework for ecological sanitation to be considered in policy, planning and budget allotments. - Rural "micro-region" development schemes / housing and settlement upgrading - To have the different levels of government establish incentives (tax deductibility, tax reduction, certifications of eco-products and eco-constructions, ISO quality, such as high level of commitment to environmental issues) to adoption of ecological sanitation systems - To have the different levels of government establish penalties regarding activities related to unsustainable and contaminating W+S practices - Lack of Mexican public policies that support an offer of ecological sanitation systems at large-scal	- To establish a framework for ecological sanitation to be considered in policy, planning and budget allotments. - Rural "micro-region" development schemes / housing and settlement upgrading - To have the different levels of government establish incentives (tax deductibility, tax reduction, certifications of eco-products and eco-constructions, ISO quality, such as high level of commitment to environmental issues) to adoption of ecological sanitation systems - To have the different levels of government establish penalties regarding activities related to unsustainable and contaminating W+S practices - Lack of Mexican public policies that support an offer of ecological sanitation systems at large-scale	- There is a lot of work to be done on lobbying at decision making levels, in order to change the way of thinking of our politicians, because there is a tendency to think that the best solutions are limited to sewerage. - Depending on the countries, we have to introduce changes in certain regulations because, for instance the use of urine for crops is prohibited in Costa Rica. In our case, for example permission is needed to implement constructed wetlands in the city.

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[13] Victoria Rudin-ACEPESA E-mail: vrudin@acepesa.org

Institutional issues	- Working closely with IWRM networks in order to integrate sustainable sanitation strategies, - Development of a "package" of W+S support mechanisms for planning and developing sustainable "integrated municipal utilities" - To insert ecological sanitation on sustainable tourism projects (Local Agenda 21) - That official government offices and public schools adopt this approach so as to promote water conservation, raise environmental awareness, fund decentralized treatment facilities, thus reducing overall economical and environmental costs to provide such services - Multi-stakeholder support - Service utilities - *"Organismos operadores"*	- Working closely with IWRM networks in order to integrate sustainable sanitation strategies, - Development of a "package" of W+S support mechanisms for planning and developing sustainable "integrated municipal utilities" - To insert ecological sanitation on sustainable tourism projects (Local Agenda 21) - That official government offices and public schools adopt this approach so as to promote water conservation, raise environmental awareness, fund decentralized treatment facilities, thus reducing overall economical and environmental costs to provide such services - Multi-stakeholder support - Service utilities - "Organismos operadores"	- In many cases ecological sanitation is not considered as an alternative for sanitation at government level.
Financial issues	- Total ecological sanitation investment (Integrated functioning closed loop systems) is 60% lower than that of conventional sanitation	- Total ecological sanitation investment (Integrated functioning closed loop systems) is 60% lower than that of conventional sanitation	- Because there is not a massive development of the ecological sanitation technologies, they have higher than conventional

	- Operational costs for decentralized treatment facilities is a fraction of conventional systems - In rural areas, one challenge is to put financial schemes in place for construction of ecological sanitation systems	- Operational costs for decentralized treatment facilities is a fraction of conventional systems - In rural areas, one challenge is to put financial schemes in place for construction of ecological sanitation systems	technologies.
Social issues	- Participatory community education (SARAR/PHAST methodology) and systematic monitoring & follow-up are critical to user acceptance, as well as training-of-trainers - Participatory planning, knowledge, management and decision-making - Development of educational tools to raise awareness on theme and allow deeper reflections before decisions regarding solutions are made	- Participatory community education (SARAR/PHAST methodology) and systematic monitoring & follow-up are critical to user acceptance, as well as training-of-trainers - Participatory planning, knowledge, management and decision-making - Development of educational tools to raise awareness on theme and allow deeper reflections before decisions regarding solutions are made	- Social and cultural issues are fundamental to achieve the acceptance of the people of these alternative technologies.

Hindering scaling up efforts	- Lack of support from government complementary service provision schemes, specially having to do with collection, treatment, and reuse of sanitized ecological sanitation by-products - Lack of information dissemination campaigns regarding low-cost ecological sanitation alternatives - Lack of financial credit schemes that would allow domestic ecological sanitation users to fund their water and sanitation infrastructure - Concentration of large subsidy schemes directed towards conventional sanitation infrastructure and practices, such as millionaire investments for sewer and typical wastewater treatment facilities - More equitable distribution of public finances to provide such services - Human nature – unwillingness to recognize that we are already living in another age!	- Lack of support from government complementary service provision schemes, specially having to do with collection, treatment, and reuse of sanitized ecological sanitation by-products - Lack of information dissemination campaigns regarding low-cost ecological sanitation alternatives - Lack of financial credit schemes that would allow domestic ecological sanitation users to fund their water and sanitation infrastructure - Concentration of large subsidy schemes directed towards conventional sanitation infrastructure and practices, such as millionaire investments for sewer and typical wastewater treatment facilities - More equitable distribution of public finances to provide such services - Human nature – unwillingness to recognize that we are already living in another age!	Work on more efficient systems for urban areas that could compete with the traditional technologies is needed now.

	Kenya[14]	Burkina Faso[15]	Malawi[16]
Governance/policy issues	- In Kenya for instance, the sanitation policy was launched three days ago. Despite the massive cry, and clear need to address issues like Kibera slums, it has taken more than 40 years since independence. The next step is follow-up and implementation of these policy frameworks, which in most cases are left on the shelves, this is coupled with clear lack of capacity within the relevant agencies to understand and appreciate the emerging ecological sanitation concepts, and thus relying on the traditional engineering practice. - A lot of external pressure and financial support to support access to water in developing nations, this has not been seen on sanitation and thus the sanitation agenda has not been a priority.	- More advocacy and political lobbying works need to take place which involve national, municipality authorities and governments in the system management of sanitation (including ecological sanitation).	- For a long time now organizations have been acting without a clear guiding policy on issues of ecological sanitation . The government has just approved a sanitation policy a couple of months ago and it is believed that things to do with ecological sanitation will now move better. Institutions that by law are mandated to handle issues of sanitation like Water Boards, do not handle them as they should. As a result therefore, there is no governing structure starting from the central, regional and local levels of government that can act as watchdogs in the delivery of sanitation issues in the country.
Institutional issues	- With corresponding weak regulatory frameworks, there is no or weak institutional frameworks especially at the government level to coordinate sanitation issues.	- Design and set up institutional arrangements which allows the participation of local communities and private sectors in ecosan systems management,	- Not so many institutions handle issues of ecological sanitation . There are only a few Non governmental organization in the country that are working in this area. However, most of them face similar problems in delivery of this service coupled with the

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	- Technical support has also been lacking to local agencies and ngos that are working on sanitation. - Interventions especially in the informal settlements or slums have been complicated by lack of planning regulations to support basic service delivery and thus impacting on the budgetary allocations of the same.	operation and maintenance.	fact that there was no guiding policy in this regard.
Financial issues	- Financing sanitation has been a major hindrance and difficulty to successful implementation of sanitation especially in developing nations. The bank interest rates going to 18-24%, requirement of collateral to support financing and clear lack of understanding of the bank on the bankability of sanitation has disabled the organisation willing to invest in sanitation.	- Make all stakeholders pay a "(correct) cost" in the systems and authorities to pay the extra costs in case there is no cost recovery.	- Since sanitation issues are not given an upper hand within institutions, finance mechanisms on the same are very little or almost nonexistent. Its only now perhaps with the new sanitation policy when funds would be available for poor people to access. In addition, people are also not willing to pay for ecological sanitation facilities and this goes to complicate things even further and hurting the poor of the poorest in society who genuinely cannot afford the services.
Social issues	- The secrecy associated with sanitation and especially excreta management in most communities ion Africa has led this to be viewed like a taboo, and thus limiting the growth and involvement of most people in this sector- its mainly viewed as an assignment of the extreme poor who cannot find anything else to do. - In most cases especially urban areas, sanitation is	- More awareness towards the population to break cultural barriers regarding ecosan approach(es). Involve population in the system planning and implementation.	- Socially, ecological sanitation is deemed necessary and welcome. However, people are unwilling to pay for this service because here hasn't been enough civic education on the same. Further, there are no known champions around on the market on issues of ecological sanitation and as long as things are like this, society will not be willing to adopt and start using this facility.

	seeing as a municipal affair, and thus most citizens are not willing to be engaged with it and meet the costs – they expect it to be provided for free		
Hindering scaling up efforts	There has not been any serious commitment to ecological sanitation systems- lack of past investor especially social enterprises has left it entirely on donor support line.	- Financing (of ecosan) and the fear of (its) success.	- Land tenure issues - By-laws that can protect the tenants who are the bulk of the urban population - Financial resources as the cost is very high - Poverty - Issues of subsidy

EUROPE

	Sweden[17]	Finland[18]
Governance/policy issues	-Need to integrate wastewater fractions in national/municipal policy and regulations e.g. urine classified as a waste.	- Ecological sanitation is an effective tool towards sustainable development and energy saving which the targets of different governments, EU and UN. The governments should remember this. - Pure human urine should be accepted as a legal fertilizer equally as industrial urea. The nitrogen molecule is exactly the same. - Also human faeces containing well-composted composts should be accepted equally as the animal manures are accepted. - At least in Finland we have a list of accepted fertilizers and if something is not listed it is not accepted for commercial fertiliser. (In home-plots people can use what they like). - Also if the governance policy claims too strict chemical and microbiological analyses from a fertiliser, small scale production according to sustainable production can not be done.
Institutional issues	- Municipalities are the key actors . They should play a role in quality control.	- More research is needed about different toilets aimed for different cultures and also for different people. For instance the disabled people. - More research about the hygienic and chemical issues. - More research about use of human urine and compost containing human faeces in different climates and different plants (edible and non-edible, roots, shoots, fruits, leaves used, plants needing plenty of fertilisers or less) - Fertilisation done early or late, split or non-split. Urine diluted or not diluted. Fresh urine or six months old as claimed in Sweden. - Effect of ecological sanitation and its use in fertilisation on greenhouse gas emissions (considering carbon dioxide, methane, nitric oxides) and comparing those from chemical fertilization with its transportations). - Ecological sanitation in mega cities. Is it possible and how? - Very often the Western research workers say that ecological sanitation can not be accepted in Muslim, Hindu, or some other cultures. Social scientists having self a strong affinitations to those cultures including women in those cultures should really study with open eyes this

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		among people including women (and especially women), generally poor people and different minorities in side these cultures.
Financial issues	- There is a gap between the costs required to implement ecosan facilities and the financial inputs given for this.	- Developing of toilets and tanks may need financing. - At least the NGO-work with human education needs money - as our work. - The research work meant in previous list would need money but it would also allow young scientists to accept the idea in their academic or professional education.
Social issues	- Need for more information on the role that ecosan can play in daily life.	- Do women benefit from ecosanitation? - Could it improve the status of women? - Could it give response to UN Millennium Goals?
Hindering scaling up efforts	- Need for more institutional support - Low cost of mineral fertilisers currently on the market - THe	- Sometimes the toilets have been too complicated and they have at cold climate constructed badly without understanding of microbiology and physics. - In Europe the ecological sanitation is often a hobby of rich people. - Traditional civil engineers who can plan traditional wastewater treatment plants may be afraid that they are loosing their jobs and their status if their serviced in this thing are no more needed, sometimes are against ecological sanitation . They claim that ecological sanitation would be expensive (as it is often in Europe). They also might mention that some diseases are transmitted by urine; I have heard schistostomiasis but not some Mycobacteria (which can also be infecting kidneys) but I have not seen any health-related microbiological study about the survival of these organisms in nature.

Annex 3: Questionnaire for Phase II- List of barriers facing the scaling up of ecological sanitation

Barriers based on case studies regarding what prevents ecological sanitation from going to scale

Objective of the discussion paper: What prevents ecological sanitation from going to scale and what can "we" do about it?

Ecological sanitation

Ecological sanitation is based on three fundamental principles: preventing pollution rather than attempting to control it after we pollute; sanitizing the urine and the faeces; and using the safe products for agricultural purposes. This approach can be characterised as "sanitize-and-recycle".

This approach is a cycle- a sustainable, closed-loop system. It treats human excreta as a resource. Urine and faeces are stored and processed on site and then, if necessary, further processed off site until they are free of disease organisms. The nutrients contained in the excreta are then recycled by using them in agriculture (Winblad and Simpson-Hebert, 2004).

The concept of ecological sanitation is based on the idea that urine, faeces and grey (sullage) water contain resources that form part of the ecological cycle. The nutrients in human excreta and grey water are valuable and should be regarded as such. Hygienic use, instead of hygienic washing away is one of the key principles. Use of nutrients in human excreta and grey water is only possible when the complete sanitation system is taken into account, from source to final disposal. This contrasts with end-of-pipe solutions. Ecological sanitation does not just promote hygienic use of human excreta and grey water after they have been produced; one of its main objectives is to recover and reuse them as precious resources.

In the discussion paper which continues to develop, ecological sanitation , based on the case studies, specifically refers to on-site toilets combining urine diversion and dehydration or composting of organic matter.

Barriers described by the various "champions" involved in ecological sanitation

The following is an overview of the barriers described by the various "champions" involved in ecological sanitation. Please note that this is not an exclusive list, as such, but is a summary- based on the case studies and interviews- up till this point.

Local government barriers:

- Lack of political will on the part of local authorities. (Philippines)
- A change in local leadership (through elections, for example) wherein ecological sanitation projects and policies are not sustained, replicated or scaled up. To repeat, an enabling environment must be created for ecological sanitation to go beyond pilot phase. (Philippines)
- Lack of support from government complementary service provision schemes, specially having to do with collection, treatment, and reuse of sanitized ecological sanitation by-products (Mexico)
- There has not been any serious commitment to ecological sanitation systems- lack of past investor especially social enterprises has left it entirely on donor support line.(Kenya)

Social barriers:

- Lack of social preparation at the household, community and city levels (Philippines)
- People participation is very weak (India)
- Eco- san is supply driven (India)
- Acceptability is poor (India)
- Human nature – unwillingness to recognize that we are already living in another age! (Mexico)

Institutional barriers:

- Monitoring of pilot projects is not strong (India)
- Institutions are not integrated (India)
- (Ecosan) is known to project people, conceived elsewhere and implemented somewhere (else).(India)
- Project officials are more interested in good documentation instead of giving right-information/constraints (India)
- We should know more (about) the failures (of ecosan) than (only the) successes. (India)
- Lack of information dissemination campaigns regarding low-cost ecological sanitation alternatives (Mexico)

Technology barriers:

- Work on more efficient systems for urban areas that could compete with the traditional technologies is needed now.

Financial issues

- Ecological sanitation projects which are heavily subsidized tend to be not sustainable. Local demand must be created. (Philippines)
- Lack of financial credit schemes that would allow domestic ecological sanitation users to fund their water and sanitation infrastructure (Mexico)
- Concentration of large subsidy schemes directed towards conventional sanitation infrastructure and practices, such as millionaire investments for sewer and typical wastewater treatment facilities (Mexico)
- More equitable distribution of public finances to provide such services (Mexico)
- Financing (of ecosan) and the fear of (its) success. (Burkina Faso)
- Land tenure issues (Malawi)
- Issues of subsidy (Malawi)
- Financial resources as the cost for ecological sanitation is very high (Malawi)
- By-laws that can protect the tenants who are the bulk of the urban population (Malawi)

In order to develop the discussion paper further on the barriers facing the scaling up of ecological sanitation, the paper will focus on three levels, namely:

- ***Level 1: User perspective- Driving forces and barriers when using ecological sanitation***

This looks at the users perceptions in terms of what keeps them away from owning their own ecological sanitation facility and how these barriers can be overcome.

- ***Level 2: The role of government (at national, intermediate, municipal, and community level) and their importance for creating an enable environment***

This focuses on the role of government at national, intermediate and community level, and its role in sanitation planning. Local government can create an enabling environment for consumers to choose for ecological sanitation systems. The key discussion point here is what is the role of government in ecological sanitation and what instruments do they have to stimulate ecological sanitation and thereby create that enabling environment.

- ***Level 3: The role of other organizations (at national, intermediate, municipal and community level) and their important environment***

This focuses on any other institutions that may affect the scaling up of ecological sanitation. Although government can play a critical role in the scaling up of ecological sanitation, other organizations may also play a role. The key here is to see what other institutions beside government may affect the scaling up of ecological sanitation .

- ***Level 4: the final users of excreta and/or urine***

This will give a further insight into the use of excreta. Some cultures are more prevalent in the use of excreta and/or urine than in others for agriculture use. However, there are also other potential strong barriers for ecological sanitation since many of the final users are not interested to manage excreta. In addition there may be other issues, such as the transportation of excreta and/or urine to its final destination.

We would very much appreciate if you fill in the rating scale boxes.

Country reflected on*: ____

*(*Please refer to **one** country when filling in the questionnaire. Please use another new form for another country, if necessary, so as to keep the answers given situation/location specific.)*

Box 1: User Perspective

Stakeholders	Barriers	Rating scale*	Comments
User Perspective	o On-site ecosan is more expensive than other on-site sanitation facilities o No regulation and support exists for stimulating ecosan o Handling of excreta and/or urine o The technology is not user-friendly o Religious constraints in handling excreta and/or urine o Socio-cultural constraints in handling excreta/urine		

* Rating scale: Please place a “1” if you find this issue extremely important in hindering the scaling up of ecosan; place a “2” for second most important issue hindering the scaling up of ecosan, place a “3” for the less important issue hindering the scaling up of ecosan and a “4” for fourth less important issue hindering scaling up of ecosan and so on. Place a “6” to the least important issue hindering the scaling up of ecosan. Place any additional barriers in the box provided. AGAIN note that “1” refers to very important and “6”, in this box, to very unimportant issue in hindering the scaling up of ecosan.

Box 2: Role of government perspective

Stakeholders	Barriers	Rating scale*	Comments
The role at the national government	o Lack of policy supporting ecosan (or sanitation in general) o Lack of sanitation planning at national level for ecosan (or sanitation in general) o Lack of adequate financing for supporting ecosan o Lack of co-ordination between sectors and actors to support ecosan		
The role at the intermediate level (regional and/or district level)	o Lack of support to local governments through backstopping o Lack of sanitation planning at intermediate level for ecosan o Lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc)		

The role at the municipal level	o Lack of support to local governments through backstopping o Lack of sanitation planning at intermediate level for ecosan o Lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc) o		
The role at the community level	o Lack of adequate financing for supporting ecosan o o		

* Rating scale: Please place a "1" if you find this issue very important in hindering the scaling up of ecosan; place a "2" for second most important issue hindering the scaling up of ecosan, place a "3" for the third less important issue hindering the scaling up of ecosan and a "4" for fourth less important issue hindering scaling up of ecosan and so on. Place a "6" to the least important issue hindering the scaling up of ecosan. Place any additional barriers in the box provided.
AGAIN note that "1" refers to very important and "4" , in this box, to very unimportant issue in hindering the scaling up of ecosan.

Box 3: Role of other organizations perspective

Stakeholders	**Barriers**	**Rating scale***	**Comments**
The role at the international organizations	o Lack of co-ordinated sanitation planning at national level for ecosan (or sanitation in general) with other stakeholders (such as government partners, etc) o Lack of adequate financing for supporting ecosan o Lack of institutional/organizational support to other partners involved in ecosan o		
The role at the national organizations (regional and/or district level)	o Lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc) o Lack of adequate financing for supporting ecosan o Lack of institutional organizational support to other partners o		

The role community based organizations	o Lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc) o Lack of adequate financing for supporting ecosan o		

Box 4: Final users perspective

Stakeholders	Barriers	Rating scale*	Comments
The final users of excreta and/or urine (agricultural or waste management sector)	o Lack of demand and use for urine (for agricultural purposes) o Lack of know-how by users regarding the potential and ways of use of ecosan products o Lack of support in financing and resources to assist in the transportation of excreta and/or urine to final destination for e.g. agriculture use o Religious constraints in handling excreta and/or urine o Socio-cultural constraints in handling excreta/urine o		

* Rating scale: Please place a "1" if you find this issue very important in hindering the scaling up of ecosan; place a "2" for second most important issue hindering the scaling up of ecosan, place a "3" for the third less important issue hindering the scaling up of ecosan and a "4" for fourth less important issue hindering scaling up of ecosan and so on. Place a "5" to the least important issue hindering the scaling up of ecosan. Place any additional barriers in the box provided.
AGAIN note that "1" refers to very important and "5" , in this box, to very unimportant issue in hindering the scaling up of ecosan.

Question: Are there any other specific recommendation(s) which you would like to suggest in terms of how to overcome the barriers/hinders facing ecological sanitation?
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Annex 4: Questionnaire for Phase II- Some quantitative data on barriers facing the scaling up of ecological sanitation

Table 1: User perspectives on the main issue in scaling up ecological sanitation

Barriers	Raw score	% responses
On-site eco-san is more expensive than	72	15%

other on-site sanitation facilities		
No regulation and support exists for stimulating eco-san	59	12%
Handling of excreta and/or urine	69	14%
The technology is not user-friendly	69	14%
Religious constraints in handling excreta and/or urine	119	25%
Socio-cultural constraints in handling excreta/urine	94	20%

Table 2: Barriers to upscaling ecological sanitation, the role of government

Barriers	**Raw score**	**Score in percentage**
Lack of policy supporting eco-san	83	30%
Lack of sanitation planning at national level for eco-san	58	21%
Lack of adequate financing for supporting eco-san	68	24%
Lack of co-ordination between sectors and actors to support eco-san	69	25%

Table 3: Role at the intermediate level

Barriers	**Raw score**	**Score in percentage**
Lack of support by local governments through backstopping	35	29%
Lack of sanitation planning at intermediate level for eco-san	38	32%
Lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc)	47	39%

Table 4: The role at the municipal level

Barriers	**Raw score**	**Score in percentage**
Lack of support by local governments through backstopping	46	35%
Lack of sanitation planning at intermediate level for eco-san	41	31%
Lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc)	46	35%

Table 5: The role at the community level

Barriers	**Raw score**	**Score in percentage**
Lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc)	31	51%
Lack of adequate financing for supporting eco-san	30	49%

Table 6: Role of international organizations

Barriers	Raw score	Score in percentage
Lack of adequate financing for supporting eco-san	27	44%
Lack of institutional/organizational support to other partners involved in eco-san	35	56%

Table 7: Role at the national organizations

Barriers	Raw score	Score in percentage
Lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc)	31	32%
Lack of adequate financing for supporting eco-san	34	35%
Lack of institutional/organizational support to other partners involved in eco-san	33	34%

Table 8: The role of community based organizations

Barriers	Raw score	Score in percentage
Lack of support in co-ordination between actual users and potential final users (e.g. farmers, etc)	31	56%
Lack of adequate financing for supporting eco-san	24	44%

Table 9: Final users perspective

Barriers	Raw score	Score in percentage
Lack of demand and use for urine (for agricultural purposes)	48	15%
Lack of know-how by users regarding the potential and ways of use of eco-san products	51	15%
Lack of support in financing and resources to assist in the transportation of excreta and/or urine to final destination for e.g. agriculture use	45	14%
Religious constraints in handling excreta and/or urine	102	31%
Socio-cultural constraints in handling excreta/urine	84	25%