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RESULTS OF AN EVALUATION OF ECOLOGICAL SANITATION PROJECTS IN THE PERI-URBAN SETTLEMENTS OF LIMA/PERU

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ABSTRACT

Ecosan systems have a high potential for application especially for the marginal settlements of the future megacity Lima with strong water supply problems. Nevertheless, hardly two thirds of 220 installed dehydration toilets since 1999 are still in use and the reutilization of the ecosan products, like water for irrigation and dried excrements for soil improvement nearly absent. The main reasons are preference of the flush toilet, high population fluctuation, social problems and the urban life style, without any interest maintaining an own sanitation system and no time nor area left for using the products. In some cases technical problems, especially of the urine separation and treatment part and the absence of technical support led to abandoning of the system or avoided further application too. The evaluation showed clearly, that ecosan conception for urban areas always have to include an adapted managing concept. Nevertheless a high potential for dehydration toilets is given, and in many urban settlements of Lima it will be the only suitable solution. That's why ecosan solutions should be recognized and supported by the official public authorities at least as conventional system.

KEY WORDS: evaluation, dehydration toilet, urine separation, acceptance, sustainability

INTRODUCTION

Ecological sanitation is quite a new topic in Peru and only few projects have been realized so far, most of them in the capital Lima. This city with over 8 million inhabitants, situated in the coastal desert, is one of the world's driest urban areas. The expansion of drinking water and sanitation services could not keep pace with the rapid expansion, resulting in a large number of people without access to adequate services, severe contamination of the environment and increasing water shortages.

Most of the ecological sanitation projects are implanted in poor suburbs and are based on dry sanitation solutions (dehydrating toilets). Experiences with other technologies, such as biogas-digesters are hardly found, and constructed wetlands for greywater or wastewater treatment and reuse are limited to a few small projects with pilot character. Nevertheless there is a growing discernment among many stakeholders (politicians, municipalities and NGOs) of the necessity for more sustainable water and waste management solutions. This paper shows the results of an evaluation of existing ecological sanitation projects in Lima, which was accomplished in order to analyze its sustainability.



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METHODOLOGY

In order to evaluate the sustainability of ecosan-projects in Lima the research methodology comprised the following components:

- Literature review to gain insight of the situation of water and sanitation services as well as urban development of Lima, practice and lessons learnt from different projects in sanitation with ecosan systems and management of ecosan systems.
- Participation in relevant workshops, lectures and public events
- Semi-structured and narrative interviews with stakeholders regarding ecosan in Lima and elsewhere
- (mostly) Guided field visits to all ecosan systems in Lima
- Household surveys in the three ecosan projects with dehydration toilets to assess the status and acceptance of ecosan systems

The fieldwork for this evaluation study was carried out between October 2006 and April 2007.

RESULTS AND DISCUSSION

1. ANALYSIS OF THE WATER AND SANITATION SITUATION OF LIMA

Many cities, especially in the developing world, are already facing serious problems in providing their citizens with adequate drinking water and sanitation services. In the Peruvian capital Lima, one of the world's driest urban areas, the situation is particularly severe. In Lima, 1.1 million of the 8 million inhabitants are not connected to the drinking water network and 1.3 million inhabitants do not possess adequate sanitation facilities (MVCS 2006). Only about 9% of the collected wastewater receives some kind of treatment, while the rest is discharged untreated into the rivers and the Pacific Ocean, or is directly used for irrigation. The consequences for human health, quality of life and the environment are serious. In addition, water shortages due to increasing demand and the consequences of climate change are expected to become even more severe.

Poor people suffer most from this situation. 43% of the *Limeños* are living in marginal settlements, the so called *Asentamientos Humanos (AHs)*. It is there, where the water and sanitation deficit is most severe (CONAM 2005). Where the public water company SEDAPAL does not provide piped water, people have to buy water of dubious quality from tank trucks for up to S./ 10 (US\$ 3.50), about ten times the price for piped water. Thus, the poor pay by far the highest prices for the worst service and worst water quality, and in consequence they consume less than 20 liter of water per capita per day.

In AHs that are not connected to the public sewage system of SEDAPAL, the most common type of sanitation service are very basic latrines, called *silos*. Those *silos* (Figure 2) do not provide effective health protection, provoke strong smells, are a breeding place for flies, contaminate the ground water and proved to be unsuitable for the urban and peri-urban settlements with high population densities. Many people do not even have silos and have no other choice than to defecate in the field or to discharge the excrements in plastic bags together with the garbage on the roadsides. The greywater is usually spilled onto the streets or is used for irrigation of small flower gardens. CONAM (2005) estimated that in Lima in 1997, 4.24 million cases of diarrhea were caused by deficient water and sanitation services.

Although the rate of population growth has declined to 1.8% and is expected to further decrease, Lima still grows by 150,000 inhabitants every year and will become a Megacity with more than 10 million inhabitants before 2020 (CONAM 2005). A huge share of the new inhabitants will settle and build their houses informally in marginal locations where infrastructure development, like installation of conventional water and sanitation systems, is very expensive or just impossible. Considering this, the target of the Ministry of Construction, Housing and Sanitation (MVCS) to raise sanitation coverage from 84% in 2005 to 95% in 2015, and drinking water coverage from 93% to 97% in the same period and to achieve treatment of 100% of the collected wastewater by 2015 (MVCS 2006) seems hardly achievable or extremely expensive.

2. ANALYSIS OF REALIZED ECOLOGICAL SANITATION PROJECTS IN LIMA

First experiences with ecological sanitation in Lima were made in 1997 by the national NGO Cenca, which developed the ECODESS (Ecology and Development through Sustainable Sanitation), that is based on a module "ecological bathroom", consisting of a double-vault urine separating toilet with two chambers for collection and drying of excrements (Figure 3), a separate urinal, a shower and two sinks (hands and washing), and a small sand filter unit for combined urine and grey water treatment. From 1999 to 2003, more than 220 of these dehydration toilet modules were implemented in poor marginal settlements in Lima (AHs)



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by the NGOs Cenca and Alternativa (similar to ECODESS System), and 35 new modules are currently installed by Cenca in the AH San Francisco, close to the penultimate project in the AH Nievería (Table 1).

Table 1: Ecosan solution, dehydration toilet modules (double-vault urine separating toilet and artificial wetland) in AHs of Lima			
Year of construction	Project location	Number of installed ecosan modules	Planning NGO
1999	San Juan de Lurigancho – Zona Húascar	38	Cenca
2001	Ventanilla – Ciudad Nueva Pachacutec	140	Alternativa
2003	Lurigancho de Chosica – AH Nievería	43	Cenca
2007*	Lurigancho de Chosica – AH San Francisco	35	Cenca

* project currently implemented



Figure 1: Nueva Pachacútec and Húascar, suburbs of Lima without water supply and installation of some "dry sanitation systems" (dehydrating toilet with sand filter for urine and greywater)

The most important factor in assessing the sustainability and the potential for increased use of any sanitation technology is the degree of acceptance in a community, as measured by the willingness to adopt or invest in that technology. Jackson and Knapp (2005) proposed the following measures:

- How many of the dehydration toilet units are still used and what are the reasons for abandoning them.
- Are the still active ecosan modules used appropriately?
- Are ecosan products used (excrement's in agriculture, effluents for irrigation)?
- Have the dehydration toilet units been copied by other households without external support?

Today, about 8 years after the first experiences with ecosan in Lima, less than two thirds of the installed dehydration toilet units are still in use (Table 2), although the users in all three project locations rated the ecosan modules mainly useful or very useful.

Table 2: Valuation of the ecosan modules by the users

Location	Useless	Little useful	More or less useful	Useful	Very useful	Number of asked households
Húascar	0%	6%	6%	18%	71%	n° =17
Nueva Pachacutec	0%	0%	0%	26%	74%	n° =19
Nievería	0%	6%	19%	25%	50%	n° =16
Total	0%	4%	8%	23%	65%	n° =52



Figure 2: Public toilet, one of the usual sanitary "solutions" in the peri-urban AHs of Lima



Figure 3: Two chambers dehydration and urine separating toilet



Figure 4: Preparation for connection to the water supply. As in this case, nearly always the water flush toilet is preferred.

The following two reasons for the discontinued use in spite of high levels of user satisfaction could be identified:

- The connection to the public water and sewage system together with the preference of the "classic" water flush toilet and the conventional sanitation system ("flush and forget").
- High levels of fluctuation of the inhabitants in the AHs and thus, temporal occupation of the tenement

Table 3: Continued use of the ecosan modules 2007

	Year of installation	Number of built modules	Ecosan modules still used in 2007	Ecosan modules still used in permanently occupied houses (%)
Húascar	1999	38	29% (n° =28)	30% (n° =27)
Households of Huascar actually always without public water system		7	86% (n° = 7)	86% (n° = 7)
Nueva Pachacutec	2001	140	63% (n° =36)	82% (n° =26)
Nievería	2003	43	84% (n° =43)	95% (n° =37)

n° = number of interviewed households

The preference of the conventional sanitation system became very obvious in Húascar, where two of the AHs with installed dehydration toilet units in 1999 (Table 1), were connected to the public water and sewage system of SEDAPAL in 2003. In those AHs, most households changed to a water flush toilet within a few months. The remaining AH (*2 de Enero*) was connected to the sewage system in March 2007 and at the time



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of the interviews in February 2007, almost all users had already bought and installed water lavatories and were impatiently waiting for their connection (Figure 4).

Project location	Preference of a water flush toilet	Number of interviewed households
Húascar	89%	n° =19
Nueva Pachacutec	94%	n° =18
Nievería	100%	n° =15
Total	94%	n° =52

Although user satisfaction with the ecosan modules was quite high, the "classic" water flush toilet obviously is by far the most desired and preferred sanitation solution, and all alternatives were only regarded as temporal solutions (Table 4). If one day, Nievería or Nueva Pachacutec will be connected to the public water and sewage system, the actually contented users of the dehydration toilet units (Table 2) **without any doubts** will shift to water lavatories too.

The second reason, high fluctuation of inhabitants or only temporal occupation of the tenement, is a common phenomenon in young and still not consolidated AHs in Lima. Insufficient social and technical infrastructure and the peripheral location, far away from working opportunities, make a fair number of people not living on their tenement, just going there from time to time and waiting for improvement of infrastructure. In addition, some of the inhabitants are land speculators, whose sell the lot after legal recognition. Especially in Nueva Pachacutec, these issues are responsible for many abandoned ecosan modules. Furthermore, the harsh climatic conditions and the absence of the promised government support for the young settlement encouraged many families especially those with children, who were selected as beneficiaries of the project, **moved** away.

3 EVALUATION RESULTS FOR CORRECT UTILIZATION OF THE ECOSAN MODULES

Some of the decentralized ecosan sanitation technologies are more demanding for the user, than the "classic" technologies. Incorrect usage can cause anything from a minor inconvenience to a major system failure and/or health hazard (Jackson & Knapp 2005). That's why intensive training and continuous support are important factors for the long term success.

In Húascar and Nievería, where the users of dehydration toilets received intensive training and an user organization was founded to give support in critical situations, the toilet modules were generally used in a correct manner. That means, for example, that enough drying material was added, little repairs were done and in most cases the sanitary units were kept clean.

In Nueva Pachacutec in contrast, in February 2007 most toilet modules were in a desolate condition. In spite of this, more than two thirds of the interviewed households stated, that maintenance is easy or very easy (Table 5). The dehydration toilets often were not used correctly and produced strong odors, because the material in the compost chamber did not dry. Water for hand washing was often missing, and necessary repairs were never done. One reason for this problems might be the insufficient training, but another one is the disperse location of the 140 ecosan modules spread over a terrain of more than 500ha. A user organization had not been founded. Hence, mutual help or exchange of experiences between the users was limited, and the single user was left alone with problems which he obviously was not able to handle by himself.

	Very difficult	Difficult	Moderate	Easy	Very easy	Number of asked households
Húascar	6%	0%	12%	29%	53%	n° =17
Nueva Pachacutec	17%	11%	6%	22%	44%	n° =18
Nievería	0%	7%	13%	33%	47%	n° =15
Total	8%	6%	10%	28%	48%	n° =50



Figure 5: Deficient and no maintained sand filter in Nievería

Though usage of the toilet modules, at least at the projects from Cenca, was good, two common problems were observed in all projects. They should be considered and improved in further projects:

- The always installed urinals were hardly used.
- The situation of the sand filter unit was disastrous in all project locations.

The non-usage of urinals could be a cultural acceptance problem, but a better understanding and above all a better function of the sand filter unit would certainly help to overcome those problems (Figure 5). In Húascar, no sand filter was used anymore, and in Nueva Pachacutec, the situation was similar. At places, where the water was not used for irrigation, the effluent seeped into the sandy ground next to the houses without any control or was spilled on the dirty roads. But even in Nievería, only 20% of the implemented sand filters were covered with plants on more than half of their area, while 38% had no plant cover at all but just consisted of gravel. The other 18% were completely out of use, with drastic hygienic consequences for the user and their neighborhood.

On the one hand, the reason for this situation can be found in technical problems, like limited dimensions of the sandfilter, missing distribution systems and high concentration of urine due to too little water consumption, causing soil clogging, dying of plants and problems with odor and mosquitoes. On the other hand, it is obvious that maintaining work, like replacement of died plants, was more than most users could or would handle.

Though all users of the ecosan modules received environmental and health education in some form, environmental awareness as well as the consciousness regarding health hazards were very low among them. Certainly, urban lifestyles and social problems in the AHs affect the interest to invest time and effort in maintenance of sanitary installations negatively. But also the fact that the dehydration toilet is poorly recognized as a final, equally good (or better) sanitary solution, makes the identification with these projects difficult.

4 EVALUATION RESULTS FOR USAGE OF THE ECOSAN PRODUCTS

The installed dehydration toilet units offer two forms of reuse: dehydrated and hygienized excrements can be used to improve and fertilize the sandy soils around many AHs, and the greywater with urine can be used for irrigation and fertilization (N, P) as well.

Since water scarcity is a major problem in Lima, and all green areas have to be irrigated, re-use of effluents for irrigation purposes has an important potential to alleviate water stress. On average, there are only 1,7m² green area per inhabitant in Lima, and even less in the AHs (Calizaya 2005), while at least 9m² are recommended by the WHO (IMP 2007).

All dehydration toilet projects in Lima are designed to reuse the greywater mixed with urine. The primary separation of urine, planned in the projects of Cenca, has not been realized until now. Reuse was designed for private gardens (Nueva Pachacutec), or for irrigation of parks, after passing a second centrally constructed wetland (Húascar and AH San Francisco), or in one case for agriculture irrigation (Nievería).



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In reality, only one park in Húascar was partly irrigated, but when this AH was selected for a public urban upgrading program (water and sewage supply, public parks, sidewalks), the whole ecosan irrigation system was destroyed. The irrigation system for another park in the AH 2 de Enero failed due to social conflicts, which resulted in the sabotage of the system and a denouncement of the AH at the health authority by some inhabitants, who did not possess an Ecosan module. The families in Nueva Pachacutec were provided in 2001 with a garden to cultivate vitamin-C rich passion fruit and fodder for rabbit breeding to improve the families' diets, especially those with small children. In 2007, nearly no one was still cultivating the garden or breeding rabbits, and the subsurface irrigation systems were broken or had been removed. In Nievería, the (poorly) treated water is partly seeped into the ground and partly discharged into the irrigation channel.

The situation regarding the use of the dried and hygienized excrements is similar (Table 6). Although the final product normally is an earthy material without any discomfort for handling, only 18% of the households used it, mainly for small flower gardens. Half of the households dumped the material near the hills or roadsides, and the others never emptied the chambers. Húascar and Nueva Pachacutec do not really have any urban agriculture with demand for soil improvers. But even Nievería has a lot of plant cultivation and expensive excrements from chicken farms are used for soil improvement, nevertheless the treated fecal material is hardly utilized.

	Húascar	Nueva Pachacutec	Nievería	Total
fertilizer / soil improvement	29 %	16 %	7 %	18 %
burry/discharge	41 %	53 %	47 %	47 %
compost chamber never emptied	29 %	32 %	47 %	35 %
number of asked households	n°=17	n°=19	n°=15	n°=51

The evaluation shows, that the people in this urban locations were not really interested in the reuse of treated effluents or compost and do not recognize the value of these resources nor the ecological dimension of their systems. The only aspect that really interests the population is a solution for their disastrous sanitary situation.

5 EVALUATION RESULTS FOR REPLICATION AND DISSEMINATION OF ECOSAN MODULES

Many sanitation projects receive substantial subsidies to "kick-start" a campaign, and this sometimes leads to participation even when people are not fully convinced of the merits of the technology. Remember that, success of a sanitation technology is demonstrable when there is an increased demand for it and when it is replicated without substantial subsidies or special inputs. In Nueva Pachacutec, the ecosan modules were granted to the families, while in the projects of Cenca, users had to pay between \$165 (Nievería) to US\$200 (Húascar). Most users considered the dehydration toilet a good solution for locations without sewage system and first interest was shown by friends and family from other AHs in Lima. Nevertheless only in Nievería, a few households decided later to built their own ecosan module. The almost nonexistent replication by other households is caused by the investment costs of about US\$400 to US\$600 per unit that poor households cannot afford, but also by the lack of information regarding the advantage of these systems and the reluctance of politicians and professionals to support it, and last but not least by the deficient operation condition of some of the existing systems.

Compost chamber	Toilet seat and urinal	Toilet cabin, washbasin, shower and laundry facilities	Grease trap and sand filter	Tubing on the lot	Tubing off the lot
250	25	175	100	30	23

On the other hand, the fact that poor families in Nievería decided to invest the price of nearly four minimum wages, shows that this system has a high potential for further replication, if enough information, support and financing mechanism would be provided. Currently, only centralized conventional sanitation systems receive high subsidies in Peru. In public projects like "Agua para Todos" or PAC (*Proyecto de Ampliacion de Cobertura*), households have to pay only about US\$ 100 to \$US 190 for a connection to the water and sanitation network, while real costs only for the conventional sanitation projects without house installation and



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without operation cost are estimated to about US\$ 508 per person (MVCS 2006). That's means nearly the same price which households in Nievería paid without any subvention for their own whole sanitation solution (dehydration toilet, table 7). Under this circumstance, a redefinition of the subvention policy, appropriate to recognize sustainable ECOSAN systems like equally good and better sanitary solutions, especially for urban areas without public water supply, seems to be the only solution for more social equality as well as the only solution for the strong water and sanitation deficit in Lima.

CONCLUSIONS

1. This study has shown that ecosan systems have a high potential, especially for the marginal settlements, of the future Megacity Lima. Their ability to save and re-use precious water and other resources and to be more flexible and considerably cheaper than conventional sanitation systems makes them a promising technology.
2. It will be necessary to support ecosan systems at least in the marginal settlements of Lima without public water supply with the same political and financial support that conventional sanitation systems receive, because in these areas ecosan is the only solution. The given situation discriminates just the poorest.
3. The evaluation also showed that the implemented systems were not always sustainable. In order to fully take advantage of the potential of ecosan systems, the following issues should be considered in future projects:
 - Technical improvement, especially of the design of the sand filter/constructed wetland
 - Separation of urine and greywater for less complicated treatment
 - Use of modern design and materials for the bathroom equipment to stimulate the social acceptance
 - Reuse concepts, adapted to the local situation of peri-urban areas
 - Carry out capacity building programs for the whole family, but also especially adapted for woman who often live alone with their children
4. Ecosan-projects always have to include a managing concept. Especially in urban environments with high contamination and health risk potential, any form of decentralized treatment needs responsibilities that support the users in maintenance of the systems and monitor the treatment quality.
5. The existence of a functioning user organization or forms of micro-companies, as it will be implemented in Nievería, which disburden the users from the operation of the system and organize the reuse, seem to be crucial for the success and further development of ecosan systems. The ECODESS of Cenca might be a good example for ecological sanitation systems in Lima.

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