Land Use and Water Resources Research

# In search of drivers for dry sanitation

**Sanna-Leena Rautanen[1] and Eeva-Liisa Viskari[2]**

[1]*Institute for Environmental Engineering and Biotechnology, Tampere University of Technology, Tampere, Finland*
[2]*Tampere Polytechnic University of Applied Sciences, Tampere, Finland*

**Abstract**

There is increasing awareness and concern about water pollution and water scarcity, and sanitation has been acknowledged as a critical dimension of both. This paper summarises the findings from the 2nd International Dry Toilet Conference 2006 (DT2006), held 16–19 August, 2006, in Tampere, Finland. The main objective is to publicise a range of research and real life experiences dealing with an uncommon subject: dry sanitation (DS). It was concluded, among other things, that continued technical and institutional development is needed because DS as a decentralised option calls for innovative approaches. Dry toilets based on urine diversion were recommended also for urban areas as urine has high concentrations of both nutrients and such micro-pollutants as pharmaceuticals and oestrogens, both of which are difficult and costly to remove by conventional wastewater treatment processes. The Conference urged continued serious and systematic research, also in the real life context, and taking small but tangible and sustainable steps towards better sanitation.

## Introduction: rationale for dry sanitation

The sanitation crisis gets more serious every year: about 2.6 billion people, or 42 per cent of the world population, lack access to basic sanitation. That is more than double the number of those who lack access to safe drinking water — 1.1 billion people, or 18 per cent of the world's population (WHO/UNICEF, 2005). In 1990, the Millennium Development Goal (MDG) 7 set the target of halving the proportion of the population not served by 2015 (The World Bank, 2004). To achieve this, an additional 1.8 billion people need to be provided with improved sanitation between 2002 and 2015. Even if that target is achieved, another 1.8 billion people will still lack adequate sanitation in 2015 due to population growth (WHO/UNICEF, 2005).

Sanitation and water quality problems are further aggravated by poor or non-existent wastewater management: about 90 per cent of sewage in developing countries is discharged untreated into water courses (International Decade for Action: Water for Life, 2005–2015). This problem applies also to so-called developed countries. For instance, it is estimated that some 74 per cent of Europe's rural areas are covered by sanitation, while urban coverage is 99 per cent. Yet this does not mean that all urban people are connected to safe and sustainable sanitation systems. Several European Union member states are yet to satisfy the requirements of the Urban Waste Water Treatment Directive (UWWTD; 91/271/EEC) which calls for all agglomerations of more than 2000 population equivalent to be provided with collecting systems and appropriate treatment by 2005 (WHO/UNICEF, 2005). These pitfalls in wastewater treatment do not only pollute the usable water sources, but water is also wasted when flushing toilets and through leaky toilets.

The results of poor sanitation and water supply are well documented. For instance, it has been estimated that more than 2.2 million people, mostly in developing countries, die each year from diseases associated with poor water and sanitary conditions (WHO/UNICEF/WSSCC, 2000). At any one time, half of the world's hospital beds are occupied by patients suffering from water-borne diseases, and every week an estimated 42 000 people die from diseases related to low quality drinking water and lack of sanitation. Over 90 per cent of the victims are children under the age of five. (WHO/UNICEF, 2005).

There is global epidemiological evidence that sanitation is at least as effective in preventing disease as improved water supply. Studies have shown that water quality alone will not reduce diarrhoea. For instance, Jensen *et al.* (2004) investigated the association between bacteriological drinking water quality and incidence of diarrhoea among

children under five years old, and found no correlation between the incidence of childhood diarrhoea and the number of *Escherichia coli* in the drinking water sources (the public domain). Faecal contamination levels in household water containers were generally high, even when the source water was of good quality, pointing towards the importance of household hygiene and sanitation rather than water quality at the public tap. Tumwine *et al.* (2002) had earlier concluded that determinants of diarrhoea morbidity included poor hygiene (unsafe disposal of faeces and wastewater), education level of household head, water obtained from surface sources or wells and *per capita* use of water for cleaning; they also stressed that hygiene practices are an important complement to improved water supply and sanitation in reducing diarrhoea morbidity. If this is 'old' news, why has the sanitation situation not improved but instead become increasingly worse?

In recent years awareness and concern about water pollution and water scarcity has increased, and sanitation has been acknowledged as a critical dimension of both. Finally, sanitation has become a burning topic in its own right, and action worth its own policy and funding. Unfortunately, many efforts have focused on water-based sanitation as the ultimate solution which, in practice, has only increased or intensified water-related problems in many areas of the world. Therefore, there is an urgent need to broaden thinking and look beyond the conventional systems: centralised and water-based sanitation systems alone cannot solve the sanitation crisis. Decentralised, integrated on-site and ecological approaches are needed also in urban and peri-urban areas. Since water supply and sanitation are inherently integrated and equally important, they also relate to land use and land-related resources. The overall system operates in a rather broad framework which has to do with public health, natural and built environment, agriculture, soil and water management, and socio-cultural and economic issues.

## Objectives and methodology

This paper summarises the findings from the 2nd International Dry Toilet Conference 2006 (DT2006), held 16–19 August, 2006 in Tampere, Finland. There were 147 registered delegates from 34 countries who participated in the seven sessions of the international programme, and a 100 participants attending the additional Finnish-language sessions. The main objective of this paper is to publicise a range of research and real life experiences dealing with an uncommon subject: dry sanitation. This, it is hoped, will encourage further dialogue on sanitation options and policies. The literature review also supports the main objective although it must be admitted that the number of serious scientific articles on dry sanitation appears extremely limited. The complete Conference-related documentation is also available on line at http://www.drytoilet.org/dt06.html and at http://kirjasto.tpu.fi/DT2006.pdf.

**DT2006 conference sessions**

The conference sessions in the international programme:

- *Session 1*: From past to future
- *Session 2*: Architecture & Construction
  Key note : Andreas G. Koestler – *Sanitation for Life* in Natural Disasters
- *Session 3*: Attitudes & Advocacy
  Key note: Ron Sawyer – A tale of two systems: Obstacles & incentives for implementing ecological sanitation in a periurban town, Tepoztlán, Mexico
- *Session 4*: Separation & Re-use,
  Key note: Joachim Behrendt – Appropriate de-central wastewater technologies for low income regions
- *Session 5*: Dry Toilet Technology & Monitoring,
  Key note: Naoyuki Funamizu – Dry toilet: An important system for controlling micro-pollutants from our daily life
- *Session 6*: Integrated Approaches
- *Session 7*: Sustainability & MDGs,
  Key note: Christine van Wijk-Sijbesma – Where softness matters most: scaling up dry toilets in developing countries
- (*Sessions F1 to F3*: Finnish language session - separate programme)

*See: Korkeakoski et al. 2006a and 2006b*

## Conceptualising dry sanitation

### *Ecological sanitation*

Public and private toilets are known to have existed in ancient cities, and the productive use of human excreta is not new. Waste disposal is as old as civilization. Sijbesma (2006) cited a well-known story of the Emperor Vespasian (Rome, 69–79 BC) who levied a tax on the sale of urine from public toilets for the production of wool and leather, and silenced his critics by his remark: *Pecunia non olet* (money does not smell) (Sijbesma, 2006). Yet serious scientific research on toilets does not have equally long roots. Water is popular as a subject of research and a metaphor, while toilets have inspired neither researchers nor artists, philosophers or folklorists. Rather, toilets have been despised and subjects relating to their use avoided as a taboo. In many cultures the caretakers of latrines are often considered the lowest class of people. Furthermore, in poor residential areas, the social status of tenants was determined by their location: the further one lived from the toilets, the higher the status (Juuti and Maki, 2006).

Ecological sanitation (ecosan) has its roots in ancient times when both human and animal excreta were valued as a fertiliser. Ecosan is a way of thinking, an approach and a new philosophy, rather than just a technology *per se*. As such, the concept is embedded in the Integrated Water Resource Management (IWRM) framework. The Global Water Partnership (2000) defines IWRM as *"a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems."* (Global Water Partnership 2000, p. 22), paying attention to downstream vulnerability to upstream activities. It further calls for integrating water and wastewater management but does not pay attention to sanitation specifically and, therefore, to the options of producing no or only a minimum amount of wastewater. In essence, sanitation belongs within the IWRM framework, but as was acknowledged by Werner during her conference presentation, the mainstream debate on IWRM still focuses on water resources, ignoring to a large extent 'land and related resources' and the option of minimising wastewater.

Encouragingly, though, the Global Water Partnership

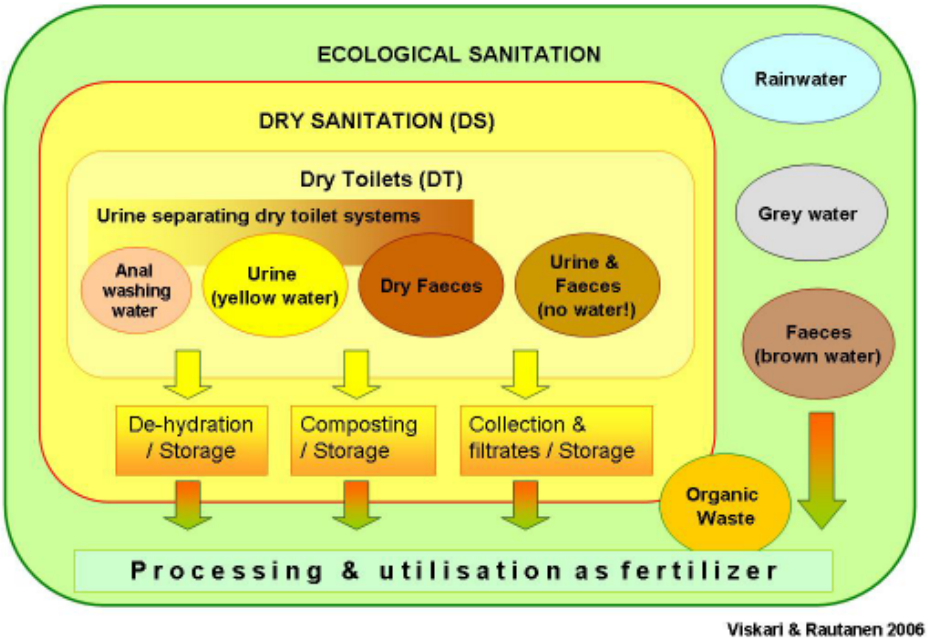


**Figure 1** Definition of dry sanitation within the ecosan framework.

has also recently paid more attention to sanitation. Rees (2006, p. 31) identified the advantages of a successful decentralised approach to sanitation: it is demand-responsive with services tailored to local conditions; it allows a wider range of technical options to be used; it minimises free rider problems; it allows phased investments; and it clearly differentiates between the private and public good segments of the sanitation service and shares the financial burden at different geographical levels.

Ecosan could contribute to IWRM in a number of ways. It has vast potential in areas such as saving drinking water, protection of water bodies, reduction in health risks, soil fertility, reduction in costs, use of grey water or wastewater for irrigation, and flood protection (Werner *et al.,* 2006a). Ecosan is based on three fundamental principles: (i) preventing pollution rather than attempting to control it afterwards,( ii) sanitising urine and faeces, and (iii) using the safe products for agricultural purposes. This approach is characterised as 'sanitise-and-recycle' and essentially aims at closing the loop (Winblad and Simpson-Hébert *eds.* 2004).

Note that ecosan is not necessarily dry, but that in the best case scenario dry sanitation (DS) falls within the ecosan framework (Fig. 1). For further detailed conceptualisation, see Winblad and Simpson-Hébert (Eds, 2004), WASTE (2006) and *Deutsche Gesellschaft für Technische Zusammenarbeit* (GTZ) (2006).

### *Dry sanitation*

Dry sanitation (DS) is embedded in ecological sanitation. Its technological manifestation, the dry toilet (DT), is part of *on-site systems* where safe disposal of excreta takes place on or near the housing plot. DS can be defined more precisely as on-site storage *and/or* disposal of human urine and faeces without the use of water as a carrier for flushing. The most modern version of DS *enables, in a controlled environment, potential recovery and reuse of the nutrients* through the 'drop-and-store-and-sanitise-and-reuse' approach which the 'drop-and-forget' approach applied to traditional pit latrines did not allow. A DS system creates a controlled environment into which, by definition, no water should be added. The authors of this paper suggest that further processing and utilisation of the end-product as a fertiliser or in other uses conceptually falls within the ecological sanitation framework, and therefore these issues relating to agriculture and soil management are excluded from the DS framework. Thus, the operational word in the definition above is '*potential':* The nutrients in the DS end-product *can be* recovered and reused (Fig. 1).

The technological alternatives available in DS are the various versions of dry toilets (DT). Traditional *on-site systems* have typically included pit latrines and septic tanks. Of these two most typical on-site solutions, the pit latrine is the one closest to DT. Pit latrines are known as relatively low cost options, consisting of a superstructure which affords privacy to the user, a hole or a seat set into a slab which covers the pit, and a pit beneath the slab into which excreta and anal cleansing materials are deposited. The ventilated improved pit latrine (VIP latrine) is intended to make the system more convenient and safe for the users. Pit latrines are not used in conjunction with conventional flush toilets. Only a relatively small volume of water enters the pit, and liquid is allowed to seep from the pit into the surrounding ground. Under fairly dry conditions excreta in the pit decomposes into humus-like solids, water and gases. Because of the long storage time in the pit, disease-causing organisms (pathogens) are eventually killed (Sanitation Connection, 2006). Yet, in most situations, the pits are rarely emptied and what takes place in the pit is rather uncontrolled. If the culture favours anal cleansing with water or the pit can be flooded with surface runoff, pit latrines will soon become anaerobic nuisances. Excess liquid seeping into the ground can also contaminate ground water in many geo-hydrological conditions. Indeed, pit latrines have given composting toilets and other forms of

DTs a bad name.

DT options can be roughly divided into those that divert the substances, usually urine and faeces, and those which do not. Liquids can also be separated at a later stage, and some applications allow using water for anal cleansing and diverting this flow away entirely from the rest of the substances. Urine diversion is based on the fact that urine contains most of the nutrients in domestic wastewater but makes up less than one percent of the total wastewater volume. Separation of urine at source allows nutrient recycling from a concentrated nutrient solution, thereby reducing the need for advanced nutrient removal from the wastewater (Wilsenach and Van Loosdrecht, 2004, in Maurer *et al.,* 2006). Maurer *et al.* (2006) distinguished between seven main purposes of urine-treatment processes: hygienisation (storage), volume reduction (evaporation, freeze–thaw, reverse osmosis), stabilisation (acidification, nitrification), P-recovery (struvite formation), N-recovery (ion exchange, ammonia stripping, isobutylaldehyde-diurea precipitation), nutrient removal (anammox) and handling of micro-pollutants (electrodialysis, nanofiltration, ozonation). Their recent review revealed that a wide range of technical options is available to treat collected urine effectively, but that none of these single options can accomplish all seven purposes (Maurer *et al.,* 2006). This definition of dry sanitation underlining the opportunity for closing the nutrient loop by treating and reusing the end product safely takes DS into the context of ecosan: re-use is within the domain of ecological sanitation.

## Results: reflections from the conference

### *Research and development*

The conference sessions gave a holistic view into the benefits, weaknesses and open questions related to research in dry toilet technology. Attention was paid especially to separate collection and treatment of urine and faeces. The first step in solving the pollution problem is to separate the various substances and flows (Fig. 1). Urine separation reduces significantly the ammonia losses from the dry toilet compost, and at the same time urine can be used for other purposes than just diluted fertiliser. 'Divert and rule' applies, meaning that urine should be diverted/separated from faeces, and various waters be kept separate as dry faeces are much easier to treat: *"dry toilet material should be dry"* (Behrendt, 2006). This was highlighted for instance in a study conducted in Japan concerning the hygienic risk associated with compost toilets using sawdust as matrix. It was found that high temperature and low water content enhanced the rate of decrease in populations of both bacterio-phages and bacteria, emphasising the importance of keeping dry toilets dry (Otaki *et al.,* 2006).

The risk of spreading diseases is real but not necessary very high if the composted faeces and urine are correctly used. Normally, urine is almost sterile and the risk of spreading diseases is low. In the tropics, however, there might be a risk of spreading dangerous diseases, such as schistosomiasis. Long-term storage destroys most possible disease causing agents in urine. Microbiological health risks are, however, not the only health and hygiene issues to be considered. There also micro-pollutants such as pharmaceuticals and oestrogens (endocrine disruptors) which concentrate in urine. The research group from Hokkaido University recommended source separation of urine as a solution to controlling the increasing level of pharmaceuticals and hormones in the aquatic environment (Funamizu, 2006). As an example, they found that the degradation rate of amoxicillin was strongly related to the ammonia concentration in the demonstration plant, and since phosphate and ammonia accumulate in the composting toilet matrix, it can be expected that the more the toilet is used, the faster the reduction in amoxicillin (Kakimoto and Funamizu, 2006).

Several growth experiments examined the use of urine alone, urine and composted faeces, or faecal compost alone. The results show clear increases in yields when sufficient amounts are used at the right time. Results with maize, cucumber, carrot and barley were good, and further research with cabbage and potatoes was under way. The amount, time and method of adding fertiliser should, however, be carefully considered to provide a good yield safely (Viskari *et al.,* 2006; Heinonen-Tanski, 2006; Guzha, 2006). Urine should not be sprayed onto the plant but over the soil. Different plants and trees need a slightly different procedure, and if there are any concerns about safety, non-edible plants, light construction materials and fibre plants should be fertilised instead. Generally, the health risk is very low when urine is used for fruit trees rather than for rootcrops. The food is very rarely eaten without any processing, and the processing destroys many pathogens (Heinonen-Tanski, 2006).

There are other uses for separated urine as well. It can be used to treat green composts, such as straw and corncob, to balance the C/N ratio and to irrigate composts as needed. For example, in Thailand, corncob composts, which require additional N to work properly, are irrigated. Re-using urine instead of water for moisture content adjustment is recommended to provide additional nitrogen for composting (Songthanasak, 2006). On the other hand, urine has been found to act as a source for P recovery as struvite. Tilley *et al.* (2006) concluded that the storage of urine is an essential step in recovering struvite, and that by removing calcium and other non-desirable compounds and allowing the pH to attain an ideal working range naturally, only magnesium needs to be added to recover a pure struvite product. Further examples of case studies presented during the Conference are summarised overleaf. The reader is encouraged to download the Abstract Book for further study (see Korkeakoski *et al.,* 2006b).

### *Construction and architecture matter*

Architecture and construction technology will be of utmost importance should dry toilets ever become as desirable and convenient an option as the present water closet systems. The Conference called for more research and real life applications of various designs: both 'branded' high tech designs and low cost options are needed. Whatever the design, it should comply with the local requirements: cultural, social, ecological and economic realities are as varied as climatic and geo-hydrological environments. Kuria (2006) stated that architecture continuously evolves to reflect changing ecological thinking, material development and changing lifestyles, but that unfortunately sanitary facilities have received very little attention. In many countries craftsmen develop, package and market the products.

An ecosan pilot project in Nakuru town in central Kenya aimed to highlight the ecological, technical and economic

***South Africa:*** More than 40 000 dry toilets have been supplied as basic sanitation facilities in South Africa. The research showed that most of the users accepted the urine diversion toilets as a toilet only, but that their acceptance as a sanitation technology was very low and people still expected to eventually have flush toilets. Only a few users were willing to use the human excreta in their gardens, or generally have anything to do with it. The general norm of not handling human faeces is preventing the full implementation of the UD technology. (Duncker, 2006)

***Zambia:*** Madimba is a Lusaka peri-urban area where local dry toilet design was developed to fit into the given geo-hydrological conditions and cultural environment through paying attention to the perceived needs of the communities and indigenous knowledge. It was concluded that integrated community-based environmental sanitation projects should include income generating activities to encourage people to participate. It was noted that most of the voluntary labour was done by women. (Kawanga and Phiri, 2006, Session 1)

***Mexico:*** the research project in Ciudad Juárez included monitoring 90 composting latrines in a low-income peri-urban community utilising US-EPA guidelines for the end product. The double vault provided clear separation and more room for the urinal but increased costs and space. The dehydrating system was consistently the better choice over the biodegrading system in this study area (very hot desert area, good for dehydration). A research component included also a study on hygiene behaviour, and paid attention to hand washing. The research process had also a strong component for community participation, focusing especially on the youth and general public awareness concerning health, hygiene and sanitation. Users were satisfied with their latrines. (Barud-Zubillaga, Corella-Barud and Peña, 2006, Session 7)

***Romania***: double vault dry urine diverting (u. d.) toilets were constructed in a primary school to demonstrate how to improve sanitation, the health of the children and to protect ground water against infiltration of human waste in an affordable way. A year after the implementation the evaluation results showed that the dry urine diverting toilets were well accepted and operated by even 6–10 year old children. There were hardly any problems with bad odours or flies. A gender specific pattern was observed: women preferred ecosan toilets while men preferred water flush toilets. More than half of the interviewed citizens were willing to use the urine diverting toilet products for agriculture. They all complained about the odour and flies of their pit latrines. (Samwel and Gabizon 2006, Session 2)

***Mexico:*** The study covered 75 dry toilets. Of all observed toilets, 67 per cent had no odour and 79 per cent had a generally clean appearance. Sixty per cent did not use the urinal even if it was installed, and 51 per cent did not follow the maintenance recommendations. Twenty-four per cent of the 'negative' cases suffered from technical problems, such as broken or blocked pipes, five per cent had turned the structure into a cistern and another five per cent had not finished the construction at all. The chamber had been filled at least once in 48 per cent of the cases, and 92 per cent considered using the contents as fertiliser. In terms of pathogens, the end products were more than just acceptable. It was suggested that the great resistance may have socio-cultural roots. (Ysunza-Ogazón *et al.,* 2006, Session 3)

***United Kingdom:*** the project with the Beacon Hill Allotment and Leisure Gardeners Society, in Cleethorpes, Lincolnshire, aimed to provide an ecological construction within the commercial limitations of a commercial build. As a result, the allotment holders have a building that is interesting both in its purpose and construction. The sanitation facility has made the site more accessible to women, the disabled and the elderly, and it has encouraged the uptake of allotments on the site. The dry toilet gave people an opportunity to test the dry toilet technology and understand its purpose. The construction company learned valuable lessons in ecological design and construction while providing important vocational training for disadvantaged youth. (Gilroy-Scott and Chilton, 2006, Session 2)

*Source: Korkeakoski et al. 2006a and 2006b*

value of ecological sanitation through a high quality architectural design. The design was geared primarily to evolve a 'modern mixture' concept to improve sanitation's image, to support entrepreneurship and to strengthen environmental linkages. Attention was paid to the different needs of women, men, children and the disabled. The facility for the disabled was constructed considering three types of users: the visually impaired, wheelchair users and those with missing limbs or paralysed. The facility was also designed to strongly portray the imagery and identity of Nakuru town, with sculptures depicting the flamingos of Lake Nakuru in the rock garden and mounted on the internal façade of the entrance lobby wall (Kuria, 2006).

China has a long and vibrant ecological sanitation tradition. The China-Sweden Erdos Eco-Town Project transferred the practices still common in rural areas into an urban context. This was the first time urine diversion dry eco-toilets have been applied to large scale multi-storey buildings in an urban area. The project area comprises about 800 households in its first phase. The community has

its own independent sanitation system (source separation and collection of urine and faeces, separate grey water treatment, sorting and collection of solid waste, composting and reuse of the resources). It is expected that daily water consumption can be cut by about a third while providing 24-hour reliable and sustainable sanitation service. In addition to its environmental benefits, the housing system also aims at resolving the housing problem of mid- and low-income people (Lixia, 2006).

GTZ, the German cooperation agency, has recently been renovating its headquarters in Eschborn, Germany. The new office buildings include a modern system for the separate collection and reuse of urine and a treatment and reuse system for brown water. The central part of the building, housing about 300 employees, the conference rooms and the restaurant, is equipped with a urine separation system. It is expected that the system will save 900 $m^3$ of water yearly. The project had four main objectives, including (1) reduced emission of nutrients, organics, pathogens and micro pollutants such as pharmaceutical residues and hormones into the public sewer system and receiving water bodies; (2) recovery of nutrients for agricultural use; (3) demonstration of the ecological sanitation concept and contribution to international dissemination; and (4) research on important aspects of ecological sanitation systems in Germany and development of treatment technologies (Werner *et al.,* 2006).

### *Dry sanitation in emergencies*

Sanitation has an essential role to play in emergencies. It is the first barrier between the possible pathogens (in excreta) and the receptors (human beings). The importance of safe excreta disposal is heightened by an oft-forgotten consequence of living in chaotic surroundings, namely stress-related diarrhoea. The local population and organisations are the primary actors in disasters, and the non-governmental organisations (NGOs) can empower the local stakeholders and provide feasible solutions and equipment to different scenarios and conditions.

The real life example from Iran showed how rapid action was crucial to prevent spread of diseases: although the environmental health staff arrived in Bam in less than 24 hours, people had already begun to defecate in various open areas, thus endangering public health (Amin, 2006). He further noted that even rapid action should not override cultural considerations: large refugee camps were built but people preferred to stay close to their homes.

Another example dealt with a refugee camp in Sudan where it was found that lack of appropriate sanitation is only one of a multitude of problems that prevail in a refugee camp. It was emphasised that a refugee camp forms a dynamic entity which is not even meant to be permanent; therefore, any attempts to build permanent infrastructure are futile. Dr Koestler from the Norwegian Red Cross noted that sanitation services can best be improved by integrating public health services with infrastructure rebuilding to be able to cope with future disasters. This could reduce hygienic risks after a disaster and reduce vulnerability of communities in the long run. Dr Koestler called for innovativeness in using local resources and materials, and trained, well-functioning sanitation teams to tackle the sanitation problem from the beginning (Koestler, 2006). The challenge for developing sustainable and appropriate sanitation systems for crisis situations is diversity and uncertainty: it is difficult to get financing for a catastrophe which has not yet happened.

## Discussion: to dry or not to dry – is there a problem?

DS is based on long traditions of managing human urine and faeces. At the same time, it also represents something novel for those already used to urinating and defecating into water closets or in traditional ways of using 'the bushes'. In many parts of the world both of these prevailing practices are challenged by the sheer number of people, water scarcity and pollution problems. Yet, even if DS were theoretically and conceptually well developed, it would still be a challenge to apply it in diverse climatic, geo-hydrological, environmental, socio-cultural and economic conditions. Due to a lack of experience and the confidence it could give, it is difficult, for instance, for local leaders and national policy makers to take DS seriously. Failed sanitation systems are difficult to hide.

Sanitation is about dignity, convenience, public health, clean water and healthy environment, and general well-being of the citizens, all of which are issues and concerns for local planning and local governance. A definition states that *"water governance refers to the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society"* (Rogers and Hall, 2002, p. 16). We would like to emphasise that a similar definition should be formulated for *sanitation* governance as it relates to protection of public health and safety, environmental protection, user participation, gender and equal opportunities, cost efficiency and effectiveness of performance, financial sustainability and transparency, and overall accountability. Many of the sanitation-related problems identified during the conference are related to these.

Sanitation should be a public concern and advanced with public resources even if the facilities as such may be private property. Keeping the environment healthy and sanitary is certainly a citizen's obligation as well as a right. As sanitation is a very local and even a household-specific dilemma, local government should provide the institutional frame of reference where these interests could be articulated and translated into action. To derive the full benefits sanitation can offer, all households must participate. The only option is to systematically work towards full coverage, and this is where local governments as community planners truly step in (Rautanen, 2006). The importance of developments in infrastructure planning and housing design, in addition to continued DT-related product development, were also acknowledged by Mattila in his recent doctoral research. Mattila (2005) called for attention to the quality of activities at all stages: design, contracting, construction, control, operation, maintenance and repair of on-site sanitation systems – with special emphasis on the DT.

During the conference a number of present challenges were identified, including issues such as lack of integrated vision, capacity and commitment at the local government level. It was noted that decisions concerning the water and sanitation sectors are often dominated by political interests and financial concerns which may not be in the best interest of the people and the environment nor sustainable. Key decision-makers are also often unfamiliar with alternative solutions which is why the official sector is not willing to

invest in research of 'unconventional' systems.

Sustainability was also debated during the conference. The findings of a number of case studies relating to the post-construction status of dry toilets exposed two key reasons for poor sustainability. Firstly, technical problems originating from initial poor construction using low quality construction materials. Secondly, there was a general lack of sense of ownership which was reflected in inadequate operation and maintenance: the users' had not chosen the technology and/or did not consider the sanitation facilities a priority. Countless toilets, both dry and otherwise, have been abused, abandoned or transformed into something more useful, such as storage facilities or even kitchens! The question is: how can something 'so simple' be so difficult to make and maintain? More financial data are also needed: what is promoted as low cost should truly be so!

During the conference it was noted that people can have unreasonable wants and needs, or just too high expectations for the sanitation solution. These can easily lead to disappointment. The importance of human perceptions, beliefs and attitudes for the success of ecological sanitation is evident, and a proper approach for managing — not manipulating — them positively towards sustainable solutions is vital. Ecological sanitation education and training should give people the ability to develop, plan and implement sustainable sanitation systems that are hygienically safe, socially acceptable, economically feasible, environmentally sound and technically appropriate, and convenient to use. To achieve this we need to modernise current educational and training systems to inspire all stakeholders. Trans-sectoral and interdisciplinary co-operation and inputs from a range of research fields and well-designed educational materials are of great importance in securing successful education, training and capacity building.

## Conclusions and recommendations – the dry future

Based on the findings presented in connection with the DT2006 conference, we recommend that all our fellow sector professionals:

- Continue their serious and systematic research, also in the real life context. Even if a number of pilot research and demonstration projects have been carried out, more research is needed, including a strong advocacy and educational component to help inspire (political) confidence to commit to DS.
- Emphasise sound technical design, good workmanship and durable materials. Cheap and poorly constructed options are not sustainable, and therefore, not cheap at all. Negative experiences undermine sanitation improvements in general, whether dry or not. Failed efforts in sanitation are difficult to hide!
- Make it their aim to bring DS technology to the same level of convenience as the water closet systems now provide. Sustainability and tailor-made products need community involvement and listening to the real users, but also an enabling environment from the local planners and decision makers.
- Always ensure that the recommended options are safe from the public health point of view. To make faecal material hygienically safe, thorough thermal composting and/or after treatment or storage are needed – there are rarely shortcuts. It is also important to pay attention to timing and the type of plants being fertilised: the health risk is very low when urine is used for fruit trees rather than for root crops.
- Dare to suggest urine diversion toilets also in urban areas. Urine has high concentrations of both nutrients and such micro-pollutants as pharmaceuticals and oestrogens (endocrine disruptors). All these are difficult and costly to remove through conventional wastewater treatment processes and, therefore, are found in increasing concentrations in the aquatic environment.
- Strive for long term monitoring of the existing pilots as there is a need for more real life performance data which spans several years into the 'post-programme' period. Anything will work as long as there are enough academics and committed local professionals involved, but what happens when the latrine owners are left to themselves? Replication, local adaptation and scaling up of lessons learnt remain limited. Good practices should be institutionalised in each community as a standard code of practice, similarly to flushing the flush toilet now.
- Do systematic cost and value analysis in a real life context: which are actually the low cost but high quality and sustainable options? What is not proven to be truly low cost, should not be advocated as such!
- Search for new institutional settings. DS as a decentralised option calls for innovative approaches to private sector involvement to ensure the necessary technical services: it should not be expected that individual house owners are willing to maintain the systems themselves or have an interest in gardening.
- Step outside their sanitation and ecosan circles and dare to approach other sectors (water, public health, environmental, social), and actively seek to integrate the principles of ecosan into, for instance, the agricultural and energy sectors.
- Actively contribute to policy and political dialogues at all levels in search for solutions to the sanitation crisis. It is politically difficult to commit to unconventional options if there is no reliable, first-hand experience from their real life performance: therefore experiences have to be effectively shared!
- Consider what are the incentives for sanitation improvements at various levels, from the national policy level to local action level. This calls for an enabling environment and good governance, a system where a positive outcome can be fed back into the broader system.
- Remember that incentives and other drivers for change are community-specific, even within one country or region. Small, tangible and sustainable steps are needed in each to show the direction.

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