First International Conference on Ecological Sanitation

Nanning, China, 5-8 November 2001

Official Conference Report

1. THE BACKGROUND

The sanitary crisis affecting nearly half of the world's population represents a mounting disgrace to human dignity and a serious threat to human health. At least 2,400 million people today either have no sanitation facility at all, or are obliged to use one which is unhygienic and foul-smelling. Every year more than 2 million children die of diarrhoeal disease and hundreds of millions of others suffer illness which proper sanitation would have prevented. On health grounds alone, radical approaches to this crisis are required.

In the 21st century, new thinking on sanitation is also demanded for reasons of environmental sustainability. Up to now, there has been a tendency to see plentiful supplies of water for flushing as the key to effective sanitation. This is no longer realistic. In large parts of the world, supplies of freshwater are scarce. Already, some 80 countries with over 40% of the world's population suffer water shortage at some time of the year. Chronic scarcity threatens the Middle East, northern China, Central America, western USA and elsewhere. Under pressure from population growth, rapid urbanization, and the extra consumption of water which comes with a higher standard of life, the threats to freshwater supplies are growing.

These threats are not confined to volumes. In developing countries, 90% of effluent from towns and cities is discharged untreated into rivers, lakes and the sea. The pollution caused to soils, surface water and groundwater is a threat not only to public health but to the whole environment – in temperate as well as tropical, industrialized as well as developing, zones. Thus during the past decade or so, new reasons for serious sanitary concern have emerged. The capacity of the earth's bio-system for absorbing the extraordinary volumes of wastewater and pollution produced by humanity has already become seriously overstretched.

Given its extravagant use of water and the pollution it causes to groundwater, lakes and the sea, sewerage is in the long term an unsustainable sanitation model even for rich countries. Its promotion in seriously water-short parts of the world is indefensible. Its elaborate systems of pipes, pumps and treatment plants, and its institutional and managerial requirements are unaffordable in much of Asia, Africa and Latin America. The safe disposal of the output from treatment plants, toxic sludge, is a mounting problem in the rich countries. Yet there has been little formal investment in safe and efficient no-flush sanitation systems, manageable by households and communities.

This was the original impetus for the ecological sanitation idea: the need of millions of households and communities for a sanitation system which was hygienic, congenial to use, affordable, and environmentally safe. But it has another important and revolutionary dimension. From the outset, the approach was based not only on human and environmental health needs, but on respect for human excreta as a natural resource. Instead of designating urine and faeces as ''wastes' and hiding them in tanks and pits or despatching them into pipes, ecological sanitation set out to recycle the nutrients in them for use in plant and animal life-cycles. Ecological sanitation is designed to interact fully with the eco-system and its own

processes. It also has a role to play in poverty reduction, especially in releasing resources for use in food production, and in improving living conditions for those degraded and harmed by a polluted environment.

To maximize efficiency in both pathogen destruction and nutrient re-utilization, ecological sanitation normally favours the separate collection at source of urine and faeces. Urine contains by far the larger share of nutrients within excreta, and is a safe and clean fertilizer. Faeces collected in a separate chamber and covered with ash, lime, or sawdust to reduce odours, assist drying, and raise pH, do not require a large container and can be left to dehydrate before being composted and recycled as fertilizer and soil conditioner.

In 1993, the Swedish International Development Cooperation Agency (Sida) launched a formal ecological sanitation initiative. The *SanRes* programme was set up under the direction of *Uno Winblad*, a Swedish architect and pioneer of ecological sanitation, to pursue a holistic sanitation approach, combining public health and urban development with environmental and economic concerns. For its first eight-year phase, the objectives of the programme were to promote affordable and replicable ecological sanitation systems; establish pilot projects in a number of countries; help build local capacity for research and development; and facilitate South-South collaboration in the field of applied sanitation research.

Since the establishment of the programme, a number of independent small-scale initiatives in ecological sanitation have been supported in a variety of climatic, geographic, and cultural locations. Exchange between them has been promoted through seminars and visits, and a network on ecological approaches to sanitation has emerged. Progress in developing and operating ecological sanitation systems, and in researching their effectiveness, has been marked. The ecological sanitation concept – now known as 'ecosan' – has been brought to the attention of a wide variety of governments, NGOs, international organizations and external support agencies. It has won followers and gained currency among a range of strategic partners.

Against this background, the First International Conference on Ecological Sanitation was convened in Nanning, China, from 5-8 November 2001. The Conference marked the climax of *SanRes*' work to date. After some years of scientific research, technological development and practical experience on the ground, ecological sanitation had reached the stage of maturity when an international exchange was needed. Around 300 participants from 27 countries met to share experiences and exchange information and views. An important intended outcome of the Conference was to help bring 'ecosan' to a new threshold of credibility and launch it into mainstream sanitation thinking.

The Conference was convened by the Jiu San Society, with the support of the Government of Guangxi Zhuang Autonomous Region and associated ministries and institutes. It was funded by the Government of Sweden and Unicef, with some input also from UNDP, GTZ, and the Water and Sanitation Programme (WSP).

This report of the First International Conference on Ecological Sanitation is intended to give a synthesis of the many subjects, themes and debates which took place during the four-day event. It cannot do justice to many of the technical and scientific papers, nor to the richness of many of the presentations which demonstrated ecosan in action. The intention is to provide a snapshot of where the approach known as ecological sanitation has reached, and assist the

process of moving it to the next stage of public acceptance and growth. (Most of the papers presented at the conference are available at www.ecosanres.org.)

2. WHY CHINA?

For a number of reasons, China was the natural venue for the First International Conference on Ecological Sanitation.

Since time immemorial the Chinese have faced problems of water and land sustainability. They are justly proud of a long tradition of managing a difficult environment in accordance with nature and making efficient use of all available resources. The use of human excreta as a fertilizer has a history of more than 2,000 years in China. Sanitation systems in cities, whereby nightsoil was collected door to door and sent to surrounding farms for crop fertilization, can be dated as far back or further. In China today, over 90% of human excreta is still used in agriculture.

In spite of the advent of modern lifestyles, Chinese attitudes are therefore already naturally predisposed towards an approach to sanitation which interacts with the eco-system rather than overloads it. Along with those of some other neighbouring countries such as Vietnam, they have helped to inform and inspire the formal articulation of 'ecosan'. Not surprisingly, China has also become the country in which the approach in recent years has been implemented on the largest scale. Official support and popularity among users means that China is likely to remain the pioneering setting for implementation at scale in both rural and urban settings.

The exceptionally high level of policy-making interest in ecological sanitation in China was demonstrated by the wide variety of presentations from Chinese experts and the high number of Chinese participants. Among these were representatives from major national scientific academies and institutes, as well as from relevant departments of the government of Guangxi province. The province harbours what is at present the most extensive ecological sanitation programme in the world. As was demonstrated by the keynote address to the Conference of *Wang Rusong*, Professor of Eco-Environmental Sciences at the Chinese Academy of Sciences, the role of ecological principles in providing workable solutions to problems of modern living attracts major scientific attention in today's rapidly industrializing China.

The importance attached to ecological sanitation in China is due to the threat to health posed by the presence in the landscape of untreated faeces. A 1993 survey indicated that 94% of human excreta were used in agriculture, but that only 13% was sanitized This represented a major health hazard as *Pan Shunchang* of the China Academy of Preventive Medicine told the Conference. Dysentery, typhoid fever, and other diarrhoeal diseases account for more than 70% of the infectious diseases in China. As for parasitic infections, 531 million people are estimated to be infected with roundworm, 194 million with hookworm, 212 million with whipworm and 870,000 with schistosomiasis. The sanitization of human excreta prior to its use on the fields is therefore a prerequisite for disease control and prevention.

Since 1987 the Chinese Ministry of Health has promoted improved standards in hygienic disposal of excreta and coverage has risen dramatically from 7.5% in 1993 to the current level of 45%. This has been achieved through the promotion of different types of sanitary toilet facilities suited to different environments. Among the various models using different technological approaches the urine-diverting ecosan toilet is the most recent to be introduced

(or reintroduced rather as urine-diverting toilets have a long history in China). High standards of construction and maintenance in all cases are promoted to assure hygienic use and health gain. According to Unicef, studies show that this drive for improved sanitation has brought villages many environmental and health benefits.

In 1998, Guangxi province, of which Nanning is the capital, became one of the first three provinces in China to receive Sida and Unicef support through the National Patriotic Health Campaign Committee Office (NPHCCO) of the Ministry of Health for a pilot ecological sanitation project using urine-diversion toilets. Once the technology was successfully tested, a campaign to improve the rural environment entitled the 'ecology and sanitation revolution' was launched with support from NPHCCO and Unicef.

During the Conference, participants were taken on a field visit to eight villages in Yongning county near Nanning. Here the concept of the 'ecological village'has been promoted by Yongning county officials and a range of infrastructural and environmental improvements have been carried out.

Yongning has a population of 912,000 in 21 small towns, 240 villages and 1,774 hamlets. The various communities visited by the Conference participants were of similar size: around 30 households comprising 150 to 180 people.

By the end of 2000, 45 villages in Yongning county had successfully introduced the 'eco-village' package. A further 44 villages were scheduled for 2001 but implementation was delayed by the severe floods affecting Yongning in June 2001. Around 4,000 urine-diverting 'ecosan toilets' have so far been installed in eco-villages in Yongning and another 3,000 in other villages in the county.

The ecosan toilets in Yongning have a fibreglass squatting pan divided into two compartments, the one at the rear covered by a moveable lid. School toilets have pedal-operated ash-dispensers developed specifically for the programme; household toilets have a container with ash and a ladle.

Technical assistance to assure sound construction – for toilet-washrooms as well as biogas digesters, roads, electricity connections, water supplies, and other amenities – is provided by specially trained teams. Various government departments are involved, including Health, Agriculture, Forestry and Urban Development. Each participating village receives a community subsidy of RMB 30,000 (USD 3,750) towards the cost of communal amenities.

Conference visitors were impressed by their tour of the 'eco-villages'. The new toilets are usually installed inside the house (which is not only more convenient but reduces the cost); are fully tiled; and many incorporate a basin or shower for washing – unthinkable with the old facilities which were too unpleasant to linger in. The cost of the total installation is RMB200-400 (USD 25-50), for which a subsidy of RMB30 is provided.

The participatory element in the programme comes not at the individual level – with households opting in or out of certain types of improvement, or a range of options being presented from which families make a choice. Once the village committee decides to participate in the scheme, in its essentials the programme takes a mandated course and everyone co-operates. The element of choice comes at community level.

In each village, work begins with comprehensive planning, followed by small-scale installations: biogas digesters, toilets and kitchens. This builds confidence for more ambitious endeavours. Construction is guided by technical teams, trained by experts and equipped with the relevant professional knowledge. Public health education is also emphasized: the maintenance and correct use of facilities – including the use of ash to cover faeces – is essential. Health impacts from sanitation programmes can prove elusive unless people fully understand the connections between toilet behaviour and disease transmission. As yet, it is too early to assess the impact on health of ecosan villages although data is being collected. However, the aesthetic and convenience impact is profound, and the rise in the quality of life, especially for women, was evident.

At present, extension of the Yongning programme to 170 villages is planned for the next three years. At that stage, around 10% of villages/hamlets in the county will have been reached. As the concept takes root and moves beyond the demonstration phase, subsidies to families and villages will be gradually phased out. This should speed up the rate of implementation. It is not difficult to picture the day when the ecosan toilet-washroom has become a consumer product as universally desirable and familiar in Yongning as a television set has already become.

3. PUTTING THE MESSAGE ACROSS

Any radical solution to an age-old problem – especially one where the existing solution is widely approved and supported by vested interests – is bound to face difficulties in gaining widespread acceptance. Where the subject is one which, in many cultures, is surrounded by silence and taboo, as is the case with human excreta and defecation behaviours, those difficulties are multiplied. Although Conference participants included those who have helped pioneer the approach scientifically, technologically or practically, there were also many who work as professionals or policy-makers in sanitation systems, but whose familiarity with ecological sanitation was limited. If the Conference was to be a launch-pad for wider dissemination of the ecosan message, the message itself needed to be fully explored.

The two keynote presentations undertook this task at the outset of the Conference: Ecosan – the Big Picture by *Steven Esrey* of Unicef, New York, and System Consideration of Eco-Sanitation in China, by *Wang Rusong* of the Research Centre for Eco-Environmental in Beijing. Esrey's presentation looked at ecological sanitation within the global picture of pressure on natural resources, while Wang's exposition concerned the position of ecological sanitation within contemporary Chinese political thought and development practice.

Esrey's emphasis was on 'closed loop thinking'. He cited the system of sanitation and recycling of nutrients used on spaceships, and the need for the spaceship on which we live – planet Earth – to be operated in a similar way. At present, earth's self-cleansing capacity – its capacity to absorb and neutralize wastes and maintain ecological integrity – is being pushed to its limits. This can only worsen in the face of rapid urbanization with all the waste generation and pollution that implies. Current sanitation solutions, which among privileged populations consist of flush toilets and sewage pipes and for many others consist of pit toilets or no organized system of sanitation at all, are not only inadequate but are contributing to the crisis.

'Closed loop thinking' connects food with people and people with food. The 'closed loop' is between the consumption of food; its passage through the human digestive system; the

sanitization of that part of the resulting excreta which contains pathogens – the faeces; the recycling of nutrients from excreta in plant growth; and the production and consumption of food. Where animals enter the loop, they too consume plants, and their manure – less controversially – are also reinvested in plant growth.

The advantages of the 'closed loop' consist not only in the fact that there is no pollution output and that human health is, therefore, extra-protected as compared to other sanitation methods; but that human excreta have a high value as soil conditioners and fertilizer. This is a potential aid to the reduction of poverty-related under- and malnutrition and can increase household food security. It also has the potential to reduce dependence on chemical fertilizers and relieve the environment from all their attendant problems.

The idea of resource re-utilization central to Esrey's presentation was echoed by Wang's wide-ranging review of eco-sanitation within Chinese systems of thought and sanitary practice. He pointed to the need for the evolution of an 'eco-culture', respecting ancient traditions and blending them with modern values to build the sustainable society. Wang drew upon Chinese technology and philosophy to explore the essential values of the ecological approach. He placed emphasis on the holistic nature of ecosan, with its mix of physical, chemical, biological, economic and cultural processes and its balanced support for the health of human beings, their settlements, farmland, and the environment.

Professor Wang also looked at strategies for dissemination of ecosan in China. He listed its strong points, which can be used to popularise the concept. He then reviewed the means through which this can be done: design principles, the structure of ecosan services, and the 'instruments' for ecosan's effective dissemination. He called for excellence in hardware – technological, financial, and servicing support; in software – institutional reform, system development and policy support; and in mindware – behavioural inducements, value changes and human capacity building.

An important part of the ecosan message is the impossible burden on freshwater resources imposed by non-ecological systems, especially sewerage. Many presentations underlined the high degree of pollution to surface waters inflicted by current flows of untreated effluent into rivers and other water bodies. In India, for example, all major rivers are heavily polluted and 70% of this pollution comes from sewers – in spite of the fact that only 200 out of 400 major cities and towns are even partially sewered. What was new to many participants was the degree to which groundwater supplies are also being contaminated by sewers, in both industrialized and developing countries.

Where sanitation consists of dug pits for the storage of excreta, and the area has a high water table, is flood-prone, or has other contra-indicative hydrogeological features, it has been open to criticism for its potential contamination of both soil and water. *Mike Barrett* of the Robens Centre of Public and Environmental Health in the University of Surrey, UK, pointed out that where rainwater, wash water or urine is mixed with human faeces it may act as a conduit for pathogens into the water table. Where the base of the storage pit intersects with the water table, contamination is inevitable.

Barrett had made a study of protected springs in Kampala, and had found that where the installation was in a poor state of repair as was often the case, there were peaks of microbiological contamination in the wet season when excreta discarded on open land were

washed into the system. However, some contamination took place even in the dry season, invariably from leakage from pit toilets to the water table.

While his findings in Kampala will not have surprised many Conference participants, the more striking evidence presented by Barrett concerned conventional sewerage in the UK city of Nottingham. Here, sewage-derived bacteria and viruses were found to be penetrating to significant depths (50 metres) within groundwater aquifers. Although there were some variations from one test-site to another, leakage from the sewers was significant whatever the age and construction material of the installation. Because the aquifer had been overdrawn, it was being recharged from surface water drawn into the city, and from leakage from water pipes. Of this recharge, 10% was from the sewers.

Although there is some way to go before ecological sanitation principles have gained a solid footing in the water and public health engineering industry and its associated institutions, they have already made a considerable impact on international thinking on sanitation policy. *Roland Schertenlieb* of the Swiss Federal Institute for Environmental Science and Technology (EAWAG) presented to the Conference the Household-Centred approach to Environmental Sanitation (HCES) recently adopted by the Environmental Sanitation Working Group of the Water Supply and Sanitation Collaborative Council (WSSCC). This approach is based on a set of principles on environmental sanitation, articulated at a meeting in Bellagio in early 2000, which reflect ecological values.

Systems of environmental sanitation, which includes management of solid wastes, drainage and stormwater, should be designed in such a way as to balance the needs of people with those of the environment to create a healthy and productive life for all. In its key characteristics, the HCES approach addresses the same shortcomings in the whole area of wastes and resources management as ecosan addresses for human excreta. It is based on the recognition that 'business as usual' – especially where water is used to transport excreta – cannot provide services for the poor, pollutes the environment, promotes the under-use of organic residues, and is unsustainable even in the industrialized world over the long term.

As the name suggests, the household is the focal point of HCES planning, reversing the usual order of centralized, top-down planning. By placing stakeholders at the core of the planning process, services respond to the needs and demands of users rather than those of the central planners. The concept anticipates that the users will play a deciding role in the design of the service, and that all environmental sanitation problems will be solved as close as possible to where they occur. Only problems which cannot be solved by the household will be 'exported' to the next level: neighbourhood, town, city, province etc. The amount of clean water imported across boundaries is reduced because wastewater is recycled for non-drinking purposes.

The other essential characteristic is that 'wastes' are seen as a resource. A circular system of resource management based on the household at the centre, emphasizes conservation, recycling and reuse of resources. By encouraging households to adopt appropriate technologies the re-use of products otherwise wastefully discarded is maximized, and the amount of downstream pollution is minimized.

Finally, the Conference respected that the gender dimension of ecological sanitation has to be addressed by the ecosan message, with due respect shown for the different roles and responsibilities of men and women in sanitation. As was pointed out in a presentation by

Ingvar Andersson of UNDP, gender perspectives in sanitation have not yet been thoroughly explored. Indeed, most sanitation programmes have been built around assumptions that the typical consumer of services is some sort of 'gender-neutral' being who does not in fact exist.

Social issues include women's greater desire for privacy, and the harassment and loss of reputation to which women are subjected in some cultures if they fail to perform toilet functions modestly. Security, too, is increasingly an issue in violent urban environments and in rural areas away from human dwellings where privacy might be sought. Parents often withdraw their daughters from schools without proper (or separate) sanitation facilities for girls, for fear that their modesty or safety will be compromised. Women are also responsible in the household for sanitary education of children, and for children's toilet functions. This may preclude the use by young children of facilities which they are too small to use safely. Where there is no piped household supply women also usually collect water, and therefore carry a greater burden where it is needed for toilet flushing. All responsibilities for domestic cleaning and hygiene also devolve onto women. Therefore, any sanitation programme, including ecosan, needs to take gender aspects on board and adapt technologies and health education messages accordingly.

All these presentations underlined the fact that the message of ecological sanitation was about something far broader than toilets or engineering systems: it was about an approach which embraced resource conservation and re-use, human dignity, public health, and environmental security. More widespread acceptance of the approach depended upon advocacy with policy-makers, professionals, the general public, the sanitation industry, and the users of the end-products. For this advocacy to be effective, a sound scientific foundation for ecosan propositions is required.

4. SCIENTIFIC RESEARCH: KEY ISSUES

4.1 Health and safety

The sanitary revolution of the 19th century was primarily inspired by the epidemics of disease, especially cholera, which rampaged through crowded slums and tenements in rapidly expanding cities. Ever since, the overwhelming rationale for investments in sanitation systems has been the protection of public health. Infrastructures of pumps, pipes and sewers have been given much of the credit for lowering disease rates in the industrialized world from the late 19th century onwards. Although their extension has subsequently overloaded the environment and caused a new generation of problems, the health imperative remains the driving motivation for public investment in sanitation.

Ecological sanitation will not be widely accepted as an alternative to conventional systems until and unless public health engineers and civic authorities are convinced that it is superior in terms of human health and safety. Since excreta-derived products are to be deliberately re-introduced into the environment there is a double onus on ecosan advocates to prove that it is safe.

The objective of recent research has therefore been to provide scientific answers to questions concerning the reduction of pathogens in excreta and the safe re-use of urine and sanitized faeces in agriculture. Pioneering research work in this area has been undertaken by microbiologists at the Swedish Institute for Infectious Disease Control, and there have also

been studies in Central America, South Africa, Vietnam, and China The sharing and comparison of results from microbial research was an important feature of the Conference.

Thor-Axel Stenström, Head of Department of Water and Engineering Microbiology at the Swedish Institute for Infectious Disease Control, made a number of presentations at the Conference. The most important finding he presented was that – if requirements of time, temperature and pH level are met – ecological sanitation can be as effective as, or superior to, conventional wastewater treatment in bringing about pathogen reduction. Investigations so far are on a small scale and more studies are required. This finding is extremely encouraging in building an *a priori* case for ecological sanitation on grounds not only of environmental security but in order to promote human health.

Among Stenström's wide range of concerns in examining safety issues was the identification of the best method of evaluating microbial die-off, as well as making accurate comparisons between the die-off rates of the various pathogens under different forms of treatment and in different systems. One critical aspect was the selection of an 'index organism' to measure. The US EPA standards tend to focus on faecal coliform counts and salmonella. Stenström pointed to the greater survival rate of viruses and parasites than of faecal coliforms or other bacteria. *Ascaris* (roundworm) is among the most resistant, and therefore destruction of *ascaris* ova could be seen as a one of the most important indicators of the safety of sanitized faeces. A number of presentations noted survival rates of *ascaris* in particular.

Another issue was the comparative effectiveness of different processes to render faeces harmless: Was dehydration, anaerobic digestion, composting, raising pH, or any practicable combination of these, more effective and/or faster at pathogen reduction? In the case of composting, the material in a pit or chamber has to be moved about to aerate it at regular intervals. In the case of dehydration, this may be desirable but is less necessary. Dehydration is assisted by the addition of ash, sawdust or soil, which absorbs moisture. Wood ash raises pH, prevents odours, and helps control fly infestation. Some ecosan toilets are installed with ash dispensers, or with instructions to users on the need to cover faeces adequately with the prescribed material. Others are installed with solar panels so as to raise the temperature within the composting or dehydrating chambers. High temperature is a good killer of pathogens as well as a good dehydrator.

The results of experiments on the effectiveness of various processes were presented by *Thomas Redlinger* of the Center for Environmental Resource Management in the University of Texas at El Paso; by *Aussie Austin* of CSIR Building and Construction Technology in Pretoria, South Africa; by *Liu Jayi* of NPHCCO in Beijing; by *Druong Trong Phi* of the Nhatrang Pasteur Institute in Vietnam; and by *Christine Moe* of the Rollins School of International Health of Emory University, Atlanta, whose work has taken place in El Salvador.

The overall conclusion was that the process of decomposition is complex, and the survival of some pathogens can be remarkably protracted. Although the raising of pH was seen as consistently helpful, no definitive conclusion could be reached about the relative merits of the various processes for all climatic, social, economic, and environmental circumstances. Moe's study in Central America had found that no single physical factor – pH, temperature, moisture, time – could predict microbial behaviour. These findings confirmed the results of earlier studies in at the Nhatrang Pasteur Institute in Vietnam.

As far as additives were concerned, plant ash was generally found to be more effective than other naturally available materials in assisting pathogen die-off; this was especially noted in a Chinese study. No study suggested that decomposed faeces should be taken out of the holding chamber earlier than six months after the last addition. Some studies suggested that a longer period was needed to give a better margin of safety. Both Austin and Moe found that some pathogens had survived beyond a year, and the Vietnamese researchers found variable rates of die-off which were not easily explicable.

Although efficiency seemed to demand a speeded-up rate of die-off, it was pointed out that in most settings where ecosan was currently in use, speed of pathogen destruction is not an important issue. In many cases, it may take a year or more to fill the two processing chambers of a double-vault toilet.

Presenters pointed out that much of their work was recent and some of it was incomplete. Those of their papers that had been published were the very first contributions to the literature of their kind.

Caroline Schönning of the Swedish Institute of Infectious Disease Control had studied the health risks associated with the re-use of source-separated urine. Urine-diverting toilets are being used on a small scale in Sweden, and the main focus of her study was to see whether the urine diverted from these facilities was as sterile as in the bladder, or whether it was contaminated by contact with faeces, and if so what level of risk to health this represented. Her study checked for risks of infection by any microbes present during the handling of urine as a fertilizer.

She also looked at the risks associated with eating crops which might have been contaminated during fertilizer application and found that these risks reduced as time passed because pathogens continued to be inactivated by sunlight or other biological processes. She concluded that guidelines for the safe use in agriculture of urine diverted at source would be needed to minimize the risk of infectious disease transmission; that, for example, urine was safe for trees including fruit trees, but less so if sprayed onto leafy vegetables which might be eaten raw.

This presentation underlined that, as is the case for the storage, treatment, handling and use of sanitized faeces, behavioural issues are critical. No sanitation system is 100% 'safe', as the Conference was frequently reminded, and the claim of total pathogen destruction in some models and studies is also unrealistic as 100% can never be guaranteed for all circumstances. Public education on the hygienic use of ecosan facilities is necessary – as with any facility. This point was underlined by *Håkan Jönsson* who described how residents of a Swedish housing development with urine-diverting toilets who had not been familiarized with their purpose did not use them properly, thereby yielding a lower and potentially more contaminated urine output.

4.2 Agricultural application

The other main scientific question concerning ecological sanitation and its promotion of 'closed loop thinking' is whether human excreta are effective as fertilizers. Not only do public health people have to be persuaded that their use is safe, but agricultural people – policy-makers and farmers – have to be convinced of their merits to use them. In China and Vietnam,

they are well-established in agricultural production. The Conference was reminded that a century or so ago, nightsoil was also collected and used as fertilizer in many societies. In some cultures, however, extreme prejudice against faeces in particular could be an obstacle to the use of fertilizers based on human excreta.

Scientific study into the use of excreta as fertilizer and of the implications for crop yield, energy consumption, and other economic and institutional factors is far less advanced than enquiries into safety. The main presentation to the Conference on this subject was by *Hakan Jönsson* of the Swedish University of Agricultural Sciences. He focused on urine, which in Sweden contains 70% of the nitrogen and 50% of the phosphorous and potassium in human excreta. When considering the use of excreta for agriculture, since urine contains most of the nutrients and does not naturally contain pathogens, there is no doubt that urine diversion at source is the most appropriate technology. The volume of nutrients recycled to the soil by source-separated urine, compared to sludge generated by sewage treatment plants, was larger by many times.

The first part of Jönsson's presentation concerned the effectiveness of current installations of ecosan toilets in Sweden in facilitating the separate collection of urine with minimum contamination from bacteria or heavy metals. The technical performance of the ecosan toilet models, and the attitudes and behaviours of those who were using them, were presented. The degree of success of the model depended considerably on the motivation of the users.

The fertilizing effect of source-separated urine on cereal production had shown that the nitrogen effect was 90% that of chemical fertilizer, and the phosphorus effect was 100%. However, nitrogen in stored urine is mainly found as ammonia, and ammonia is toxic to some plants if applied to the plants themselves. Therefore, it is best applied to the ground or injected below the ground surface. No toxic effects had been observed with barley, oats or wheat. The heavy metals content was extremely low, making urine a clean fertilizer. The emission of ammonia after spreading was slight; if the system was correctly designed, ammonia emissions in collection, transport and storage were negligible.

Another aspect examined was the energy costs of transporting urine to farmland and spreading it on the fields. Here, too, given the savings made from the production of alternative fertilizers, the usage of electricity, oil and energy was lower where urine was applied. Other types of assessment had also been applied to compare the environmental impacts of urine diversion systems as compared to conventional waterborne sewerage, and had concluded that the separate collection of urine was an improvement to standard sewage systems under almost all conditions and assumptions. An ecosan system which diverted urine and handled faeces dry had even larger advantages, in that almost no potential nutrients were lost.

Other presentations on agricultural use of sanitized human excreta focused on the advantages of organic agriculture, and the value of using natural sources of phosphorous for food production instead of exhausting finite reserves of mineral phosphates. In these contexts, the ecological sanitation approach was seen as 'a piece in the puzzle of the global recycling of nutrients' – as expressed by *Bekithemba Gumbo* of the Department of Civil Engineering in the University of Zimbabwe. His estimates indicated that the diversion and storage of urine, and its application in urban agriculture which is widespread in Harare, would attain fertilization rates higher than the recommended commercial farming rates in Zimbabwe.

4.3. Technological issues

A number of specific technologies used in ecological sanitation were discussed at the Conference. Urine diverting toilets with above ground double-vault processing chambers are the most common ecosan solutions today but a number of other technologies can be used. These range from the Zimbabwean 'arborloo', basically a shallow pit toilet where a tree is planted once the pit is two-thirds full, to biogas toilets.

In China more than 8 million household biogas digesters and 800 large biogas plants have been built over the past 20 years. Biogas is regarded as a way of enabling rural households to gain access to 'free' energy while utilizing all organic residues, including human excreta and livestock manure, as fertilizers. Although the driving motivation for a household's adoption of anaerobic digestion may be energy-related, the effect also makes an important contribution to safe sanitation and environmental improvement.

Other presentations on technological issues were largely concerned with the development of dry toilets in industrialized countries. This has been inspired by the environmental pollution and the high consumption of water by flush toilets – commonly 15,000 litres per person per year.

In Japan, dry toilets were developed after the Kobe earthquake of 1995, when flush toilets could not be used because of lack of water and broken sewers. They are of three types: water circulation, in which water used to flush the toilet is recycled, portable toilets whose product is dried and incinerated, and composting toilets, operating on the same principle as a family garbage processing machine, which uses a small motor to stir the garbage with sawdust or wood chips. Several kinds of water circulation and bio-toilets are produced commercially, and the latter system is also used for public toilets.

The technological implications for the collection of excreta on a large-scale, its management and reuse in agriculture, was examined by presentations from Sweden and from Vietnam. Nightsoil collection on a mass, organized scale is part of the sanitation system for Hanoi. One stimulating presentation on institutional implications for the introduction of ecosan in modern cities suggested a parallel with the Austrian chimney-sweep for the 'ecosan officer'. The chimney-sweep is a licensed practitioner, who is paid by the household and responsible for maintaining fire-regulation standards. In a similar way the independent, duly trained and licensed ecosan officer would be hired by the household for installation, maintenance and collection, and would have his/her actions governed by standard regulations.

Another futuristic presentation explored ecological sanitation and urban sustainability. *Mayling Simpson-Hebert* presented a vision of how ecological sanitation could form part of urban planning in those parts of the world now undergoing rapid urbanization. At present, 25-30% of the world's urban population live in slum and squatter settlements where housing is inadequate and the environment squalid. Paving, drainage, safe water supplies, garbage collection and sanitation are absent or inadequate. Simpson-Hebert proposed that systematic recycling of household refuse and human excreta would not only help improve the living environment and public health, but provide job opportunities.

At the heart of this approach would be the 'eco-station' – a neighbourhood recycling centre where all kinds of household residual products would be processed, and outputs such as methane gas, hard-core for roads, and compost, produced. These eco-stations would be run by

municipalities, cooperatives or by private enterprise. Some enterprises in Australian cities and elsewhere are already operating high-tech, commercially viable recycling plants.

5. CASE STUDIES

5.1 Africa

Presentations on practitioner experience in Africa came from South Africa, Zimbabwe, Mozambique and Uganda. Various local and international NGOs and other organizations have been involved, including the Mvula Trust (South Africa), Estamos and WaterAid (Mozambique), Mvuramanzi Trust and Aquamor (Zimbabwe), the Water and Sanitation Programme, Sida including the *SanRes* programme, and – in the case of Uganda – the government of Austria. Many of the programmes in question have learned from each other, notably from long-term work on pit sanitation undertaken at the Blair Institute in Zimbabwe.

One common theme to emerge from the presentations concerned the need to pay due respect to existing beliefs and behaviours relating to sanitation. Cultures in Africa, by comparison to those in East Asia, tend to be 'faecophobic': people do not want to talk about, let alone handle, faeces in any form or for any purpose; and although they may not have the same reservations about urine, there is no knowledge about its re-use potential. Although inhibitions may be overcome, and in some places have already been so either naturally or in the course of ecosan promotion, they should not be underestimated. One way of overcoming such problems is to set up a system of communal collection of the outputs from household toilets.

Presenters from Zimbabwe, Mozambique and the Water and Sanitation Programme in Africa underlined what they perceived as a necessity: the need to be technologically inclusive and not be dogmatic about urine diversion or above-ground construction. In their opinion too much emphasis had been laid on the disadvantages of 'drop and store' sanitation, especially the contaminating effect on groundwater of excreta storage in pits. These might not apply where the water table was low, settlement sparse, and there was no other hydrogeological reason – rocky terrain, for example – to avoid pit sanitation.

Therefore, the adaptation of pit systems to meet ecological standards and enable nutrient re-use should be seen as a viable alternative. This case was made strongly by Peter Morgan of Aquamor, who has made a major contribution to rural sanitation in Zimbabwe and in Africa generally, and echoed by many others. The need for demonstration, choice, and for access to information in a 'learning stage' was seen as critical.

Another general principle concerned the need to market sanitation in Africa, and to find ways to build demand while developing sanitation as a business in which a living might be made. Experience had shown over the past 20 years that people in Africa do not want sanitation primarily for health reasons and supply-driven approaches invariably fail. But there is a demand for reasons of status, convenience, security and other factors, if the facilities on offer are affordable, work well and are pleasant to use. Where a population – rural or urban – is experiencing environmental pressure, ecosan may seem an attractive alternative to other possibilities.

The programme to introduce ecological sanitation in rural and peri-urban areas in Niassa Province of northern Mozambique, conducted by Estamos and WaterAid, has been formed along these lines. Alternatives to standard pit toilets are being introduced successfully, despite initial scepticism from public health officials about cultural acceptability. These are of two types, also used in Zimbabwe and Malawi: the 'fossa alterna' with two shallow pits, so that the faeces can compost in one while the other is in use; and the 'arborloo'. (In both, users apply a soil/ash mix to cover faeces, keep flies away and raise pH to improve pathogen destruction. The 'arborloo' is usually used at seasonal farming locations for growing orchards, and evidence suggests that growing fruit-trees over disused sanitation pits is becoming more widely practised. The programme also offers conventional pit toilets, but the majority of people prefer the ecosan toilets because they are easier to build (require less digging) and odour-free. Thus, cultural reservations are far from insuperable and appear to be eroding.

The programme in Kisoro and other townships in south-western Uganda addresses a different sanitation problem. The locality is densely settled and needs a good sanitation system, but water is at a premium, the terrain is rocky, and due to the nature of the geological formation, urban water supplies are easily contaminated by polluted wastewater discharge. Ecological sanitation was introduced in an attempt to solve this problem. Between 1999 and 2001, 140 compost toilets and 107 dehydration toilets were installed in households, as well as seven dehydration public/school toilets.

Some operational difficulties were encountered due to leakage, overuse, and lack of maintenance, most of which have been resolved. The public toilets, operated as a private business, are functioning well. But persuading some of the families to switch over to using their new facilities in place of their old pit facilities has not been easy. The difficulties surrounding the promotion of ecological sanitation in a faecophobic environment were seriously under-estimated. In spite of these obstacles, a visionary plan has been developed to take ecosan forward in the country as a whole with a greater emphasis on awareness building and education.

So far, apart from the Ugandan experience with urban facilities, there have been few experiences on an urban scale in Africa. However, some interesting insights were presented from South Africa, where the Mvula Trust is starting to introduce urine-diverting ecosan facilities in Johannesburg townships and low-income housing developments. Here, the crowdedness and insecurity of urban living space puts a premium on a facility which is odour-free and therefore can be built indoors; does not take up much room; and is a permanent investment in that its life does not end when the pit is full. It was also noted that water shortage and the size of water bills is beginning to act as an ecosan incentive. Urine-diverting toilets are on the threshold of being accepted as a standard component in some low-cost housing developments.

No-one doubts that reaching the 400+ million people currently without proper means of sanitation in Africa is a major challenge. Commitment from government and the private sector is needed, and the growth of an institutional framework which is able to offer alternative technologies including ecosan, balancing environmental concerns with the demands of consumers.

5.2 Latin America

Ecological sanitation approaches are being applied in various countries of Latin America, including Bolivia, Chile, Ecuador, El Salvador, Mexico and Peru. Scientific studies from El Salvador and the Mexican-US border were presented to the Conference but the main practitioner presentations came from Mexico, the country with the most extensive experience with ecological sanitation in the region.

Ecosan toilets were introduced into Mexico 20 years ago, in response to the severe water pollution caused by inadequate sanitation. The model came originally from Vietnam, and is a double-vault dehydrating toilet, built above the ground on a solid non-permeable base, with a squatting slab which allows urine to be diverted. The model has been further developed in Mexico and today has the look of a standard WC but with urine diversion and no flushing. The sales appeal of the facility has been mainly based on its sanitary features: it is odour-free, conserves water, is affordable and eco-friendly. The re-use of nutrients from excreta in agriculture was not a traditionally established practice in Mexico as in Vietnam, and has more recently been emphasized as a bonus.

There have been a long succession of small-scale ecosan projects in Mexico of varying degrees of success. An important contributor to ecosan has been a socially motivated architect and entrepreneur, *César Añorve*, who set up a workshop to manufacture urine-diverting toilets 18 years ago in Cuernavaca. The toilet seat-risers, known as 'Sanitario Ecologico Seco', are made in polished concrete or fibreglass, cost around USD. Over the years Añorve has expounded the advantages of ecological sanitation and facilitated the establishment of community workshops for the production of seat-risers. There are now 15 such community workshops in Mexico.

However, despite positive small-scale experiences, ecosan in Mexico has not managed to take off on a large scale. Poor understanding of the technology and its value hampered large-scale implementation – to the point where its reputation was damaged. In an attempt to remedy this, an organization in the state of Morelos, Espacio de Salud (ESAC), has adopted a strategy specifically aimed at 'scaling-up'. ESAC set out to build community capacities so that people would be able to analyse their own sanitation problems and become self-sufficient in meeting them. It also worked in five different regions, so that communities where ecosan took off could become resource centres for others nearby, disseminating information and providing skills and hardware.

The programme works through a system of regional 'promoters'. These have been trained in appropriate excreta management technologies, how to put messages across to the community effectively, and gender issues. They in turn work with promoters in the communities themselves. The take-up of the programme has been slow but sure; gradually, ecosan toilets are being installed and properly used in new communities without input from ESAC. The increased awareness of health and environmental issues brought about by the promoters seems to have been decisive. Some families and communities have been so won over to ecosan that they have even opposed the local installation of sewers. They have also been open to the use of urine as a fertilizer, and this previously ignored aspect has even become a selling-point.

Key to the success of the approach is the emphasis on persistent follow-up by promoters – and persistent follow-up with them. Their skills are critical. They are trained to facilitate community planning and decision-taking, letting projects respond to the nature of local

demand. This might come from a coffee co-op keen on organic fertilizer, or a local politician campaigning on an anti-pollution platform. Monitoring tools – checklists of good construction features and proper use – have been made educational in themselves. Local workshops to make seat-risers have been set up, and their sales help fund the promoters' work.

Although ESAC felt that they had successfully identified the key elements needed to make ecosan viable on a wider scale, the rate of adoption has still been slow. The project managers now feel that impact would be greatly enhanced with more attention to three areas: local government involvement; public policy changes to provide incentives for keeping the environment unpolluted; and public education through the mass media.

5.3 Asia

There is no doubt that the programme in rural Guangxi is at present the jewel in the ecosan crown. Apart from the 'ecological village' project in Yongning county, visited by the Conference participants, there has been an extensive take-up of ecosan elsewhere in the province, with a total of 24,500 ecosan toilets installed and in use by the end of 2001. Those in charge of the programme are confident that it has become virtually self-generating: interest is now spreading spontaneously as villagers hear about this form of sanitation and set about adopting it. The infrastructure, in terms of manufacture of squatting pans, and technical back-up is gradually spreading and creating employment and occupational opportunities. Current plans are to set up an R&D institute on ecological sanitation in Guangxi, to serve the province and the nation, and to embark on an urban pilot project during 2002. Ecosan activities are already underway in half of China's 31 provinces.

There were several presentations on aspects of ecological sanitation in different contexts in Vietnam and one from Kerala in southern India. India is a country where the handling of excreta was traditionally assigned to people of the very lowest social status. The traditional behaviour has been to empty bowels and bladders as far from the home as possible, in open ground or along a river or seashore. To do this in the home, unless in a flushable toilet, is regarded as highly undesirable. In spite of these obstacles to 'closed loop' sanitation practice, in-house ecosan technology in which urine and wash water are re-used for cultivation has been promoted and implemented successfully. Altogether, 200 ecosan toilets are now installed and functioning in Kerala and Sri Lanka.

One of the current pioneers of ecological sanitation in India is *Paul Calvert*. His attempt to introduce ecosan in the fishing villages of Kerala where he was working in a different context stemmed from people's desperate need for a type of sanitation which suited the coastal environment and the local culture. The water table is high, settlement dense, and the proximity of private pour-flush toilets and soak-aways to communal wells was causing a high level of faecal contamination to the water supply. Over 95% of households had no toilet at all, diarrhoeal disease and intestinal parasites were endemic, and outbreaks of cholera and dysentery arrived with the rainy season. Once people understood what caused all this disease they were keen to find a solution. Their first effort – a communal toilet using well-water for flushing – failed when the over-used well ran dry.

The model of ecosan developed in this setting uses a courtyard toilet-wash-house, in which the processing chambers are built above ground. These usually open to an outside wall. Urine and wash water – including water from laundry – is diverted by pipe into a shallow evapo-

transpiration bed usually placed inside the courtyard. The bed is filled with coarse sand and has its own containing walls and a thick plastic sheet at the bottom to prevent seepage. In this bed flowers, shrubs and even fruit trees and coconut palms are grown. Thus, urine does not have to be handled. The processing chambers are not opened until their content is odourless and sanitized. Any anxiety about handling the contents disappears once it is seen to be inoffensive.

Calvert's presentation also addressed gender issues. Motivation for a decent household toilet often comes from women, who – in the absence of a household facility – are obliged to walk far from the house, under cover of darkness to assure personal modesty. As vegetation is successively reduced with population pressure, this nightly journey becomes longer and less secure. In some cases, men were persuaded of the benefit of an in-house facility because they are currently expected to accompany their wives and daughters on their toiletry outings to prevent their harassment and defend them from assault.

The importance of the Kerala ecosan project is that it has proved what many in India would think impossible: that an ecosan system based on urine-diverting no-flush toilets can be culturally accepted. There is considerable scepticism still among Indian sanitary engineers and policy-makers that ecosan is a viable approach. Interventions at the Conference from South Asian participants implied that ecosan is greeted cautiously. It tends to be regarded as just another toilet technology, rather than as an approach which, at scale, would address the lamentable level of sewage pollution in Indian rivers and the extravagance represented by the use of scarce water for transporting human faeces in pipes. Calvert calculated that the current discharge of human excreta into the environment could produce 4 million tons of NPK fertilizer per year.

6. CONCLUSIONS

The First International Conference on Ecological Sanitation was primarily a forum for the exchange of experiences and views, and an opportunity to hear about some of the latest findings from scientific research. The Conference was not structured to resolve issues or come up with any kind of blueprint for the future, in either practitioner or research contexts. In addition, the number of presentations on a wide variety of subjects given in a short period meant that opportunities for debate within sessions were relatively few. However, consensus around certain key themes did emerge.

Some of these areas of consensus were as follows:

- Ecological sanitation is an approach, a way of thinking, rather than a technology or a device. The approach is characterized by 'closed-loop' thinking and practice, whereby the human need for a safe, congenial and dignified means of sanitation is met, the nutrients excreted are safely redeployed in agricultural production, and ecological security is maintained.

- Ecological principles for sanitation are just as valid for industrialized as for developing countries. Ecosan should not be seen as a low-cost, second-class system which is only for the poor. Promising developments in Sweden, Germany, Australia and elsewhere show that this attitude is invalid.

- There is no single ecological sanitation prescription or solution. A menu of options must be considered, and choices offered to households and communities. There should be choice of technology, and of focus to meet different needs and interests – including health, agriculture, environmental stewardship, quality of life, and poverty reduction. In order to make choices, people need to be informed about available alternatives and their consequences by education, information exchange, popular media, drama, and demonstration visits.

- 'Bottom-up' approaches (as used in grass-roots development), and 'top-down' approaches (guided and promoted by government) are not mutually exclusive and both are needed.

- Affordability at both the household and national level is an important issue. Programmes in which there is strong reliance beyond a demonstration phase on subsidies by government or external donors have invariably proved non-sustainable. Demand-led strategies, including the promotion of demand by demonstration, incentives and other means, are preferred.

- Ecosan is now ready to move beyond the small-scale demonstration project to the large-scale sustainable programme, especially in urban areas. To achieve this, by-laws and regulations may need to be adjusted and a system of incentives and sanctions devised.

- For ecosan approaches to become more widely accepted and practised, it will be necessary to reduce cultural prejudice and professional resistance. The continuing development of a strong scientific basis for the safe application of ecological sanitation is essential for the advocacy task.

Participants at the Conference were extremely positive about the event, and many reported a new sense of motivation and encouragement from their attendance. The Conference did not produce a formal declaration or set of recommendations, but in order to facilitate the onward dissemination of its work in international fora and elsewhere, it did produce a concluding message, whose text was as follows:

Concluding message from the Nanning Conference

On 5-8 November 2001, 300 participants from 27 countries met in Nanning, China, at the First International Conference on Ecological Sanitation to share recent experiences and research findings in the application of sanitation approaches based on ecological principles. The Conference was convened by the Jiu San Society, with the support of the Government of Guangxi Zhuang Autonomous Region and associated ministries, institutes and associations. It was funded by the Government of Sweden and by Unicef, with additional input from UNDP, GTZ, and the Water and Sanitation Programme (WSP).

Ecological sanitation is a term used to describe a sanitation approach which respects ecological integrity, conserves and protects freshwater, promotes healthy and dignified living, and recycles nutrients from human excreta for the growing of food and non-food tree crops. Its 'closed loop' thinking is fully compatible with the principles articulated at the WSSCC meeting in Bellagio in 2000, and falls within the framework of its approach to environmental sanitation.

Research and development on ecological sanitation is now taking place in many settings, including on a small scale in industrialized countries. In developing countries, a number of projects have been carried out in diverse physical and cultural contexts. The largest current programme is in China, where results are particularly encouraging. In its different forms, ecological sanitation has begun to demonstrate that it can be widely acceptable and effective at scale.

The Conference reviewed the results of a number of recent studies on technical and scientific issues. These are starting to provide a strong scientific foundation for the implementation of the ecological sanitation approach and are building confidence for its future large-scale application.

The Conference recommended:

- *Further research, especially into health aspects; economics and financing; institutional implications; the use of the sanitized human excreta in agriculture; market development; and behaviours, attitudes, and practices concerning the use of ecological sanitation facilities by men, women and children.*

- *Extension of pilot studies and research into urban and peri-urban areas.*

- *Awareness-building of ecological sanitation principles and 'closed loop' thinking at all levels of society and with all stakeholders, including young people and school children.*

- *Wider implementation of ecological sanitation in both developing and industrialized countries.*

- *The systematic incorporation of ecological principles into conventional water and sanitation management systems and national policies.*

- *Forging of stronger links between proponents of ecological sanitation and partners in agriculture, energy, health, urban planning, water resources, and environmental security.*

To implement these recommendations financial resources, technical support and endorsement will be needed from government at all administrative levels, external support agencies, professional bodies, NGOs and the private sector. To generate this support, strong political will is required.

Participants recognised that this Conference had brought ecological sanitation to a new threshold of credibility and launched it into mainstream thinking. For this achievement, much credit is due to the Swedish International Development Cooperation Agency (Sida), which has played a leading role in investing in this pioneering work.

Conference Rapporteur: Maggie Black
Editor: Uno Winblad
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