Ecological Sanitation and Reuse of Wastewater

ecosan

A Thinkpiece on ecological sanitation

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Preface

The Agricultural University of Norway is heading the development of ecological sanitation in Norway and was commissioned to write this "Thinkpiece" by the Norwegian Ministry of Environment. The text is the responsibility of the authors.

Ecological sanitation is an option for all, but in this text the main focus is on developing countries. Successful implementation of ecological sanitation requires a multidisciplinary approach, hence, we have invited authors with a diverse background.

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Abstract

The challenges and opportunities given by the global community at the World Summit on Sustainable Development (WSSD) and in the Millennium Development Goals (MDGs) to improve livelihood for people and to restore the degraded environment are historically unique.

Investments in water supply, health, and sanitation will be given priority during the coming years. In order to meet requirements of sustainability, cost effective and appropriate technologies must be introduced parallel with new attitudes, especially in the field of sanitation.

This paper is a "Thinkpiece" to show that there are comprehensive experiences and available technologies that meet new and sustainable sanitation requirements. Ecological sanitation constitutes a diversity of options for both rich and poor countries, from household level up to wastewater systems for mega-cities. The objective of this paper is to show that ecological sanitation can play an important role in this context and that it needs to become recognised by decision makers at all levels.

1. Ecological Sanitation

– AN OPTION FOR ALL

Most of the people in developing countries do not have access to safe sanitary systems. If we are going to tackle this problem we have to leapfrog the centralised end-of-pipe sanitary systems of the industrial world. New affordable technologies based on ecological sanitation, which save water, recycle local nutrients and extract energy, open sustainable options for all both in rich and in poor countries.

International Water and Development Organizations with ecological sanitation on their agenda:

SIDA, DANIDA, GTZ, Dutch Dev. Coop., WSP, WSSCC, IWA, Unicef, UNEP,ATV/DVWK, NORAD

The United Nations, during the Millennium Summit in New York in 2000 and the World Summit on Sustainable Development in Johannesburg (WSSD) in 2002, developed a series of Millennium Development Goals (MDGs) aiming to achieve poverty eradication and sustainable development by rapidly increasing access to basic requirements such as clean water, energy, health care, food security and the protection of biodiversity. The specific target set for the provision of water supply and sanitation services is to halve the proportion of people without access to safe drinking water and adequate sanitation by 2015.

The progress towards meeting the MDG sanitation target is the slowest of all MDG's, with an enormous gap existing between the intended coverage and today's reality (1). Water supply and sanitation are cornerstones of public health as well as social and economic well-being. Sanitation, however, receives less priority during planning, policymaking, budgeting, and implementation, while more resources are allocated to water supply. To reach the sanitation MDG more attention and allocation of resources are needed. The amount of resources needed is strongly dependent on the choice of technology.

The WSSD estimates that 2.4 billion persons lack adequate sanitation (2). Most people lacking sanitation live in developing countries. In addition, farmers in rural and urban areas experience shortages of water and nutrients in agriculture and aquaculture. It is therefore high time to look at safe reuse options for urban wastewater.

In order to meet the demands of sanitation for all, prevent environmental degradation, and to make long-term economically efficient investments, new approaches to wastewater management must be implemented. Ecological Sanitation is a promising approach whose potential contribution for achieving the MDG's is increasingly recognized among international development organizations.

This paper gives an introduction to ecological sanitation as a tool for meeting the goals of urban sanitation as expressed in the MDGs

The water born toilet paradigm

With the invention of the water toilet and subterranean gravity sewers the development of sanitation systems moved from decentralised to centralised wastewater management. The water toilet improved health, but severely polluted waterways. At the same time the costs for sewage treatment started to exceed the range of affordability for most people in develop-

Water well (right) adjacent to an open sewer.

ing countries. If the water toilet had been invented today it would probably not have been certified as sanitation technology meeting sustainability criteria.

In cities, water toilets account for 20-40% of the water consumed (3). Potable water, a limiting factor for development, is misused to flush human waste where both water and the excreta should be considered as a resource. Theoretically, the nutrients in domestic wastewater are almost sufficient to fertilize all the crops needed to feed the world population (4). As much as 80-90% of the major plant nutrients (nitrogen, phosphorus and potassium) in wastewater are present in the toilet waste (5). If these nutrients are reclaimed using hygienically safe pathways, they can be used locally as a fertiliser in sustainable agriculture.

Alternatives are on the market

Technological alternatives to conventional sanitation that provide the same comfort, save water and facilitate separate collection of toilet waste do exist (6). Vacuum and gravity toilets that use only one liter (or even less) per flush are on the market (7). The downstream treatment facilities for concentrated toilet waste can easily handle organic kitchen waste, hence, most domestic organic waste flows can be safely collected, reclaimed and turned into bio-energy and fertilisers. Several manufacturers provide urine diverting toilets that are easily retrofitted in existing buildings, making urine collection possible (8).

Urine, needs only storage (time dependent on climate) before it is suitable for use as a hygienic fertiliser (9). Recent improvements in compost technology have made the treatment of human waste, safe efficient and odourless (10).

Why are these options not widely used? There are several reasons. The systems are relatively new. The options to supplement and even replace traditional sewer systems with inexpensive decentralised, resource saving systems are not widely known. With few exceptions ecological engineering is not a part of the curricula at engineering schools. If engineers are not aware of these developments, we cannot expect the decision makers to be aware of them either.

2. Advantages and Challenges of Ecological Sanitation

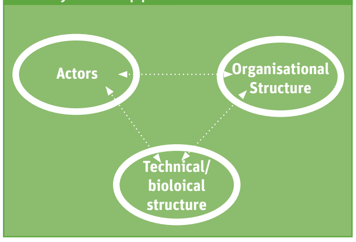
The UN Millennium Goal of supplying people with safe drinking water and adequate sanitation can be met with inexpensive solutions that are well adapted to the local conditions. Sanitary systems used in developed countries are often too expensive, require much maintenance and have a high water demand.

Ecological sanitation implies separating waste streams, saving water and energy, nutrient recycling, cost efficiency, and the integration of technology to environmental, organisational and social conditions.

In developing countries there is often no established infrastructure for wastewater handling. Water, money, and fertilisers are scarce resources while labour is cheap and available. These conditions poorly match the characteristics of conventional wastewater systems which are water intensive with a costly infrastructure. In addition conventional systems rely more on imported goods while ecological sanitation to a larger extent utilises local resources.

Moreover ecological sanitation systems are often locally managed with low transport costs, minor requirements for water, and reuse of nutrients. These are some of the reasons why ecological sanitation may be more appropriate in low-income countries than conventional systems

System approach



Planning sustainable wastewater systems needs to integrate the organisational system, the technical system, the users of the system and the interactions between these (39).

Expensive conventional intrastructure

Collection and transport account for 80-90 % of the capital cost and more than 65 % of the annual cost of conventional wastewater handling facilities (12).

Advantages of ecological sanitation

Affordable options for all

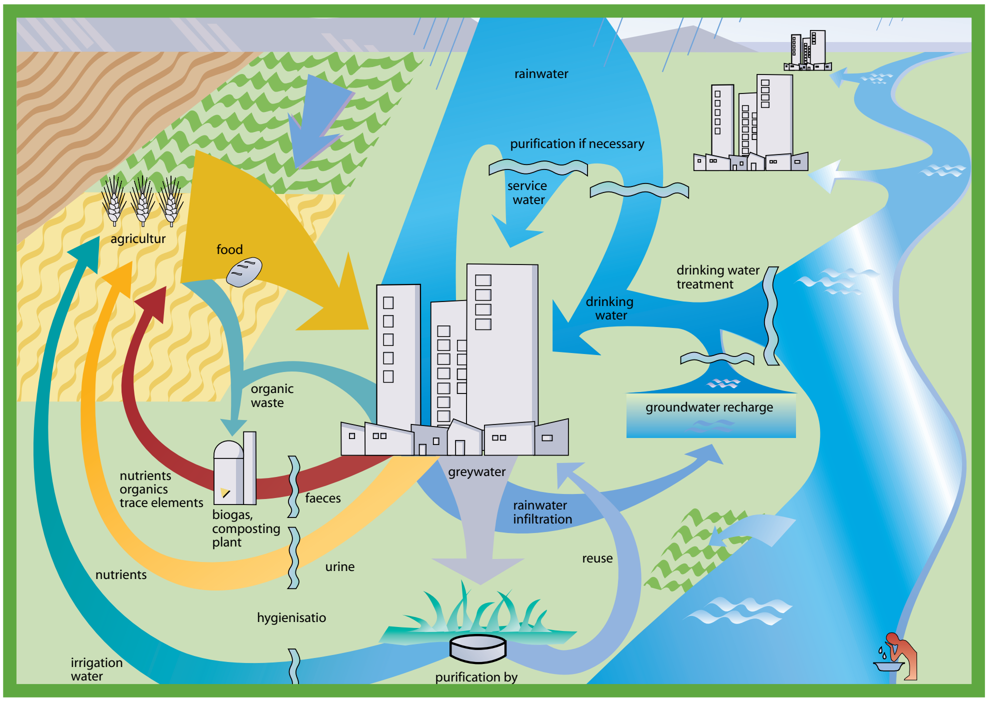
Ecological sanitation reduces the need for pipelines - the most expensive part of a traditional sewer network. Ecological sanitation can provide both the poor and the wealthy with sustainable sanitary systems at an affordable cost.

It is difficult to give exact cost figures for ecological sanitation systems because the local conditions on which they rely vary greatly. General figures from UNEP (11) show that the annual costs of ecological sanitation options are lower than most conventional options. As an example the ecosan toilet system in Bangalore has an annual cost per person of 10USD. However, more cost comparisons for different system options are needed.

- Ecological Sanitation is flexible, and centralised can be combined with decentralised, waterborne with dry sanitation, high-tech with low-tech, etc. By considering a much larger range of options, optimal and economic solutions can be developed for each particular situation.

Increasing health and dignity

- Ecological sanitation eliminates large quantities of blackwater, which is the main fraction carrying disease causing organisms, and pollute water supplies specifically for the poor in developing countries.
- Ecological toilet systems for the poor enhance their dignity, quality of life and health.



System approach to ecological sanitation closes loops in wastewater management (10).

The implementation of ecosan leads to:

- **Improved health** by introducing new methods of handling faecal matter
- **Affordable solutions** with low capital and maintenance costs
- **Increased food security** by better fertilser availabilty
- **Substantial water savings** by using water saving toilets and reuse of greywater
- **Economic development** by generation of local buisiness opportunities
- **Bioenergy production** by integrated solutions for wastewater and organic waste
- **Stakeholder involvement** and system acceptance (considering social cultural, technical and environmental issues)

Recycling and saving resources

- Ecological sanitation saves at least 20-40% of the domestic water consumption (3). Adding water saving devices or recycling greywater makes it possible to save even more water. This is of key importance since water is a major limiting factor for development in many countries. After filtration, greywater can be used for irrigation, groundwater recharge. or even for production of potable water.
- Ecological sanitation enables of 80-90% of the nitrogen, phosphorus and potassium in excreta and wastewater to be recycled for agricultural use (5). This provides inexpensive local fertilisers that help long-term poverty alleviation through enhanced food production and a series of local business opportunities.
- Ecological sanitation facilitates energy production from organic waste resources.
- Ecological sanitation creates local business opportunities for construction, operation and maintenance of sanitary facilities and sale of fertiliser products.

Challenges of ecological sanitation and possible responses

- Existing legislation in many countries favours conventional, centralised sanitary systems and must be revised to encompass ecological sanitation. This means encouraging the implementation of decentralised solutions and more focus on promoting health and resource management aspects.
- In order to prepare the legal basis for wider implementation of ecological sanitation, performance-based regulations for wastewater treatment systems should be introduced. This means that a system has to meet requirements (e.g. discharge limits, health and resource recovery) set by the authorities. Such regulations stimulate creativity and development of new systems because any system can be used as long as it meets the requirements and has been properly characterized.
- The water closet and centralised sewers are perceived as the ultimate solution. This perception increases the gap between rich and poor, specifically in developing countries. Knowledge about the concept of ecological sanitation must be communicated to engineers, decision makers and stakeholders.
- Cultural taboos and attitudes can hinder the use of excreta-based fertilisers. Information is important to change this.

Design guidelines are needed

Ecological sanitation is a young discipline. However, on a global basis, much data and experience is available. This comprehensive knowledge must be compiled as a basis for new design guidelines.

3. Ecological Sanitation in Practice

Ecological sanitation offers flexible solutions that are used in high tech environments such as Volvo's Conference centre on the Swedish west coast, the slums of Bangalore India and to treat wastewater in mega cities in Asia and Australia. Below are some examples from the rapidly growing field of ecological sanitation.

China

China has a long tradition of effective management of natural resources. This includes reuse of garbage and human excreta in agriculture and aquaculture. The classical night soil system was reported to reuse as much as 90% in agriculture (13). Tradition therefore facilitates implementation of modern ecological sanitation in China.

In 1998 70 households in the rural areas of Guangxi, installed new urine diverting toilets and by the end of 2002 more than 100 000 households had similar toilets (14). This has paved the way for urban implementation in China (15).

The reuse in aquaculture of wastewater from large cities started in 1951 in Wuhan, reaching about 20 000 ha by the 1980's (16). The reuse of wastewater in aquaculture systems has been linked to traditional concepts of integrated farming and fish polycultures, which are seen as effective solutions to meet a growing pollution problem in watercourses (17). Irrigation with municipal wastewater reached about 1.5 million ha in 1995 covering around 1% of the total cultivated land of China (18). However wastewater irrigation poses potential health problems that are not always properly dealt with.

India

A toilet centre provides sanitary facilities for 600 – 800 slum dwellers (19). The urine is used as fertiliser after storage and the faecal matter is composted with wastepaper and garden waste and used for soil amendment. In addition to improving public health the toilet centre enhances the dignity of women through eliminating sexual harassment associated with the traditional practices of defecating in the open.

The toilet centre, which generates 200 t of urine and 100 t of faeces per year, produces 50 t of compost, which in turns yields 50 t of bananas. The project has created 8 new full-time jobs. The annual cost of the existing systems is approximately 10 USD per user.

Ecosan toiletcenter in Bangalore, India.

Wastewater fed aquaculture purifies water, produces food and provides green areas.

Wastewater aquaculture in Calcutta
The main sewers of Calcutta began functioning in 1875. In the 1930s sewage-fed fish farming started in the extensive pond system used for wastewater treatment. The fisheries developed into the largest single excreta-reuse aquaculture system in the world with around 7,000 ha in the 1940s, supplying the city markets with 10-12 tons of fish per day (14, 20). Today the Calcutta Wetlands using wastewater both in agriculture and in aquaculture covers an area of about 12,000 ha, known as the Waste Recycling Region (21). Wastewater-fed aquaculture systems like the Calcutta Wetlands represent controllable public health risks (22) . This is due to a combination of long retention times, high temperatures, high solar irradiance, high natural microbiological activity, and adequate personal hygiene and food handling.

Lessons learned from Calcutta are that the wastewater reuse system meets modern criteria of sustainable development of a mega-city in terms of:

- The Environment by providing low-cost wastewater treatment, storm-water drainage and a green area as a lung for the city
- Social and economic benefits, including employment for about 17,000 poor people and production of about 20 t of fish per day for the urban poor (23)
- Serving as a model to be replicated elsewhere in India and other countries
- Reducing environmental impacts of contamination from heavy metals from major industries, e.g. chromium from the tanneries in Calcutta (24)

Botswana

The villages of East and West Hanahai are located in Botswana's Kalahari Desert. On-site sanitation facilities allow the families to produce their own soil conditioner and fertiliser for their vegetable gardens (25). The toilet systems collect urine and faeces separately.

Villagers meeting discussing ecological sanitation

After a period of awareness raising, information sharing and mobilisation, which included meetings with the community chiefs and other events targeting all women and men in the villages, 20 families volunteered to pilot the concept of ecological sanitation. All of them selected urine diverting dry toilets, to provide privacy and comfort.

South Africa

After a successful pilot project involving 12 families, a new medium-income housing area for 3000 inhabitants in Kimberly will be equipped with ecological sanitation systems (26).

∞ Urine is collected and will be used by the forestry department as fertiliser for silviculture

∞ Faecal matter is collected regularly for composting

∞ Greywater is treated in soak pits and then drains to a wetland.

Australia

In Melbourne, the Werribee wastewater system was opened in 1897. Half of the wastewater from the 4 million citizens is used for irrigation of pasture fields for cattle and sheep. The public water company Melbourne Water manages 54% of its wastewater in 11,000 ha of ponds, wetlands and meadows, i.e., 500,000 cubic metres of wastewater per day. The present livestock graze on 3,700 ha of pastures irrigated with raw or sedimented sewage and 3,500 ha non-irrigated pastures. The livestock yield a substantial return of about 3 million Australian dollars per year, which significantly reduces the cost of sewage treatment. (27).

Sweden

In the Swedish capital of Stockholm, urine diversion is used in several urban housing areas, e.g. Palsternackan (50 apartments), Understenshöjden, (44 apartments), Gebers (30 apartments) and the newest Kullan (250 apartments). These are all family homes and show that people easily adapt to the new system (8).

Bokenäs, Volvos conference centre has source separation and biogas-production

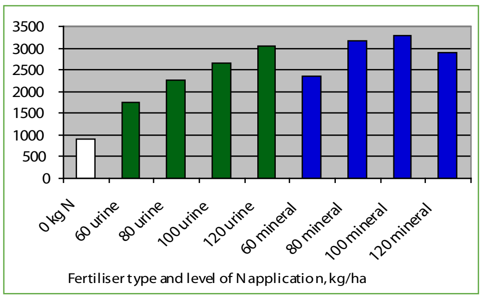
On the Swedish west coast Volvo has established a new conference centre (28) for 500 people where blackwater and organic household waste are used for biogas production and the greywater is treated in a natural system.

In several Swedish cities nitrogen reducing wetlands are cost efficient ways to meet increased water quality demands.

Greywater treatment using a biofilter and constructed wetland for 100 persons in Oslo, the capital of Norway. The effluent meets the current European swimming water standard with respect to indicator bacteria.

Germany

In Lübeck the condominiums at Flintenbreite (117 apartments) are served by vacuum toilets. Household waste is ground and added to the blackwater prior to anaerobic digestion. Greywater is treated onsite in a planted filter bed (30). In Germany compact mechanical greywater treatment systems for urban use are commercially available.



Crop yields are similar for equal amounts of nitrogen derived from urine and mineral fertiliser (29).

Norway

In Bergen, Norway's second largest city, 42 condominiums collect blackwater using 1-liter flush vacuum toilets and have onsite greywater treatment. In Ås 24 student flats (48 students) have an identical system (7).

Liquid composting provides a sanitised mixture of organic household waste and blackwater. Injecting the liquid fertiliser hydraulically into soil provides equal yields to mineral fertiliser (32).

When the blackwater is removed, the remaining greywater meets drinking water standards with respect to nitrogen, swimming water standards with respect to bacteria, and is discharged to the stormwater drain. The greywater treatment systems are compact (1-2 sq. m per person) and can be landscaped (31).

4. Culture, Gender and Poverty

Cultural aspects define important boundary conditions for the implementation of ecological sanitation. It is crucial to develop sanitation systems together with the system users and emphasise gender issues.

Excrement naturally repels people. 'Natural' in the sense that the repulsion is an involuntary reaction. The reason is as much evolutionary as cultural. In the course of human evolution, those unfortunate to come in contact with excreta were exposed to a plethora of pathogens, and consequently less likely to survive than those who did not come into contact with excreta. Therefore, some assume that man's instinctive repulsion is genetic in nature.

Despite our instinctive repulsion towards excreta, culture influences our attitudes towards handling (33). Religions vary considerably in addressing excreta. In the Bible, the act of elimination is mentioned only once, and it does not address the subject of using excreta for agricultural purposes.

The Koran, however, prescribes strict procedures to limit contact with faecal material, including its use in agriculture, because excrement is considered impure.

The principal Hindu text that details the code of conduct for rituals, the Artha Veda, clearly specifies the use of water for personal hygiene. But nowhere do we find excrement included more in a religious context than in Buddhism. An integral dimension of Buddhism is reincarnation, which promotes the harmonious concept of recycling life's treasures; it is therefore not surprising that Buddhist cultures treat earthly resources similarly.

The Gender Approach

Gender refers to the specific roles and responsibilities adopted by women and men in any society. It is related to how we are perceived and expected to think and act as women and men, because of the way society is organised, not because of our biological differences. A gender approach implies that attitudes, roles and responsibilities of men and women are taken into account. It requires an open mindedness and aims at the fullest possible participation of both women and men.

When introducing ecological sanitation it is important to train the whole family so that the responsibility of operation will not be a burden only to the women.

How does ecological sanitation contribute to a new understanding of gender roles? Both men and women are producers of waste, contaminating the water and the soil. It is significant that the ecosan toilet can improve health, generate fertiliser, and consequently increase family income. Both the sanitation and the agricultural aspect can increase women's power to control their own lives. Instead of a producer of waste, she becomes a producer of resources, which can benefit herself and her family.

Ecological sanitation – by Dr. Ken Gnanakan:

The poor are the ones who suffer both because of their own “sins” and the “sins” of others. Not only do they face the pollution of their own defecation, but often have to live beside water bodies that have been released from urban sewers. Access to clean water and proper sanitation is therefore a necessary precursor to development. Lack of clean water and adequate sanitation contribute to people remaining in the poverty trap. Some 1.1 billion people – one sixth of the world’s population – do not have access to safe water and 2,4 billion lack basic sanitation.

Water and sanitation are major factors in the health status of populations. Conventional toilets have been guilty of converting massive quantities of clean water into ‘blackwater’. In developing countries 90 % of this sewage is flushed into surface waters, polluting rivers, lakes and coastal areas. This has contributed to the spread of disease mainly amongst the poor.

A basic issue in poverty is that of identity and dignity. The poor often lack identity as humans, and therefore lose their dignity. Water and sanitation are factors that highlight this indignity even more. While the rich can be identified with their bottles of mineral water, the poor must be content with polluted water from any source, mostly contaminated by the rich. Most houses will have no direct water supply. Women have to line up for a bucket full of water. Present unsheltered defaecation options leave women exposed with a sense of shame Poverty in India is also a caste issue. The lower the caste, generally, the poorer. Hence these are confined to undignified jobs like handling the sewage of the rich; even drinking their wastewater. “Night-soil” or sewage carrying was the job of the lowest caste condemned to such occupations. Women’s role in decision-making in all ecological sanitation projects must be increased. Women should be shown to be equal partners with men in the community. Further, involving both women and men in ecological sanitation initiatives can increase project effectiveness. This is mainly because women normally take on more social responsibility than men. Men tend not to be committed to such initiatives.

Water, health, sanitation, agricultural and nutritional aspects have to be integrated. Ecological sanitation propagates recycling principles in a very powerful way. The implementation of a material-flow-oriented recycling process as a holistic alternative to conventional solutions is the key to such practices. The poor, as well as the rich, will be able to observe the wider ecological issues as they focus attention on this basic problem.

5. Health aspects
– A SYSTEMS VIEW

The introduction of a new sanitation approach needs to demonstrate that the general requirement of reducing the potential for disease transmission is feasible and valid.

The most important criterion of ecological sanitation, as for all sanitation approaches, is that the system forms a barrier against the spread of diseases caused by pathogens in human excreta. This is also one of the basic aims in conventional "flush and discharge" or "drop and store" sanitation systems which have well-known drawbacks in downstream or groundwater contamination, eutrophication, and long-term destruction of freshwater ecosystems, coastal areas and loss of plant nutrients.

Ecological sanitation implies separate, often dry, handling of the faecal matter, with the objective to recycle the resources contained in it back to agriculture. By not introducing human waste into the water cycle, contamination of superficial and ground water bodies can be avoided. From a public health point of view, this is an important achievement. Ecological sanitation faces specific challenges to counteract pathogen transmission in the handling of the material and in the use of the "products" on agricultural land for food production. The system should be efficient both when it is introduced, and in the long run.

With dry handling of the faeces as in some ecological sanitation systems, the primary treatment has moved to the household installation instead of being part of a centralised system. This is a fundamental difference from a barrier perspective. To ensure the necessary safety against pathogen transmission it is essential to have simple installation, handling and management guidelines. For this reason WHO is currently planning the publication of guidelines for the safe use of excreta and greywater in agriculture, which will provide a reliable basis for planning ecological sanitation projects

International research on pathogen destruction in sanitation systems show that the dry sanitation systems may give an equal or higher reduction of pathogens than conventional systems and a high reduction in the subsequent risk of exposure (34). Low flush gravity or vacuum toilet systems, with or without urine separation, provide as good hygiene as traditional water toilets, but facilitate local collection and subsequent fertiliser and energy (biogas) production. Management routines that ensure acceptable risk reduction exist.

For large systems, urine storage regulations even in a cold climate give high level protection prior to agricultural application on all crops (9). Similarly the treatment of the faecal fraction either dry or anaerobically (biogas reactor) or aerobically (liquid composting) can provide pathogen reduction in compliance with existing regulations for application to agricultural land. The soil also acts as a barrier with further pathogen reduction. Greywater has been perceived as relatively free of pathogens but the indicator

Slum dwellers defecate into open sewers and play along open sewers.

bacteria, that some guidelines are based on, may multiply (35). These, therefore, overestimate the faecal load and associated risks of greywater use (35). Viral contamination may pose a potential risk and their reduction to acceptable risk levels has been calculated, dependent on the type of greywater discharge (35). A 3-log reduction, as suggested, with respect to bacteria can be obtained by simple treatment systems (31, 36).

Ecological sanitation has a large potential impact in the reduction of risks in poor countries. The health risks linked to poor sanitation severely affects the ability of families to improve their livelihoods. Ecological sanitation will reduce health risks, improve access to water and make it possible to recycle nutrients back into agriculture. This represents an important contribution to poverty reduction. Wastewater recirculation and reuse on agricultural land has recently been largely practiced in many developing regions. Although nutrients are also reused here, a much larger potential threat exists (both through direct contact for the farmers and due to industrial pollution) than when source-separation and reuse is practiced. The reuse of wastewater will also continue to develop, but there is a need to include other options than conventional wastewater treatment, to minimise the negative impacts both on health and the environment of untreated wastewater irrigation (37, 38).

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A Thinkpiece on ecological sanitation

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