CLOSING THE LOOP

Ecological sanitation for food security

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Ecological sanitation for food security

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Díaz, the Primary School of Santiago Tepetlapa, CITA and CEDICAR for generously opening their homes, institutions and projects, allowing for such stimulating field visits in the state of Morelos and Mexico City. Our special prayers and appreciation also go to the monks from the Benedictine Monastery in Cuernavaca, who graciously hosted the workshop. They provided a serene and scenic environment, which most certainly contributed to the spirit of learning, co-operation and constructive dialogue.

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FOREWORD

Concerted efforts have been made in the past twenty years to provide adequate sanitation, latrines and sewers, to people to dispose of their excreta. Despite these efforts, almost three billion people –half of humanity– are without these services. Lack of these services is a major cause of suffering and death for millions of children and their families. Many of those with "adequate" excreta disposal services are not aware of the pollution generated by these systems nor of the resources wasted by them.

Ecological sanitation offers an alternative to conventional sanitation, and it attempts to solve some of society's most pressing problems: infectious disease, environmental degradation and pollution, and the need to recover and recycle nutrients for plant growth. In doing so, ecological sanitation helps to restore soil fertility, conserve freshwater and protect marine environments –which are sources of water, food and medicinal products for people.

Ecological sanitation is different from conventional approaches in the way people think about and act upon human excreta. First, those promoting and using ecological sanitation take an ecosystem approach to the problem of human excreta. Urine and faeces are considered valuable resources, with distinct qualities, that are needed to restore soil fertility and increase food production. Thus, sanitation systems should be designed to mimic ecosystems in that the "waste" of humans is a resource for microorganisms that help produce plants and food. Second, ecological sanitation is an approach that destroys pathogens near where people excrete them. This makes reuse of excreta safer and easier than treatment of wastewater that often fails to capture the nutrients it transports to downstream communities. Third, ecological sanitation does not use water, or very little water, and is therefore a viable alternative in water scarce areas. Fourth, ecological sanitation can provide hygienic and convenient services at a much lower cost than conventional sanitation, and therefore, should be considered both in developing and developed countries.

Ecological sanitation is a system that encourages local initiatives and local leadership, from workshops that sell the toilets, to home gardens that produce food. Important advances in ecological sanitation have occurred over the past two years since the book on Ecological Sanitation was published. The workshop publication, on which this book is based, captures many of those important advances, particularly the experience and advances in designing ecological toilets, reuse of excreta and prospects for urban agriculture and food security. The south-to-south exchange of experiences depended on experts in sanitation, public health, agriculture, nutrition and participatory development to address the ecosystem approach - closing the loop to food security.

We hope the present publication will inspire UNDP and Sida funded projects and programmes as well as other development interventions, to consider ecological sanitation in all water and sanitation activities.

New York and Stockholm, October 2000

Roberto Lenton
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EXECUTIVE SUMMARY

An international, interdisciplinary workshop held in Cuernavaca, Mexico from 17-21 October 1999 brought together professionals in the areas of alternative sanitation, public health, nutrition and agriculture from countries in Latin America, Africa, Asia, North America and Europe.

Ecological sanitation represents a shift in thinking about and acting upon human excreta.

The outcome of the workshop represents a shift in the way people think about and act upon human excreta. A different paradigm, based on an **ecosystem approach**, is evolving. Nutrients and organic matter in human excreta are considered a resource —food for a healthy ecology of beneficial soil organisms that produce food or other benefits for people. Sanitation practitioners must link with others in public health, agriculture and nutrition to close the nutrient loop in a safe, non-polluting way. What is perceived as human waste must be managed in the future as an important resource to be recovered and recycled.

Human excreta are a resource, not a waste.

In the alternative approach to sanitation **—ecological sanitation—** excreta are processed on site, and if so required off site, until completely free from pathogens and inoffensive. The faeces are sanitised (composted or dehydrated) close to the place of excretion, and the composted organic matter is applied to the soil to improve its structure, water-holding capacity and fertility. Valuable nutrients contained in excreta, mostly in urine, are returned to the soil for healthy plant growth.

Ecological sanitation is a "closed loop" approach preventing pollution by recycling nutrients and organic matter.

It is a different way of thinking: a **"closed-loop-approach"** to sanitation, in which the nutrients in excreta are returned to soil instead of water or deep pits. Ecological sanitation is not merely a new latrine design. The closed-loop approach is also a zero-discharge approach, keeping fresh and marine water bodies free of pathogens and nutrients.

Ecological sanitation is applicable in the North and the South, for rural and urban areas, and for rich and poor alike.

Ecological sanitation is applicable: in the North and the South, for rural and urban areas, and for rich and poor alike.

Workshop participants presented experiences in ecological sanitation from a variety of physical and socioeconomic environments such as Mexico, Zimbabwe, China and Sweden. It was clearly demonstrated that, if applied properly, the approach can be culturally and socially acceptable, even though cultural resistance to handling and using human excreta must be addressed. At the same time there is a definite need for further research, development and adaptation of technical issues in different cultural settings; a better understanding of economic and financial issues; as well as better social marketing and hygiene education.

Very little water —if any— is used in ecological sanitation.

In ecological sanitation systems no water, or very little water, is required. It is thus very appropriate for areas with water shortages or irregular water supplies. It is a decentralised system, based on household and community management, and the need to invest in large-scale infrastructure and operate centralised institutions is drastically reduced. Fewer sewers and deep pit latrines will reduce the risk of pollution of ground and surface water.

An important finding from the workshop is that ecological sanitation is highly relevant in the contexts of both urban agriculture and poverty reduction. Households can improve the productivity of their gardens, reduce food costs, grow fruits and vegetables nearby for their own consumption, and improve the nutritional status of children and their parents.

A brief introduction by Ingvar Andersson introduced the workshop and the ecosystem approach. The section on toilet design is based on a presentation by Peter Morgan, and discussions centred around working group deliberations and field visits. Because the goals of ecological sanitation are different than those from conventional approaches, an ecological toilet will not only look different, it will also function differently than conventional toilets. Experiences from Mexico and

The report presents deliberations from an international, interdisciplinary workshop.

Zimbabwe are highlighted. A presentation by Thor-Axel Stenström offered data from different parts of the world on pathogen destruction, as well as general issues about measuring the safety of this approach. The basic products, urine and faeces, were discussed from different points of view: safe management, resource value and the benefits of recycling. The connection of ecological sanitation to urban agriculture and food security is based on presentations by Jac Smit and Steve Esrey, both of whom showed data from several parts of the world and highlighted key statistics around these issues. Finally, the report presents deliberations of the participants on how to promote the concept of an ecosystem approach at the global, regional and Mexican levels, as well as how to put it into practice.

INTRODUCTION

An international, interdisciplinary workshop held in Cuernavaca, Mexico from 17-21 October 1999 brought together professionals in the areas of alternative sanitation, public health, nutrition and agriculture from countries in Latin America, Africa, Asia, North America and Europe.

The purpose of the workshop was to increase the understanding of how to develop more sustainable sanitation systems, particularly in urban/peri-urban contexts, while contributing to food production and improved nutrition. More specifically the objectives were to:

The purpose of the workshop was to increase the understanding of how to develop more sustainable sanitation systems.

- generate greater awareness and understanding of, and appreciation for, an ecosystem approach that links sanitation, agriculture, nutrition and health;
- foster these interdisciplinary relationships among participants;
- identify knowledge gaps in establishing an ecosystem approach to sanitation with links to food security, and the means to fill these gaps; and
- formulate concrete strategies for fostering an integrated ecosystem approach to sanitation, particularly in Latin America.

Participants included experts in sanitation, public health, urban agriculture and nutrition.

The interdisciplinary group of participants worked together to advance an integrated and safe approach to sanitation. An informal, participatory approach facilitated learning, and this was complemented with a dynamic mix of formal presentations, group discussions, plenary presentations and field visits. The participants included resource people with field experience in ecological and conventional sanitation, public health experts, urban agriculture experts, nutritionists, and members of the academic research community concerned with health and agriculture applied to the use of ecological sanitation products for food production. Partners from governments, NGOs and bilateral and multilateral agencies also participated.

A special focus was given to experiences in Mexico and Zimbabwe.

Cuernavaca was chosen as the venue in order to learn from the rich experience with ecological sanitation in Mexico. The workshop also provided access to relevant experiences with alternative sanitation, reuse and composting of human excreta, and urban agriculture in other regions of the world. In particular, participants from Zimbabwe shared their experiences with professionals in Latin America. The development of ecological sanitation in Zimbabwe covers many interesting aspects of an ecosystem approach to sanitation. Other contributions covered a number of relevant aspects of creating a circular flow of nutrients: designs for various toilets, health aspects, reuse, urban agriculture and nutrition.

The workshop was organised through an initiative from the United Nations Development Programme (UNDP), and supported by the Swedish International Development Cooperation Agency (Sida), the United Nation's Children's Fund (UNICEF), the Pan American Health Organisation (PAHO), the Thrasher Research Foundation, the World Bank Water and Sanitation Program, and UNDP's Country Office in Mexico. *SARAR Transformación*, an international NGO based in Mexico, was responsible for managing and facilitating the workshop.

This is a report of the workshop's major deliberations.

Closing the loop

Half of humanity lacks sanitation, and as a result every year between two and three million people die.

About three billion people —half of humanity— lack safe sanitation. Within 20 years it is expected that an additional two billion people, living mainly in towns and cities in developing countries, will be demanding sanitation. Every year between two and three million people die because of inadequate sanitation, insufficient hygiene, and contaminated food and water. A contaminated environment places people at obvious risk of exposure to pathogens, harmful organisms that lead to infection and disease. Those most affected are poor people —children, women and men living on marginal rural land and in urban slums— in an environment contaminated with pathogens. Poor people are victims caught in a vicious circle —a "pathogen" cycle— in which offenders and victims live, *The most affected are children and poor people living in contaminated environments.*

work and play in close proximity to each other. The rich can export their excreta through sewers, polluting the environment, and exposing and infecting those living downstream. Pit latrines may leak or the contents may spread during floods, placing others at risk of infection and disease (*Fig. 1*).

To break out of the vicious cycle of infection and reinfection, we must address the causes of the problem and take preventive measures to break the pathogen cycle. There is a need for safe management of excreta and quick destruction of pathogens before excreta enter the environment. In short, a different approach to sanitation is urgently needed.

The current situation is a fundamental denial of human dignity, and the need for action is urgent. This is why UNDP, UNICEF, bilateral agencies and NGOs have water, sanitation and hygiene education on their agendas.

But a major and very basic question must be raised: *Have we been doing the right things*?

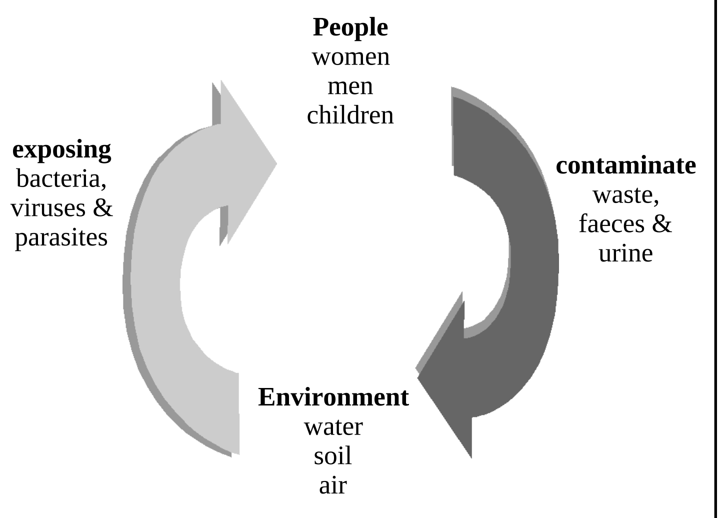


Figure 1:
People contaminate the environment and are infected by it.

Linear flows

"Flush-and-discharge" and "drop-and-store".

Water-based sewage models were designed on the premise that human excreta are a waste suitable only for disposal.

Conventional sewage solutions based on the flush-toilet —the "flush-and-discharge" model— have been successful in disposing of excreta for the few who have access to a regularly functioning flush toilet. The water-based sewage models were designed and built on the premise that human excreta are a waste suitable only for disposal, and that the natural environment is capable of assimilating this waste. Yet these models have failed to solve the sanitation needs for developing countries. Annual investments for "modern" water and sewer systems have been estimated to be $30 billion, and by 2025 it may cost $75 billion.[1] This excludes the cost of maintenance. It would cost $150-215 billion to achieve full compliance for sewage by 2010 in the European Union, and in the United States pollution control over the next 20 years may cost $325 billion, with $200 billion for treating sanitary sewer overflows. This is unaffordable for poor countries. In addition, a regular supply of water is required for flushing. In water-stressed countries facing scarcity of other resources, it is ill-advised to use 15,000 litres of treated and safe drinking water per person every year to flush away an annual per capita output of 35 kilograms of faeces and 500 litres of urine. Over 90% of the sewage in developing countries is discharged untreated into surface waters, polluting rivers, lakes and coastal areas, and thus causing the spread of so-called "waterborne" diseases (*Fig. 2*).

It is ill-advised to use treated, safe drinking water to flush away human excreta.

"flush and discharge"

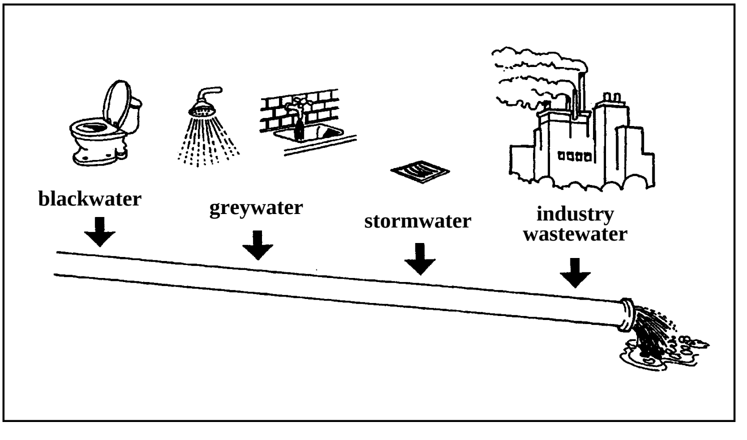


Figure 2:
Small amounts of dangerous materials pollute huge amounts of water

Groundwater can be contaminated with pathogens and nutrients from pit latrines.

"drop and store"

The conventional solution for poor people in developing countries is the pit latrine —the **"drop-and-store"** model— that also has its shortcomings, especially in densely populated areas where space is limited. It cannot be used in areas with impenetrable ground, high water tables, nor where flooding is a problem. There is an obvious risk that groundwater will be contaminated with pathogens from pit latrines, threatening the drinking water supply. Furthermore, certain disease vectors breed in humid pits, causing diseases such as filariasis, yellow fever and arboviruses.[2] Research has also found evidence of increased nitrate levels in ground water caused by leakage from pit latrines.[3] And as with other sanitation solutions that are not properly constructed and managed, pit latrines are disdained because of smells and flies.

It must be clearly recognised, however, that successful sanitation programmes have saved lives and reduced disease.[4] When conventional sanitation has been combined with improved water supply and hygiene education, millions of lives have been saved in rural and peri-urban communities in Africa, Asia and Latin America.[5]

But disposal solutions lead to other problems. When excreta are disposed of, nutrients and organic matter are wasted. Therefore, there is a linear and massive flow of nutrients in the form of agricultural products from rural areas to the cities, and a massive flow of nutrients, in the form of excreta and other organic matter, to water or deep pits. Because excreta are regarded as a waste, nutrients are not recycled and dedicated to productive uses on land.

Linear solutions have contributed to water pollution, scarcity of water, soil infertility, and food insecurity.

The above "linear" solutions based on "flush-and-discharge" and "drop-and-store" concepts have solved some problems, but they have also contributed to many other problems faced by society today: water pollution, scarcity of water, destruction and loss of soil fertility, and lack of food security. The continuing decline of soil fertility is of growing concern, and even conservative agronomists agree that current farming methods are not sustainable.

It is impossible to solve non-linear problems with linear solutions. As Einstein once said, we cannot solve problems with the same kind of thinking that created them.

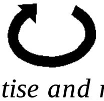
A circular flow

Nutrients from food to people to food.

Ecological sanitation is a safe approach to recovering nutrients from human excreta.

Sanitation needs to be rethought because human excreta contain valuable resources for food production. The concept of ecological sanitation has evolved from this premise. Ecological sanitation is a safe approach to recovering nutrients from human excreta, recycling them back into the environment and into productive systems (Fig. 3).

Until recently, the reuse of human excreta as a fertiliser was the norm in most cultures and societies, and it was an established practice in Europe and the United States earlier this century. What might be considered new is to view urine and faeces separately as two components with different characteristics in terms of pathogens, nutrient content and benefits to soil and plants. Faeces contain basically all the pathogens,



"sanitise and reuse"

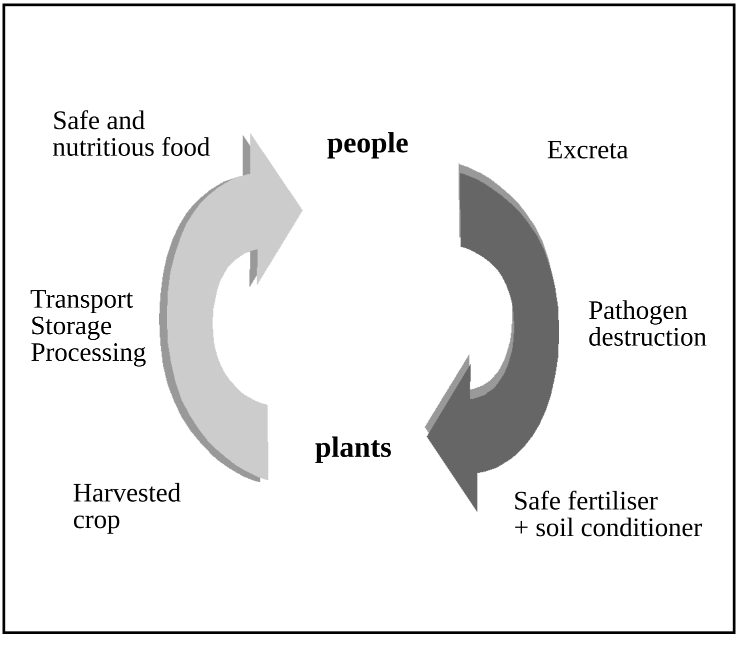


Figure 3:
The ecosystem loop:
excreta food

while urine has up to 80% of the fertiliser value, in terms of important plant nutrients (N/P/K –nitrogen, potasium and phosphate). By using a “don’t mix” approach, different solutions to old problems can be developed.

It represents a different solution to old problems.

Most ecological toilets foster the production of two separate products, urine and a dry soil conditioner comprised of dried faeces and other compost materials. These can be recovered and recycled, returning nutrients to the soil, thus supporting and improving food production and food security.

Ecological Sanitation can be defined as a system that:

- *Prevents disease and promotes health*
- *Protects the environment and conserves water*
- *Recovers and recycles nutrients and organic matter*

DESIGNING ECOLOGICAL TOILETS

Ecological sanitation represents a different approach —an ecosystem approach— to sanitation. An ecosystem approach prevents disease by destroying pathogens before excreta are returned to the terrestrial environment, and it recovers and recycles plant nutrients and organic matter, thus closing the nutrient loop. Ecological toilets are designed with these goals in mind. Plus, little or no water enters the ecological toilet, so water is conserved and pollution is prevented. In addition, excreta are not discharged or buried in deep pits. These characteristics facilitate the prevention of disease, a reduction in water usage and pollution, and the recovery and recycling of plant nutrients. All of this makes the ecological toilet an important part of the ecosystem approach, or closed-loop system.

Conventional toilets are designed to dispose of excreta, flushing them away in water or burying them in deep pits.

The design of toilets is a critical aspect of ecological sanitation. Conventional toilets are designed to dispose of excreta. The easiest way to do this is to combine urine and faeces and flush them away in water or bury them in deep pits. Attempts to retrofit existing toilets only make the problem more expensive and the consequences usually don't go away. Retrofitting, (or end-of-pipe solutions,) makes it difficult and costly to sanitise excreta, recover nutrients and prevent pollution. In order to achieve the goals of ecological sanitation, new designs are needed.

Ecological toilets should prevent disease and conserve water while recovering and recycling nutrients.

For the remainder of this report, we use the term ecological toilet, or toilet, to refer to the entire structure illustrated in Figure 4. We use the term toilet because of its function, not its appearance. All ecological toilets should be designed to prevent disease (see section on Ecological Sanitation and Health), recover and recycle nutrients (see section on Recovery and Recycling of Human Excreta) and reduce the need for, as well as, the contamination of, water.

Each toilet is compromised of at least three minimum components: a pedestal or squatting pan, a slab and a chamber, plus

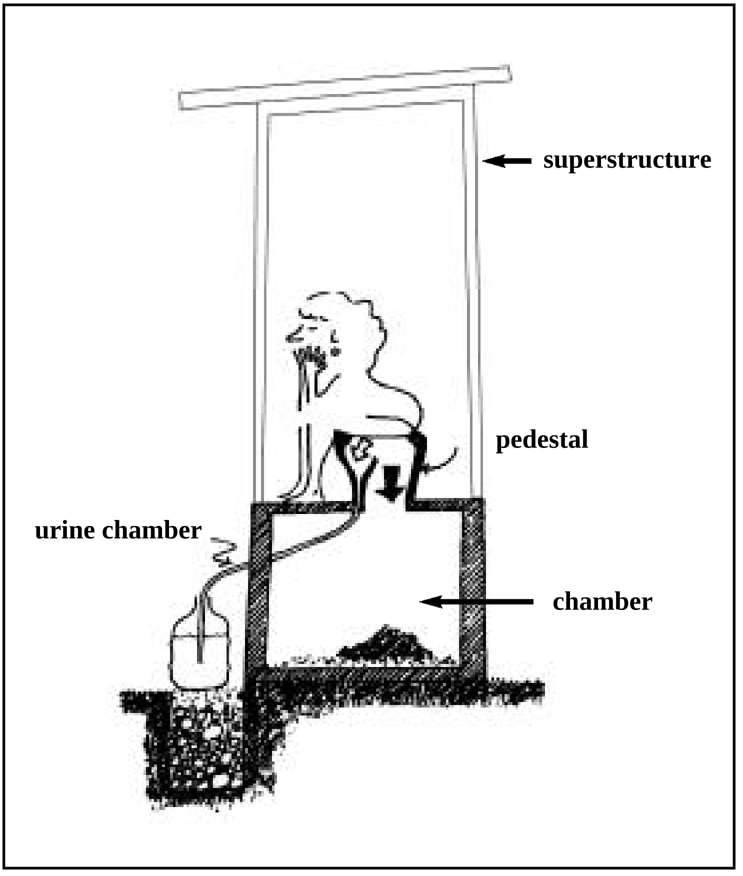


Figure 4:
Ecological toilets are comprised of several components.

sometimes a superstructure (Fig. 4). These components may be separate from each other or permanently attached to one another. The chamber is below the slab, and this is where excreta, or urine and faeces separately, are captured and stored. There may be one or two chambers, they may be above or below ground, and they may be portable or fixed in place. If a toilet is installed in the home, it may be entirely above the floor. The superstructure is above the slab, and it may be elaborate with permanent walls in a house, simple with thatched walls and without a roof, or anything in between. A screened ventilation pipe may also be used. In urine-diverting toilets, a separate urinal may be installed, in which case urine may be collected in a separate chamber or piped away from the toilet.

Ecological toilets should also be designed to facilitate the destruction of pathogens.

Urine-diverting toilets sanitise faeces through desiccation, increasing pH or elevating temperatures.

A variety of ecological toilets are currently in use and mostly distinguishable as either urine-diverting or non-urine-diverting. Urine-diverting toilets (*Fig. 5*) may sanitise faeces through one or more different processes: desiccation, increasing pH or elevating temperatures. Non-urine-diverting toilets rely on "moist" processes, such as composting or co-composting of human excreta. The ecological toilet can be the place where excreta receive a primary treatment. Additional treatment may occur outside the chamber off-site.

While such ecological sanitation approaches work in fundamentally different ways, they fulfil the common goals of safely treating human excreta, conserving water, recycling nutrients, and minimising adverse environmental impact. All approach-

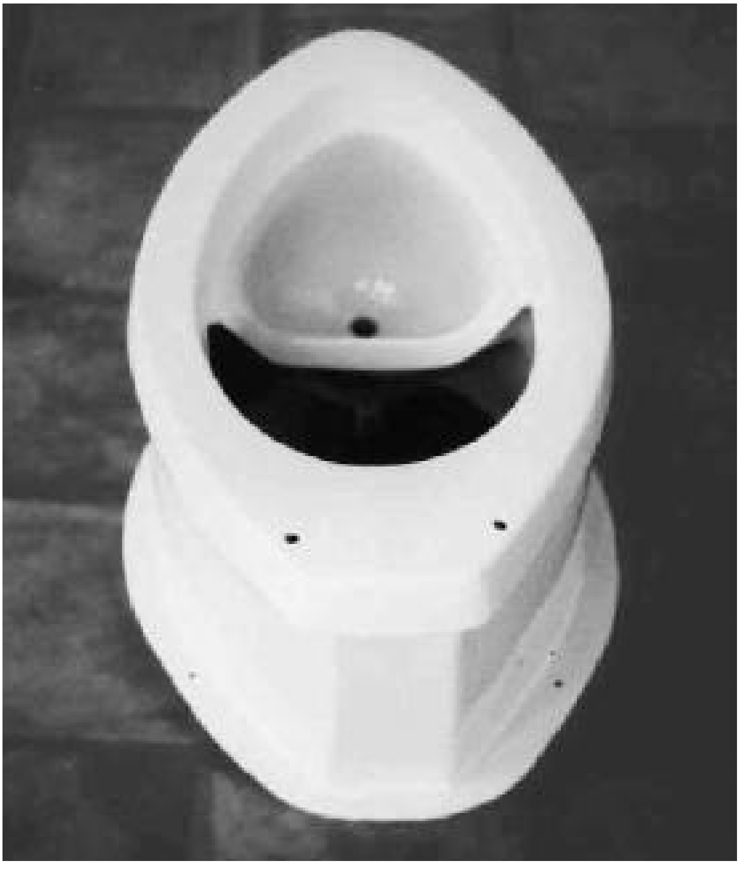


Figure 5: Urine-diverting pedestal made from fibreglass

es to specific designs need to be flexible, affordable, consider local conditions and customs, take into account socioeconomic and other conditions, and designed according to urban and rural differences.

In urine-diverting toilets, urine is collected, diluted and used as a plant fertiliser.

The most commonly used ecological toilet is urine-diverting. Urine is diverted away from faeces via a specially designed pedestal. Urinals can be installed separately. Urine is collected, diluted with water, and used as a plant fertiliser without further treatment. Urine is usually sterile, with special exceptions (see section on Ecological Sanitation and Health). Faeces are sanitised in the collection chamber of the toilet through drying and the addition of lime, soil, wood ash or other material after each use. Lime raises the pH, which may accelerate pathogen destruction. There are usually two alternating faecal chambers, one active and one for storage. Whereas urine can be used immediately or after limited storage time as a safe plant fertiliser for food and non-food crops, faeces are safe only after processing and/or storing them for at least several months after the first chamber is full and taken out of use. This will secure pathogen destruction (see section on Ecological Sanitation and Health).

In composting toilets, which involve moist processes, an appropriate moisture level and internal airflow must be maintained.

Composting toilets are another ecological approach that enables the return of plant nutrients back to the land. Typically, composting toilets do not divert urine, but they may work better if they did. An appropriate moisture level and airflow must be maintained in the defecation chamber to enhance optimal degradation of human excreta. The product —in the form of humus— can be returned to soil to enhance gardens and food production (see section on Ecological Sanitation and Food Security). This closes the nutrient and organic loops.

Ecological sanitation approaches are being used in diverse sociocultural contexts in many countries and regions of the world – such as India, China, Vietnam, Mexico, Central and South America (Bolivia, Chile, Ecuador and Peru), and Eastern and Southern Africa (Ethiopia, Kenya, Mozambique and South Africa). Ecological toilets are built into Swedish

Ecological toilets can be incorporated into a typical middle-class family bathroom.

Figure 6: Urine-diverting toilet in a Mexican home

homes according to the expectations for contemporary bathroom design. They are also built into homes in Mexico (Fig. 6), India, El Salvador and China.

Ecological sanitation in Mexico

Dried faeces are stored in the chamber for at least six months.

The Mexican model of the urine-diverting toilet represents a modification of the Vietnamese double vault toilet. The urine is diverted and can be used as a liquid fertiliser (approximately 1:5 to 1:10 dilution with water). The faeces are sanitised through drying and the addition of lime to raise the pH above 9.0. The dried faeces are stored for at least six months before the chamber is emptied. The dried faeces product is either post-treated through co-composting with other organic materials or added directly as a soil conditioner. Studies are under way to further investigate pathogen destruction, which appears to be complete after the storage and processing described here.

The main motivations in Mexico for using ecological toilets are limited water availability and non-functional or non-existent sewage treatment.

Urine-diverting toilets in Mexico are manufactured in either concrete or fibreglass by César Añorve in a family-owned workshop or in other shops in which owners have been trained and equipped by César (Fig. 7). The price of the toilet pedestal includes follow-up and advice on the correct use of the toilet including the proper preparation and application of ashes or lime and soil. The same moulds have been exported to South Africa, Uganda and Zimbabwe where they are now mass-produced with only small modifications.

The main motivations in Mexico for using the urine-diverting *sanitario seco* or dry toilet are limited water availability and non-functional WCs. Other motivations, such as protecting

Figure 7: Family owned urine diverting manufacturing shop

the environment and using the products for fertiliser and in urban agriculture, are at present only limited.

First field visits in Mexico

Workshop participants visited three separate sites in the state of Morelos in order to receive a quick overview and insight into the development of the dry toilet "movement" in Mexico:

Ecological toilets exist in homes and schools.

- At César Añorve's home participants were able to see a functioning dry toilet incorporated into a typical middle-class family tiled bathroom together with a washbasin and bath. In addition, in the small workshop adjacent to his house, César gave an overview of the history and evolution of the urine-diverting dry toilet system in Mexico, and a demonstration of the design and construction process of the attractive urine-diverting toilet pedestals from a fibreglass mould.

- In the nearby Municipality of Tepoztlán, participants visited a primary school where two local NGOs, CITA and Luna Nueva (New Moon), have collaborated with the Ministry of Education in a special project to construct demonstration dry toilets for primary school teachers (Fig. 8). The toilet construction project, which usually includes a ferro-cement water catchment tank and organic vegetable gardens, is a central part of a strategy to familiarise communities with alternative, ecologically friendly technologies. Convinced of the benefits of the demonstration dry toilet units, local families have begun to replicate them in their own homes, as a viable response to the acute seasonal water scarcity.

Some people have converted from conventional to ecological toilets.

- Finally, participants visited the home of Feodora Stancioff de Rosenzweig-Diaz, who has added a urine-diverting system to her home, as well as in two rental cottages. Feodora's experience is illustrative. She and her husband, the first "outsiders" to settle in the village of Santiago Tepetlapa more than 40 years ago, were also the first to install a flush toilet —a system that was gradually copied

Figure 8:
School teachers' toilet in Mexico

by many of the local residents. Concerned by the water scarcity and environmental degradation that has resulted, she was again the first to install a dry system and has been an active promoter of ecological sanitation. The local mason, who installed the toilets, has become an important resource in the area.

In Mexico a movement promoting ecological sanitation has been driven by the needs of the civil society.

Participants came away stimulated and motivated by the visits. It was noted that the Mexican experience has been essentially a "spontaneous," grassroots phenomenon driven more by the needs and initiatives of civil society, than by top-down externally funded programs. On the one hand, the lack of strict application of outmoded and unsustainable regulatory structures has created a vacuum, and NGOs with popular support have been able to make gradual but progressive inroads. There is also clear evidence that where government has become involved with massive supply driven programs, there have been disastrous consequences, poor acceptance rates, and ultimately, abandonment of the toilets.

The Vietnamese dry toilet model was adapted to Mexico and Central America, and, more recently, transferred to southern Africa.

The particular people and their reasons for using dry toilets also impressed participants. In general, users have been driven by the lack of adequate water supply and, in many cases, the environmental consequences of non-existent or inadequate sewerage and treatment facilities. It is significant that in many cases it has been the middle-class families that have opted for alternative systems, spurred on by growing environmental awareness. Rarely, however, has the potential of reusing the by-products of the ecological toilets been an important motivating factor.

Finally, Mexico stands in the middle of a South-South technology exchange process that began with the transfer and adaptation of the Vietnamese dry toilet model to Mexico and Central America (e.g. Guatemala and El Salvador); and, more recently, from Mexico to the southern part of Africa, including Zimbabwe.

Ecological sanitation in Zimbabwe

Ecological sanitation in Zimbabwe has included transforming human excreta into humus for use in agriculture.

Ecological sanitation was introduced several years ago in Zimbabwe. All ecological sanitation approaches in Zimbabwe are based on the following premises: providing a means to remove human excreta safely and simply from the toilet; preparing human excreta for use in agriculture by encouraging the formation of humus; and reducing the pollution of groundwater and atmosphere as much as possible.

There are four basic types of toilet systems used to promote the principles of ecological sanitation in Zimbabwe. They are the Modified Blair latrine, the ArborLoo, the Fossa Alterna, and a series of toilets using a urine-diverting pedestal. A description of each is provided below, and its uses and obstacles are highlighted.

Composting toilets[6]

Modified Blair toilet: Modified Blair (VIP) compost toilets have underground chambers that are more shallow and elongated than in the conventional Blair latrine, which has 3 m deep pits. The shape of the chamber allows the contents to be more easily removed and recycled. Most have double chambers that are used alternately. Frequent adding of soil and wood ash helps to promote composting and reduce odour and fly breeding. The screened ventilation pipes, which are fitted to all Blair VIP toilets, also help to aerate the chamber and reduce moisture content. These toilets were designed for use in homes, where they work quite well. They have also been tried in communal settings in peri-urban areas, where they failed due to too much water entering the vault, hindering the decomposition process. Ecological toilets are best used at the family level where they get the necessary attention to maintenance.

The ArborLoo composting toilet has a portable superstructure over a shallow pit, ultimately creating a sanitary orchard.

The ArborLoo: The ArborLoo is a simple, composting toilet with a portable slab, pedestal and superstructure (Fig. 9). The chamber is a shallow pit (maximum 1 meter in depth) dug in the ground with a protective "ring beam" securing the pit head, which raises the latrine slightly above ground level. The shallowness of the pit reduces the likelihood of groundwater contamination in comparison to deep pits. Wood ash and soil are added after each use to reduce fly breeding and odour. Layers of organic matter, such as leaves, can be added as well to assist in the decomposition process. When the pit is nearly three-quarters full, the slab and superstructure are removed. The pit is topped off with at least 15 cm of fertile soil, and a young tree is planted over the pit contents. The slab and superstructure are mounted over another shallow pit nearby and the cycle is repeated.

Because the toilet is portable and moves on a never-ending journey, a sanitary orchard or wood lot appears over time.

Figure 9: ArborLoo - leave the contents, move the “loo” and plant a tree

Several types of tree species have been experimented with: guava, paw paw, mango, avocado and mulberry. And, other trees are currently being investigated: citrus and peach trees, and trees for construction and fuel wood such as the eucalyptus. Multipurpose trees such as the neem and moringa oliefera are also being tested.

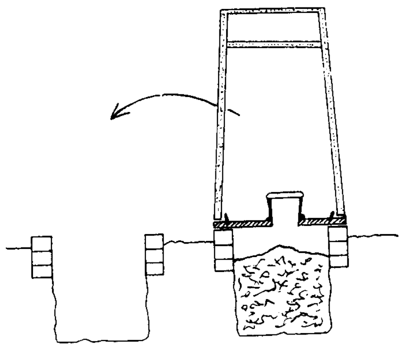
With the ArborLoo there is no handling of excreta, and the risk of ground water contamination is reduced because of the shallowness of the pits and the rapid conversion of pit contents into humus, in about 3-4 months. Because space is required for this concept, it is used mainly in rural areas, but it can be adapted to peri-urban areas if space is available.

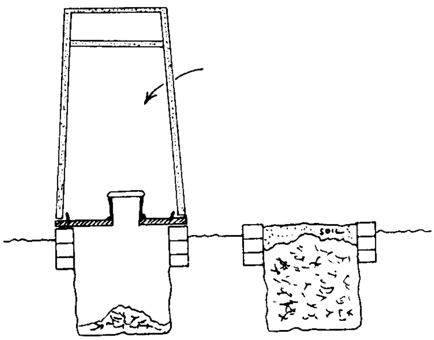
The fossa-alterna uses two shallow, partly lined, alternating pits to produce humus for agriculture.

The Fossa Alterna: The Fossa Alterna, meaning alternating pits in Latin, uses two shallow, partly lined, permanently sited chambers below a portable slab, pedestal and superstructure (Fig. 10). Like the ArborLoo, both urine and faeces accumulate in the shallow pit together with wood ash and soil. When the first chamber is nearly full, the slab, pedestal and structure are moved to the second chamber and the contents of the

Two shallow pits are dug and partially lined in a permanent location, to be used in an alternating fashion.

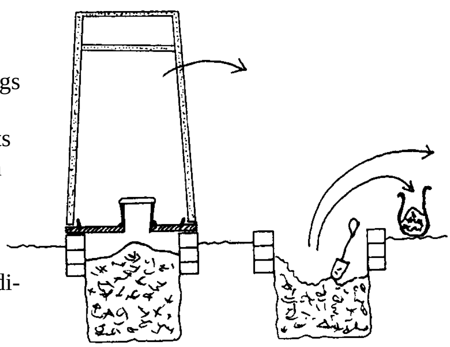
Step 1:
The first chamber is used until it is almost full, adding soil, ash and organic plant matter in layers to cover the urine and feaces. Then, the light superstructure, pedestal and slab are moved over the second chamber.





Step 2:
The first chamber is topped off with soil. The second chamber is used in a similar manner, while the contents of the first pit decompose. Occasional watering and the growing of seasonal plants can assist the decomposition process.

Step 3:
When the second chamber is full, the contents of the first are removed to bags for additional storage or to gardens, while the structure is moved back to its original position for the cycle to begin again. The mature contents of the first chamber look and feel like rich compost, which can be sold to generate income if the household has no immediate use for it.



The total area required for a fossa alterna is about 2.5m X 1.5m.

Figure 10: Fossa Alterna - alternating chambers for making compost

used chamber are covered with topsoil between 15 and 30 cm deep. Vegetables or flowers can be planted in the topsoil if desired. The second chamber is used while the contents of the first chamber decompose, a process that takes between 3-4 months depending on the season. The decomposing chamber is kept watered. After the second chamber is full, the contents of the first chamber, which have turned into a friable humus-like soil, are dug out and introduced into agriculture, mainly in the production of vegetables. The material can also be stored in bags for use during the next rainy period. Chambers are alternated about every six months depending on the number of users. The friable humus-like soil makes an excellent soil conditioner and can be used to enhance soil fertility within the peri-urban/urban setting.

The fossa-alterna occupies little space, thus ideal for peri-urban areas.

The Fossa Alterna occupies a relatively small space (2.5 m x 1.5 m), so it is ideal for higher density peri-urban areas. One thousand of these toilets are currently being tested in such settings. The contents from the chamber can be easily removed, without offensive smells, and put to productive use, stored in bags and sold, or mixed with top soil and added to tree pits, fertility trenches or buckets for growing vegetables. Earthworms can be added to the Fossa Alterna chamber. The earthworms multiply as they accelerate the decomposition process, and they have economic value as well.

Rain or excessive moisture must not enter shallow chambers.

Ecological toilets are more complex to maintain than conventional pit latrines, but they provide many more advantages.

Shallow chambers below the ground can present problems. Rain or excessive moisture should not be allowed to enter the chamber as this would disrupt or halt the decomposition process. And, pathogens could spread from overflowing chambers. Hence, ring beams or an elevated pit lining are strongly recommended for the ArborLoo and the Fossa Alterna. High water tables can penetrate the shallow chambers, but this can be corrected if they are built on higher ground. The ritual of changing chambers, emptying each out periodically, must be maintained. Chamber contents should be stored for at least four months and not be allowed to overflow. All these factors make ecological toilets, even the simplest type, more complex to maintain than simple or ventilated pit latrines. However, they provide many advantages.

Urine diversion toilets

The urine-diverting toilets in Zimbabwe are similar to those used in other parts of the world. There are home-made as well as commercial varieties of urine-diverting pedestals. Urine diversion is being tried in homesteads as well as in schools. These toilets divert urine either to a seepage area or the urine is collected and stored for later use as a fertiliser.

Faeces accumulate either directly in the chamber, or they can be held in plastic buckets or basins. Both soil and wood ash are added after toilet use, which helps to dry the faeces and increase pH (alkalinity). The semi-dried product can be introduced into agriculture in many ways, such as adding it to compost, to planting trenches or pits for planting trees. The evolution of these toilets is moving toward a version with smaller chambers above ground called the *Skyloo*. Usually, portable buckets or basins or plastic bags are used for easy access and transfer of contents.

Screened vent pipes are still used. They provide a constant flow of air through the toilet which removes odour, controls flies and also takes humid air away from the chambers. This helps to reduce the moisture content of the chambers and assists in the decomposition of faeces.

Links to national programmes

Infertile soils and the rising cost of chemical fertilisers may force policy makers to rethink sanitation and adopt ecosystem approaches.

The Ministry of Health and Child Welfare in Zimbabwe has been promoting ecological sanitation. With this new emphasis on ecological sanitation, the production of humus can be linked to agriculture. Infertile soils and the rising cost of chemical fertilisers may force policy makers to rethink sanitation, seeing it in a more positive light. And, ecological sanitation fits in with the current self-reliant approach that encourages rural families to dig their own wells and run their own vegetable gardens. Local economists see a net economic value when the resource value of the output is considered.

Efforts in Zimbabwe will only be successful if residents use toilets correctly.

Efforts at ecological sanitation in Zimbabwe will only be successful if residents learn to use the toilets correctly. Proper use of the urine diversion toilets is the key to prevent mixing of urine and faeces. Ash or other material must be added to the faeces at appropriate rates and in the appropriate part of the toilet. Proper storage time is needed in all toilets to assure pathogen destruction. ArborLoos and Fossa Alternas require light, movable superstructures that should also keep out the rain, since the shallow chambers are more prone to flooding if the superstructures are not properly secured. Flooding, however, is not a problem for the Skyloos, as the urine-diverting toilet is entirely above ground.

Working groups

Mapping conventional versus alternative sanitation systems and outcomes

At the workshop, working groups addressed the flow of human excreta in an alternative and a conventional sanitation system. Groups were asked to map the flow of excreta from the point of excretion to its final destination. The advantages and disadvantages of each system were discussed, and the results of the discussions are described below.

Working groups mapped the flow of excreta in different systems.

Conventional systems: The conventional systems commonly used in Latin American countries were discussed. These systems rely on flushing —specifically excreta are flushed via a pipe into a ravine, flushed via a pipe that is emptied into the ground, or flushed directly into a pit. All of these designs have risks leading to pollution of the receiving waters. Figure 11 below shows the fairly common flush toilet discharging directly into a ravine —the “flush and gone” system.

Septic tanks are another commonly used —and often poorly managed— system in Mexico. They are used without soil absorption or leach fields, and as a result, they discharge nutrients, pathogens, and other contaminants into open waters. It appears that the main advantages of septic tanks are

Most flush and discharge approaches shift the burden of disease and responsibility to communities downstream.

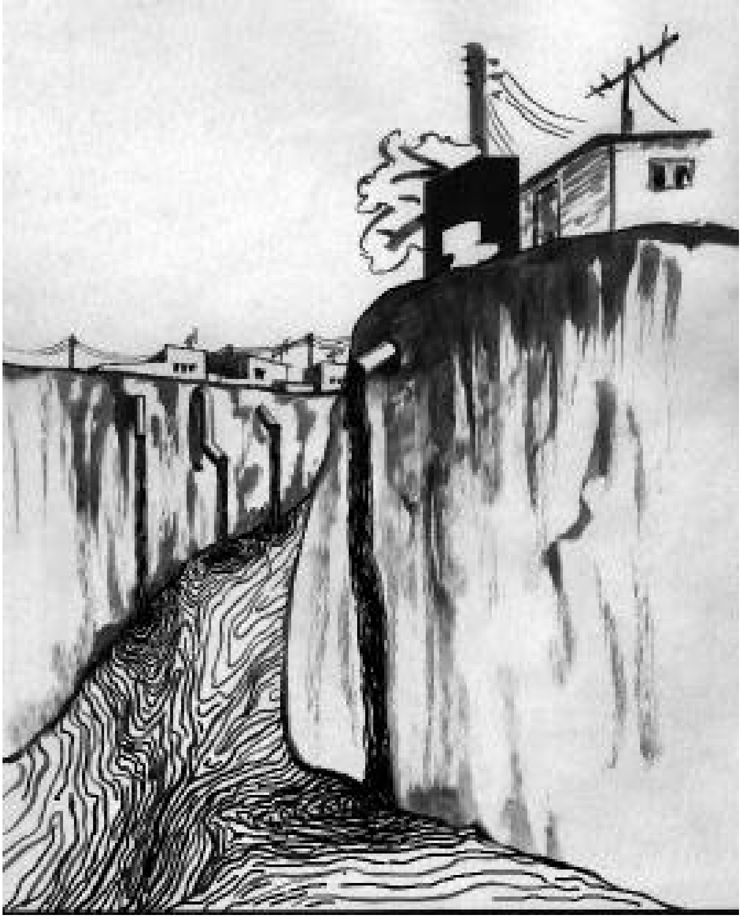


Figure 11:
"Flush and gone" approaches hide the problem of water-based solutions to excreta disposal.

the avoidance of direct contact with faeces and pathogens, and the modern appeal of a flush toilet. The lack of a proper and regular water supply requires either additional water storage in an elevated tank or carrying water to the individual toilet tank before use.

Alternative systems: Two alternative systems were considered: constructed wetlands (the "Living Machine") and urine-diverting toilets. Both offer a more holistic approach to sanitation through the reuse of excreta —that is integrated into the environment— and the prevention of the spreading of pathogens. The main problems foreseen that need to be addressed within ecological sanitation concepts are:

- the "technical side" (improper usage of toilets, maintenance of toilets, and the availability and addition of lime and/or ashes);
- environmental concerns;
- land requirements (wetlands);
- the design of toilets and transfer of knowledge;
- sociocultural aspects (gender issues of sharing benefits and burdens);
- sufficient hygiene education;
- proper use by children;
- cultural and practical concerns for use of urine diversion toilets; and
- reuse of products in terms of convenience, health, and recycling in high density areas.

Many problems, needs and gaps were identified.

Needs and gaps

Participants in the working groups felt that ecological sanitation approaches in this workshop need to address issues of:

- sociocultural dimensions (social convenience and acceptance, effects at different levels of society: households, neighbourhoods, and communities);
- participatory implementation and issues of lack of awareness;
- health aspects (pathogenic risks through handling and use of products);
- institutional and funding options; and
- flexibility of design options (adapted to local conditions in regards to population density, geographical and socioeconomic settings, cultural aspects).

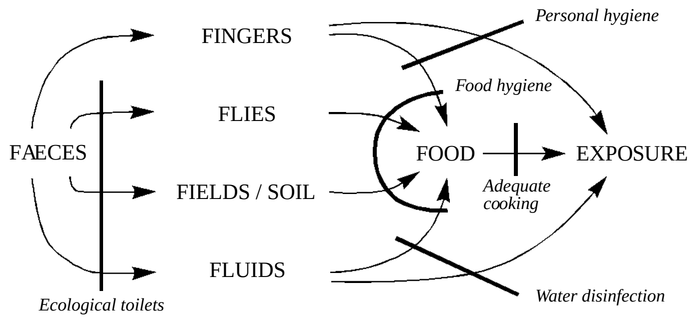
ECOLOGICAL SANITATION AND HEALTH

Improved sanitation acts as a barrier to protect people from the pathogens in faeces.

Improved sanitation has been associated with better health and nutritional status. Evidence accumulated over the last quarter century indicates that improved sanitation substantially reduces childhood illnesses and deaths, and improves nutritional status. It does this primarily by acting as a barrier, keeping excreta away from people who, if exposed to the pathogens in faeces, become ill.

The barrier approach to sanitation prevents faeces from gaining access to the environment: specifically fingers, flies, fields, and fluids, all of which can contaminate food (Fig. 12). When people ingest pathogens from these media, they become ill. When faeces contaminate the environment, the vicious cycle of people contaminating the environment and becoming infected by the contaminated environment continues.

Improved sanitation, through either "drop-and-store" or "flush-and-discharge" approaches, can reduce contamination of these media. Evidence suggests that improved sanitation could reduce diarrhoeal disease by 35-40%, and reduce child mortality by half. Child malnutrition could also be reduced by



Source: Esrey SA et al, Ecological Sanitation. 1999

Figure 12:
If sanitation fails, it is hard to prevent people from becoming ill.

50%. In the absence of improved sanitation, purifying water may have little or no effect on diarrhoea, but in the presence of improved sanitation, cleaner water may reduce diarrhoea by as much as 10-15%, whereas improved personal and food hygiene could reduce diarrhoeal disease by one-third or more.[7]

Transporting excreta away or burying it deep in the ground results in pollution "downstream."

Use of the barrier approach to sanitation has other health implications. Transporting excreta away or burying it deep in the ground results in pollution "downstream." Thus, others may be exposed to pathogens, causing illness. Direct health problems are caused when people are exposed to pathogen-containing faeces via oral or subcutaneous routes. Exposure to pathogens leads to increased incidence and severity of disease, increased risk of dying and malnutrition.

Indirectly, nutrients not recovered and recycled can cause other types of health problems, particularly when these nutrients get into water bodies (e.g., rivers, lakes, and marine environments). It is well documented that nitrate pollution in drinking water leads to the "blue baby" syndrome, but less well known are the effects of nitrogen pollution related to reproductive problems[8] and growth faltering in young children.[9]

The disposal approach to sanitation leads to many other health problems besides infections.

The disposal approach to sanitation, in which human excreta are wasted, opens up the ecosystem to linear flows (Fig. 13). Chemical fertilisers and pesticides are used on crops, causing further pollution. The practice of feeding hormones and antibiotics to animals leads to large quantities of manure, hormones and pharmaceuticals polluting water supplies. Ultimately, opening up the ecosystem to linear flows leads to:

- loss of soil fertility (reducing food production);
- destruction of marine life (declining fish populations, reducing a major source of protein for human consumption);
- loss of biodiversity on land and in water;
- global warming and ozone depletion, when nutrients form gases that escape into the atmosphere.

All of these problems place people at risk of a multitude of

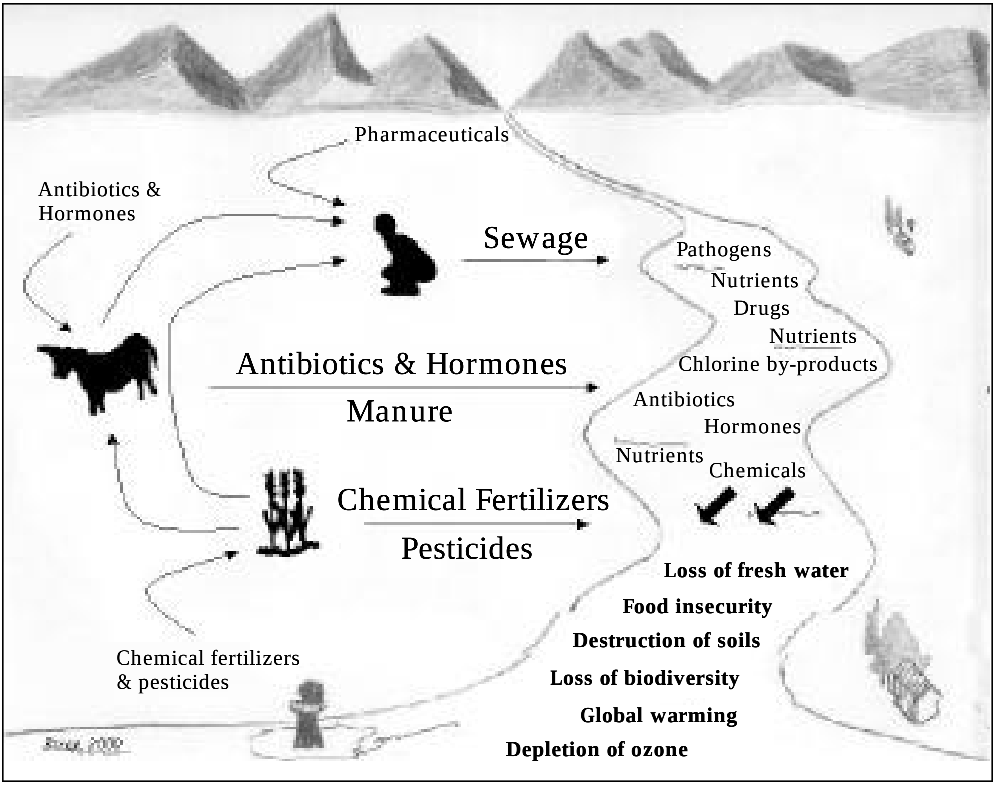


Figure 13: Linear sanitation solutions cause multiple problems.

health problems, and increase the risk of becoming food insecure, not just for the poor and vulnerable, but also for the more well-to-do.

Ecological sanitation sanitises excreta prior to recovery and reuse, and nutrients are recycled back into the land for productive purposes.

A second way that sanitation can improve people's health and nutrition is by recovering and recycling the nutrients in excreta to grow food. This is already taking place in many parts of the world (e.g., night soil collection and wastewater reuse). Most attempts, however, are associated with an increased risk of ill health because faeces are not sanitised prior to reuse, thereby spreading pathogens and increasing people's chances of becoming ill. Ecological sanitation helps to reduce these risks by sanitising excreta prior to recovery and reuse, and recycling nutrients back into the land for productive purposes.

Potential health risks from human excreta[10]

Infectious diseases cause one-quarter of the total global burden of disease. Infectious diseases are now the world's biggest killer of children and young adults, accounting for 13 million deaths every year. One out of every two persons in low-income countries dies at an early age from infectious disease.[11] Children and the immuno-suppressed are the most vulnerable to the principal organisms that contribute to this burden, specifically bacteria, viruses and parasites. Some of these organisms remain viable in the environment for long periods of time, either with or without the need for an immediate host.

Assessment of contamination

Most of the worrisome pathogens are in faeces, and most of the valuable nutrients are in urine.

Most of the worrisome pathogens are in faeces, and most of the nutrients are in urine. Assessing the presence of pathogens in either faeces or urine is more difficult than simply looking for specific indicators of faecal contamination. Historically, attention was focused on the measure of *E. coli* in water. Although *E. coli* has been a useful indicator in the North, it may not be the best indicator of pathogen contamination in most regions of the world. The idea is to focus on the indicators or pathogens that represent the presence of specific bacteria, viruses or parasites that are particularly resistant to environmental stress and therefore, survive for longer periods of time than all other pathogens. Two types of organisms are particularly resistant to environmental stress: bacteriophages, an indicator, and *Ascaris* eggs, a pathogen.

Human excreta can be made safe

Human excreta, specifically faeces, can be made safe in several ways. At the point of excretion, the addition of adsorbents, such as lime and ashes, to faeces and/or excreta can destroy the resistant pathogens in a reasonable amount of time. Lime raises the pH and helps to desiccate faeces. Recent studies from Vietnam indicate that *Ascaris* eggs and *salmonella* bacteriophages can be made safe within 6 months. The median die-off rate of the bacteriophages was 37 days, about 5 weeks, and the median die-off of *Ascaris* eggs was 65 days, about 9 weeks. The average pH in the chambers was around 9.5 to 10.0. Of the three main factors affecting survival of pathogens —pH, moisture and temperature— raising the pH was more effective in killing persistent pathogens than modifying the other two factors. A reduction in moisture levels or an increase in temperature may be too difficult to achieve in the absence of vent pipes or solar heaters or materials that foster desiccation and higher heat. Different adsorbent materials affect pH differently. Recent research in cold climates in China[12] indicates that plant ash is better than coal ash, sawdust or dry soil for destroying pathogens. Additional studies are currently under way in other locations in the world, and results should be available in the next year or so.

Raising the pH may be more effective in killing persistent pathogens than by modifying moisture or temperature.

Urine is usually considered sterile, free of pathogens. Only a few disease organisms are passed through urine.[13] In this regard its reuse has an advantage over excreta or faeces. In urine-diverting toilets, however, cross-contamination from faeces to urine may occur. In the Swedish experience of mostly middle and upper middle class family homes, faecal cross-contamination is infrequent. If urine is stored in tanks, as found in Sweden, then the nitrogen in urine converts to ammonia, and the pH rises to about 9. This elevated pH helps to kill off possible contamination. In general, if urine is to be stored, a low dilution with water should be sought, and temperatures should tend toward a warmer environment than a cooler one. These conditions will foster die-off of pathogens in urine. If cross-contamination does occur, storage of urine for several months should make it safe. In conclusion, urine is an excellent fertiliser (see section on Recovery and Recycling of Human Excreta), and it can be used on arable land with a higher degree of safety than wastewater or sludge.

If cross-contamination from faeces to urine occurs, storage of urine for several months should make it safe.

Treatment near the point of excretion

Experience with urine-diverting toilets indicates that pathogens in faeces can be destroyed within a few months time by elevated pH, drying, and storage time in the chamber away from people. This time could be shortened if temperatures could be elevated to 50-55°C, with pathogens dying within days, and almost instant kill at above 60°C. Elevating temperatures to 50°C or higher is probably not possible, however, without a change in technology.

Traditional wastewater treatment plants normally reduce the viability of pathogens by 90-99%. Stabilisation ponds can be used, and the end product can be used for agricultural purposes, but it is not considered pathogen free. Wastewater treatment plants and stabilisation ponds, therefore, may give a higher likelihood of infection than would a primary treatment of excreta from a urine diversion toilet in which faeces are treated to a pH of 9 or higher. Furthermore, wastewater treatment plants fail to capture phosphorous and nitrogen during treatment. These nutrients become lost and pollute the aquatic environment.

Hygienic use of toilets can be learned

Proper use of ecological toilets is vital, and different types of local materials can sanitise faeces.

Proper use of ecological toilets is vital to achieve pathogen destruction. And, it is important to know that such proper use can be learned. In Vietnam, a number of toilet designs were sampled for hygienic conditions after having been used for at least six months. Some toilets were unhygienic. People added different types of material and differing amounts to the chambers; thus, pH varied. For example, the quantity of wood ash ranged from 100-300 ml after defecation, and pH from wood was 11.3, higher than from rice husks, with a pH at 10.6. After this survey, additional hygienic instruction on the use of toilets was provided, and usage improved.

Working groups

Health and human excreta

During the first day of the workshop, working groups discussed the transmission of pathogens from the point at which excretion occurs through the food security loop. One group focused on urine only, another on faeces, and a third on urine and faeces combined.

Faeces and associated pathogens should be dealt with at the point closest to excretion.

The *faeces only* group constructed a closed loop diagram from defecation to compost pile to the crop to harvest and through consumption back to defecation (*Fig. 14*). As with the other groups, this group insisted that faeces and associated pathogens should be dealt with at the point closest to excretion —in the chamber. If this did not occur, then the problem of transmission of pathogens, through multiple routes, presented a challenge to ecological sanitation approaches, much like that of conventional solutions. For example, composting could serve as a secondary treatment of faeces prior to applying the material to soil, but transmission could nevertheless occur via a number of routes (e.g., hands, transport container, etc.) if pathogens were not sufficiently destroyed in the chamber. In the event that transmission did occur, at each step

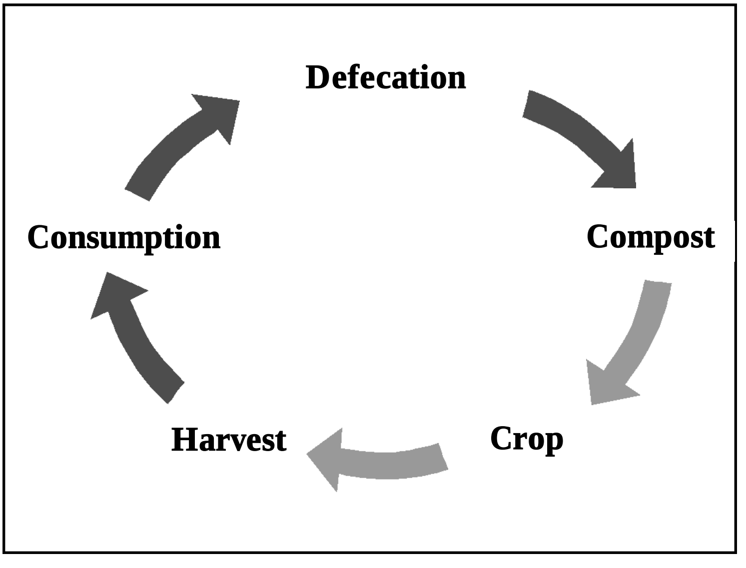


Figure 14:
A closed loop diagram of ecological sanitation

around the loop, behaviours and barriers could be introduced to interrupt transmission.

If primary treatment failed, the acceptance of ecological toilets not only by households and communities, but also by donors, governments and others would be jeopardised. Therefore, more research on treating and testing for pathogens in faeces is needed, including practical indicators that can be measured to determine the safety of faeces.

Reusing urine poses fewer health risks than disposing of it, but cultural resistance to reuse needs to be addressed.

The *urine only* group felt that the health risks of urine reuse were minimal, and disposing of urine may pose greater health risks than reusing it. Nutrients in urine, such as nitrogen, can contaminate ground water as well as surface water (rivers, lakes and oceans), causing a variety of health and non-health problems. On the other hand, reuse of urine diluted sufficiently with water poses no health problems. Cultural resistance against reuse should be addressed. This working group felt that it would be useful to find ways to get urine to gardens without the use of buckets or open containers. In addition, information exchange between agricultural and sanitation experts and practitioners would be helpful, especially with respect to the type of plants/trees that absorb nitrogen best or need nitrogen most.

The third group focused on *urine and faeces* combined. They considered many uses of human excreta, ranging from agro-forestry, energy production (e.g., biogas or growing of trees), horticulture, agro-industry and aqua-culture. Many of the same types of risks and concerns identified by the faeces only group were also mentioned by the third group. The following issues were deemed important:

- hygiene education;
- transfer of matured excreta;
- consideration of sociocultural conditions, patterns and preferences;
- selection of crops; and
- food hygiene.

Needs and gaps

Participants felt that ecological sanitation approaches need to assuage people's health fears. Knowledge of pathogen destruction using different toilet designs under a variety of field conditions is necessary to ensure that communities and households can rely on producing and receiving a sanitised product.

Technical and cultural issues of pathogen destruction and safety of excreta need to be addressed.

Probably the most important gap to fill is how to destroy pathogens in the chamber at the point of excretion. If faeces are to be transported to another location (e.g., to compost piles), then more information and knowledge is needed for practitioners to know how to minimise exposure. If pathogens are not adequately destroyed in the chamber or are spread during faecal harvesting and transfer to a secondary processing site, then traditional interventions focused on installing barriers to prevent transmission (e.g., hand washing, improved food hygiene and water purification) need to be employed.

RECOVERY AND RECYCLING OF HUMAN EXCRETA

Urine, faeces, and the combination of urine and faeces can be processed in a number of different ways. Regardless of how processing occurs, the goal is to return excreta to soils. It may be useful to categorise the different processes according to urine diversion and non-urine diversion devices (Fig. 15).

Human excreta are composed of urine and faeces, which are produced in different quantities, have different qualities, and provide different benefits.

In urine diversion toilets faeces are kept separate from urine. Faeces are desiccated and treated to destroy pathogens prior to application to soils. It is sometimes necessary to subject desiccated, treated faeces to a secondary level of processing, such as composting, to further break down the faecal-lime/ash material in order to produce humus. Urine can be diluted and applied directly to soil, or stored underground in storage tanks prior to applying it to soil. Either way, it is desirable to preserve the nitrogen in urine, keeping it in a form that is usable by microorganisms and not letting it escape as a gas into the atmosphere.

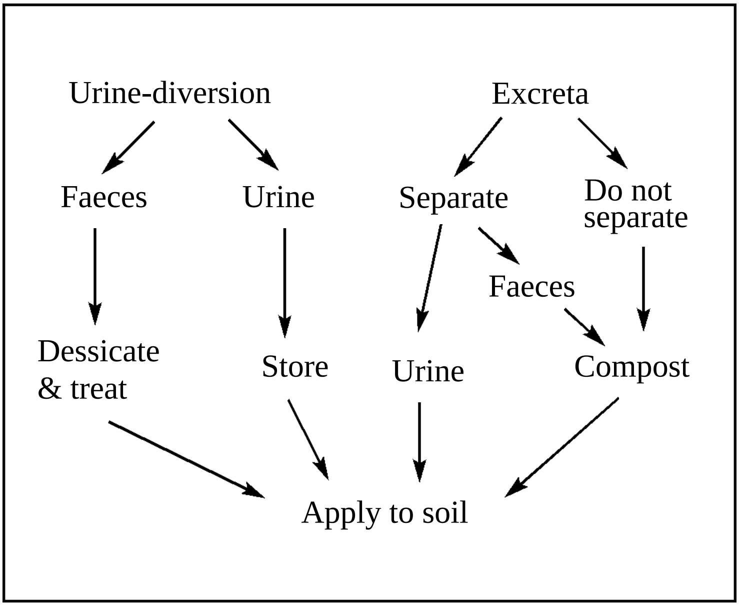


Figure 15: Excreta can be processed by different means.

In non-urine diversion toilets, urine and faeces are mixed. They can remain mixed, in which case they can be composted. Because the carbon-nitrogen ratio in human excreta is not desirable for composting (the mix contains too much nitrogen in relation to carbon), additional carbonaceous matter must be included for optimal composting. Once composted, excreta can be applied to soils. If urine is first mixed with faeces and then separated, the urine may need to be treated prior to soil application. Faeces that have been mixed and then separated from urine will be moist and contain live microorganisms, some of which may be pathogens. At this point faeces may be co-composted with other organic matter, thereby destroying any pathogens, or may be desiccated and then co-composted.

The goal is to make urine and faeces safe to use.

In all cases the goal is to make urine and faeces safe prior to applying them to soil for growing food or non-food plant products.

Basic plant nutrition[14]

All plants need oxygen, carbon and hydrogen, which they get from the air, sunlight and water. And equally important for healthy plant growth is the presence of elements in the soil. These elements are divided into major elements (nitrogen, phosphorous, potassium, magnesium, calcium and sulphur) and trace elements (such as iron, zinc, copper, manganese, boron and molybdenum).

Ninety-six percent of what is needed for healthy plant growth is provided by oxygen (45%), carbon (45%), and hydrogen (6%). Elements are required in smaller amounts, such as nitrogen (1.5%), phosphorous (0.15%), potassium (0.15%) and others (0.2%), but they are equally as important as the major elements.

Different plants need more of certain nutrients than others.

In general, green, leafy, non-legume vegetables need more nitrogen than other types of plants. Flowering and fruiting vegetables need more phosphorous, and root vegetables need more potassium. Each of these nutrients performs complementary functions. An imbalance of nutrients available to plants may be the reason for increased incidence of pests, and excessive nitrogen fertilisation makes plants more susceptible to attacks by disease and insects.

Nitrogen is needed for leaf and stem growth, and it gives a dark green colour to plants. The level of nitrogen added to the soil is important since it affects the plants' access to other nutrients such as phosphorous and potassium. Nitrogen is also important from the point of view of nutrition as it increases the protein content of some foods and feed crops.

Phosphorous helps make plants more drought resistant and hardy. It hastens maturity, helps seed and fruit formation, and stimulates root growth. It also helps legumes grow and form nodules.

Potassium increases resistance of plants to disease, creates winter hardiness and drought resistance, and produces stiff stalks and stems to reduce water logging. It also increases grain plumpness as well as growth of fruit and root vegetables.

Fertiliser value of human excreta

Most of the data on the value of human excreta —urine, faeces, or urine and faeces combined— come from Scandinavia (Tab. 1). For example, excreta output varies by the size of the person (e.g., adult vs. child), type of diet (e.g., vegetarian vs. meat), and climate and lifestyle, but the proportion of nutrients and water excreted remains roughly the same regardless of the total output.

The three major nutrients used in chemical fertilisers are found in human excreta.

Eighty percent of total nitrogen is excreted in urine (Fig. 16); and there is 5-7 times more nitrogen in urine than in faeces. Urine contains two-thirds of excreted phosphorous and up to 80% of excreted potassium. These are three major nutrients used in chemical fertiliser preparations.

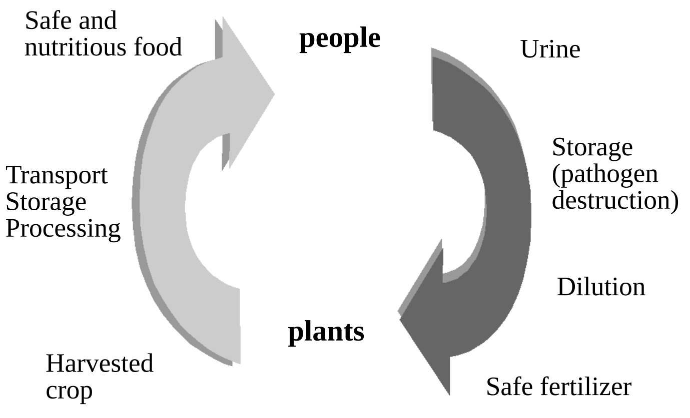


Figure 16: Urine supplies valuable plant nutrients.

Other nutrients, such as calcium and magnesium, are excreted in nearly equal amounts in urine and faeces. And, of course, faeces provide most of the carbon that is excreted; faeces have nearly four times as much carbon as urine. Thus, reusing only urine would fail to return all the nutrients excreted by people to soil.

Table 1: Elements found in human excreta[15]

Element (g/ppd)	**Urine**	**Faeces**	**Urine + faeces**
Nitrogen	11.0	1.5	12.5
Phosphorous	1.0	0.5	1.5
Potassium	2.5	1.0	3.5
Organic carbon	6.6	21.4	30
Wet weight	1,200	70-140	1200-1400
Dry weight	60	35	95

Faeces can make soil healthy

Composted faeces become humus/compost that smells and looks like good earth.

Faeces have several positive qualities when they are transformed into compost or humus (Fig. 17). Transformation can occur through several different processes, such as desiccation, addition of materials to raise pH, and composting. Desiccated faeces look different than compost. They are lighter in colour with larger particles. They may or may not have the same properties as compost once they are added to other organic matter or soil, at which time decomposition into humus/compost may occur. Faeces, or faeces and urine, that are composted, usually by adding them to existing compostable materials, become humus/compost that smells and looks like good earth. **Compost** has many desirable qualities[16]:

Compost has many desirable qualities.

- **Compost improves soil structure**: An ideal, friable garden soil consists of airy crumbs in which particles of sand, clay and silt are held together by humic acid. Compost helps these particles to form.

- **Compost increases the water-holding capacity of soil**: While 50 kg of silt holds 12 kg of water and 50 kg of clay holds 25 kg of water, 50 kg of compost holds 100 kg of water. A soil rich in compost requires less watering, and plants growing in compost will better withstand drought.

In general, compost adds to the productive value of resources by making soil healthy.

- **Compost moderates soil temperatures**: Adding compost to soil tends to keep the soil from heating up or cooling down too rapidly. Soil darkened through the addition of compost absorbs the light and moderates its effect on the growing plant and beneficial soil microorganisms.

- **Compost breaks up organic matter into the basic elements that plants need**: Compost is teeming with microorganisms, which continually break down organic matter.

- **Compost returns to soil what agriculture takes out of it**: Compost is made up of decaying matter, and it includes nearly every chemical a plant needs, including boron, manganese, iron, copper, and zinc which are not present in commercial fertilisers.

The nutrients in compost are readily available to plants when they need them.

- **Compost releases nutrients at the rate plants need them**: Compost acts as a storehouse for nutrients, and slowly releases the nutrients throughout the growing season as the organic material decomposes in the soil. The compost layer prevents the surface from drying out, which increases uptake of nutrients and improves the growth of plants.

- **Compost can neutralise soil toxins and heavy metals**: Compost binds metals such as cadmium and lead, making it difficult for plants to absorb them.

- **Compost reduces pests and disease**: Compost improves plants' ability to withstand attacks by disease and insects by enhancing naturally occurring microbial agents. Furthermore, it reduces the effects of soil-borne pathogens and reduces the amount of plant parasites and nematodes in the soil.

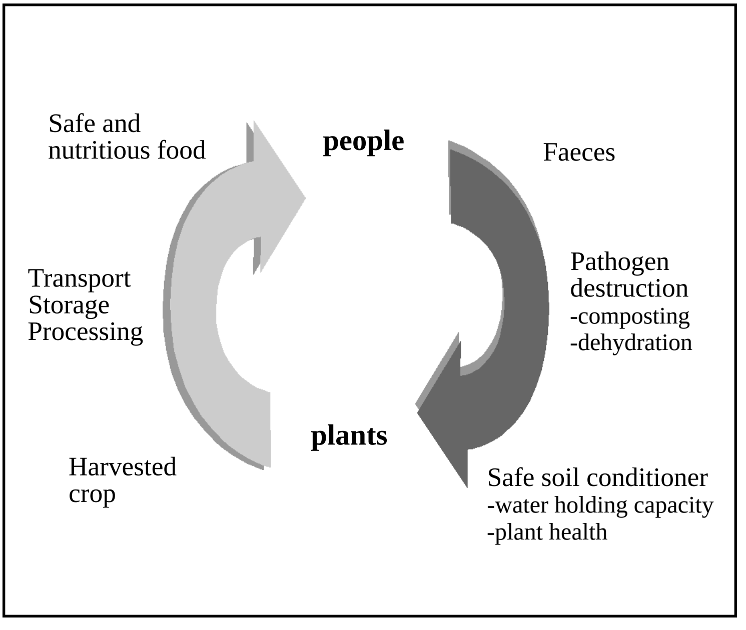


Figure 17:
Faeces are a good soil conditioner.

Composting reduces environmental problems, preserves fresh and marine waters, and protects biodiversity.

Compost can also reduce environmental problems and other ills of society. Failure to return nutrients and carbon to soil, and using water bodies as sinks for excreta/nutrients reduces soil fertility. Fish populations, a major source of the world's protein, are also protected through the use of compost. Reliance on chemical fertilisers, instead of natural fertilisers, leads to excessive nitrogen use, which promotes the dominance of heavy nitrogen feeding grasses and pushes out low nitrogen feeding grasses.[17] Excess nutrients kill coral reefs and cause algae blooms that intoxicate fish, plus nutrient gases such as nitrous oxides, carbon dioxide and methane escape to the atmosphere contributing to global warming and ozone depletion.[18]

The five essential elements for successful composting are: organic matter, microorganisms, water, air and time.

There are five essential elements for successful composting: organic matter, microorganisms, water, air and time. **Organic matter** can be divided into two categories: carbon and nitrogen. Carbon is energy food for microorganisms, and nitrogen provides microorganisms with protein needed to break down carbon. Faeces provide a good source of carbon, while urine supplies a good source of nitrogen, as shown in the table above. **Microorganisms** transform organic matter into compost. Good sources of microorganisms are soil and finished compost. **Water** is needed in a compost pile to keep the pile moist, but not wet. In some places, rain may be a sufficient source of moisture. **Air** is necessary for a compost pile to breathe because microorganisms need lots of oxygen to do their work. Finally, the **time** to convert organic matter into compost varies according to the above four elements and the frequency with which a pile is turned. In general, if the five elements are present, compost is generated, whether within a month or a year.

Composting recycles nutrients and conserves water.

In summary, compost improves soil and its fertility. It makes soil easier to cultivate, reduces the need for chemical fertilisers and pesticides, and adheres to the principles of ecological sanitation. Composting serves as a secondary level of processing of faeces, making it safe and preventing disease. Composting conserves water because it holds more water in soil for a longer period of time. And finally, composting recycles nutrients.

Second field visit

Urban agriculture in and around Mexico City focuses on composting to improve soil fertility and produce organic food for low-income settlements.

Workshop participants visited CEDICAR (*Centro de Investigación y Capacitación Rural A.C.* -Rural Research and Training Centre) in Mexico City, where they were able to see first hand an urban agricultural project with its various components (Fig. 18). CEDICAR has two parallel program components: the older rural Agro-Ecology Program emphasises soil fertility, particularly through the use of vermiculture, the cultivation of worms for composting. The Urban Agriculture Program, initiated in 1993, is concerned with the production of organic food for inhabitants of low-income settlements on the outskirts of Mexico City. CEDICAR has promoted containers for use with different types of compost and "liquid organic fertilisers," including human urine, for household and community production of vegetables and herbs. The program is focusing on generating family micro-industries for local production and supply of inputs for domestic gardens.

Plenary discussion
Following visit to CEDICAR

A presentation on the vermi-composting of animal manure in the La Paz zoo followed the visit to CEDICAR. The humus produced has been used to reforest significant areas of the park.

Compost can be produced everywhere using a variety of organic materials.

The presentation generated a discussion on the difference between “compost” and “humus.” Participants agreed that the natural process that takes place in forests and jungles produces humus, a very stable organic mixture with a carbon/nitrogen ratio of 20 to 30. Humus can be found everywhere, as it is part of the soil’s organic matter that is relatively stable. It is not restricted to forests and jungles. The content of humus is even higher in uncultivated grassland than in forests. In addition, various artificial techniques are used to produce compost, an organic fertiliser, which ideally should also be stable and have the appropriate C/N (carbon to nitrogen) proportions. Whether or not the desired results are actu-

Figure 18: Urban agriculture can use human excreta.

ally achieved depends on the technique used, the quality and mixture of ingredients, as well as the ability and "art" of the manufacturer. Vermiculture is a very satisfactory method for obtaining a stable compost of high quality, with nutrients readily available for plant assimilation. It was noted that human faeces have a low carbon content relative to the level of nitrogen in urine. It is therefore advisable that human excreta be mixed with compounds that are rich in carbon, such as wood shavings, grain husks and straw.

Compounds rich in carbon must be added to human excreta to produce compost.

It was agreed that the contents of dry toilets require the addition of some sort of bulking agent to destroy the pathogens in fresh, untreated faeces. Whereas lime helps to dehydrate while significantly raising the pH, it may also "kill" the beneficial ecology of the product. In Zimbabwe, for example, lime is not added to ecological toilets. There is a strong preference for the addition of a combination of soil and wood ash, which provides the desired effect of pathogen destruction without killing the beneficial organisms in the final product. A period of 3-4 months of decomposition appears to be adequate to reach the quality of product required for agriculture. The resulting humus-like material —processed faeces, paper, soil and wood ash— are normally mixed with topsoil and used for growing vegetables, flowers and trees.

In urban areas it may be feasible to add ash (where available) and then utilise the dry toilet output as simply a minor ingredient in the preparation of compost. CEDICAR has been experimenting with the production of compost containing approximately 2% treated faeces from dry toilets (minimal six-month storage time and lime used as a bulking agent).

Both pathogen destruction and agricultural benefits should be considered.

Finally, it was suggested that a better understanding of the role of benign microbes —which help to accelerate the composting process— is needed. Is it important to achieve a balance between pathogen destruction and agricultural benefits? If the information does not exist, more research may be necessary.

Human excreta, urine, faeces or both, with or without other organic matter, can be recycled to support a variety of uses in addition to agriculture: biogas generation, aquaculture, horticulture, and industrial uses.

ECOLOGICAL SANITATION AND FOOD SECURITY

Urban agriculture is once again on the rise in some parts of the world.

Urban agriculture is the growing of food and non-food plant and tree crops and the raising of livestock (e.g., cattle, fowl and fish) both within the city limits and on the fringe, in peri-urban areas. Throughout history, urban agriculture has been widely prevalent around the world. But during the last century it has been on the decline, partly because it has been neglected, forgotten or discouraged. Nevertheless, in several parts of the world it is once again on the rise. In Moscow, for example, urban agricultural activity increased three-fold between 1970 and 1990. In Dar es Salaam it nearly quadrupled from 1968 to 1988, and in Romania it more than tripled (up 333%) from 1990 to 1996. In Argentina home gardening association members grew from 50,000 in 1990 to 550,000 in 1994. In metropolitan areas in the United States, food production increased from 30% in 1988 to 40% in 1996, and from 1994-1996 the number of farmer markets selling locally-grown produce increased 40%. In greater Bangkok 60% of the land is under cultivation.

Urban agriculture in Harare is mostly for home consumption with vegetables, fruits, maize, potatoes and livestock (e.g., poultry, sheep, goats, rabbits, cattle and horses) being produced in addition to flowers. Tobacco, pigs, ostriches and wildlife are produced in peri-urban sites. Acreage being farmed in Harare doubled between 1990 to 1994. In Mexico City production is mainly for subsistence, which includes livestock production, milk and more recently vegetables. The urban production of ornamental plants accounts for 45% of Mexico City's supply.

Urban agriculture has many benefits, including the enhancement of gender equity.

Some of the many benefits of urban agriculture include:

- improved food security and reduced malnutrition;
- creation of jobs and business;
- conservation of natural resources;
- savings on investments in infrastructure;

- reduced cost of waste management;
- cleaner and safer environments; and
- more gender equity.

Food costs can be reduced by growing food for direct consumption.

Food costs can be reduced by lowering the costs of transporting food, as a result of producing food closer to where people live. Urban agriculture and home gardening can also reduce food costs by growing food for direct consumption. This in turn improves food security, and when food and non-food products are grown to generate income, food security and nutritional status can also improve. It is well known that women, who dominate the sphere of urban farming and gardening, are more likely to spend their extra income on food than men.

By closing nutrient loops and improving soil fertility and structure, yields will be higher per unit space, plants will be healthier and more nutritious, and lower levels of external inputs and less water will be required. Growing food closer to consumers also strengthens local communities.

Food security means sustained access for all individuals to an adequate and safe supply of food.

One of the most important considerations for urban agriculture is food security, and this is one of the strongest arguments used to accommodate the rise of farming in cities. Food security can be defined as sustained access for all individuals to an adequate and safe supply of food for an active, healthy and productive life.[19] Depending on how food security is measured, as many as one in three children, and one in six adults are malnourished.

Nearly half of all the deaths of children occur because they are malnourished.[20] Even a mildly underweight child has an increased risk of dying. WHO estimates that of the 10.4 million deaths of children less than 5 years of age that occurred in developing countries during 1995, about half were associated with malnutrition (Fig.19). Approximately 80% of malnutrition-related deaths were due to mild or moderate forms of malnutrition. Malnutrition not only increases mortality, but it also reduces the quality of life, impairs immunity against diseases, and hinders cognitive development. Certain nutrient

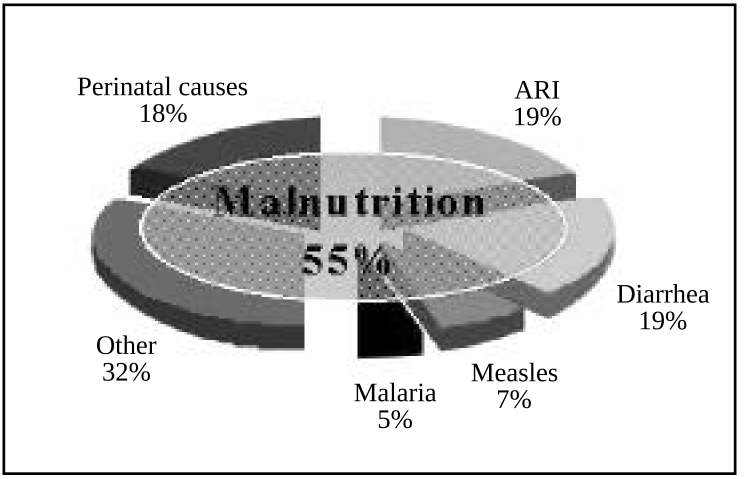


Figure 19:
Half of all deaths among young children are associated with malnutrition.[21]

deficiencies lead to blindness, decreased work capacity and increased morbidity. All of these conditions financially drain families, communities, and countries.

Many children and women suffer from "hidden hunger" or micronutrient deficiences.

In addition, many children and women —the most vulnerable groups who are at risk of becoming malnourished and food insecure— suffer from "hidden hunger" or micronutrient deficiencies. The most common micronutrient deficiencies are in iodine, Vitamin A and iron, and in some locations zinc, selenium or other nutrients may also be deficient. Urban agriculture can help supply these needed nutrients.

Food insecurity is growing over time. Broad trends in food production and prices indicate an improvement in food security, but the aggregate picture masks variations in food security among regions, countries and income groups. A recent report of 67 countries indicates that while some regions are improving, others are getting worse.[22] Food consumption in Latin America and the Caribbean is expected to stagnate over the next ten years, and 32% of the people will not be able to meet their nutritional requirements. Sub-Saharan Africa is expected to account for 50% of the food gap in the next decade. Despite increasing agricultural production, the high population growth rate and limited financial resources constrain imports, leading to a decline in per capita consumption.

Food can be grown anywhere there is water

The key to urban agriculture is adequate access to water.

Urban agriculture is ubiquitous. Practitioners have availed themselves of opportunities and adapted their know-how to select landsites and to market plants, trees and livestock. Access to land may seem like the most critical necessity, but gardening of food and non-food products can take place on rooftops, walls, fences and inside buildings (Fig. 20). The key is access to water.

Figure 20: Organic gardening in a confined peri-urban patio in Mexico City.

All major food products can be grown in urban areas

The full range of agricultural products can be produced in urban areas.

There are no agricultural products that cannot be produced in urban areas. Vegetables, fruits and meat/fish are produced, and non-food products, such as flowers and trees, are also cultivated. In Nigeria, cattle are raised in central wards, and vegetables in outer wards. In Bengal, cattle rearing has moved to the urban fringe. In both cases, trucks transport offal or fodder from crop and vegetable producing areas to livestock producing areas. A similar symbiotic relationship exists between dairy producers in Mexico City and vegetable farmers who use the cow manure for their gardens on the urban fringe.

Many cities have streets that are lined with vegetable, fruit and grain production. There is rice in Dakar; cassava, plantains, potatoes, cocoyams and maize in Uganda; and a variety of food products in New York, where farmers sell organic food products both within the city and to communities in neighbouring states. Food produced in cities can be consumed directly by the producers or sold to increase incomes. Non-food products, such as flowers, seedlings and ornamentals, can also be grown and sold to generate income. The extra money often controlled by women can be used to purchase a higher quality diet.

Because urban agricultural production is close to potential markets, the transportation costs for the products are low. More effort and investment can, therefore, be focused on improving soil fertility and conditioning, thereby improving the quantity and quality of the products grown. Even if growing occurs in containers, rooftops or other non-land locations, the addition of compost will improve the soil in which plants are grown.

One of the keys to urban agriculture production is to find a profitable niche market. Commercial surveys should consider how best to reuse urban nutrients (excreta and other organic matter), to identify idle land and societal development trends, and to define ways to enhance the environment, human health, nutrition and well-being.

Urban agriculture can improve food security

Ecological sanitation is not only safe, it also seeks to improve nutritional status through improved diets.

There are three basic approaches to correcting nutritional deficiencies and malnutrition: food supplementation, control of public health diseases, and food-based approaches. Food supplementation provides nutrients in some form (e.g., Vitamin A capsules). Public health measures prevent and/or treat diseases that lead to specific nutritional problems (e.g., through deworming or improved sanitation). Because ecological sanitation seeks to sanitise faeces prior to releasing them in the environment, it should be a powerful public health tool to not only reduce disease and death, but also to improve nutrition status through improved diets (Fig. 21).

Food-based approaches include dietary diversity, food fortification and genetic alteration of seeds/plants. Efforts in dietary diversity use existing foods available to people, trying to alter the quantity and/or quality of the diet. For example, foods that are rich in Vitamin A or that enhance absorption of iron may be promoted. Table 2 shows the types of foods that are rich in certain micronutrients of major concern in the world today.

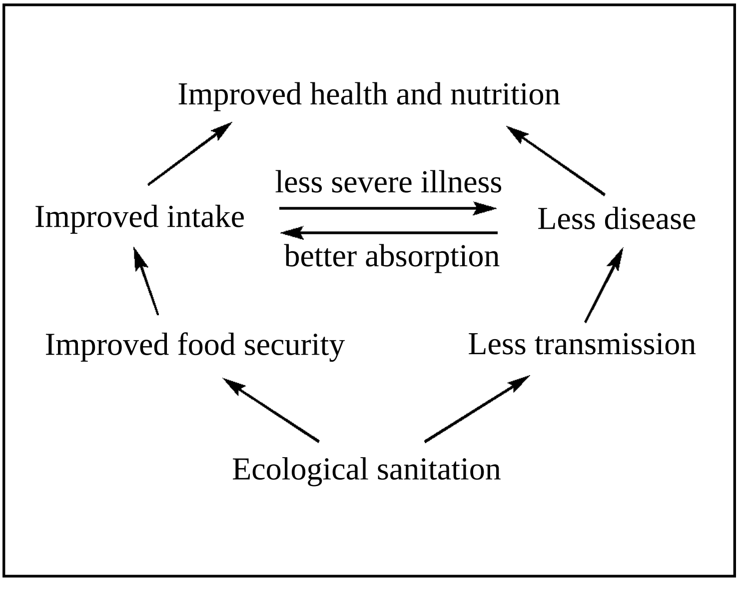


Figure 21: Ecological sanitation can reduce disease and improve nutrient intake.

Animal products and fish can supply valuable nutrients and could form part of urban agricultural programmes.

In general, meat and fish provide a wider variety of nutrients that are more readily absorbed than plant nutrients. Efforts in urban agriculture among the poor should try to include animal foods for consumption. Plant foods do provide valuable nutrients, and in some cases, absorption of nutrients from plants can be enhanced by adding or eliminating other foods in the diet. For example, citrus can increase the absorption of iron from plant foods. In addition, certain cooking methods can release more nutrients than others.

Sole reliance on food produced in rural areas will not achieve food security among urban poor. It is necessary for cities to enhance urban and peri-urban food production. Production of food in urban areas can contribute a considerable share of a household's total food intake. This is important for poorer households, which may spend 60% or more of their household income on food. Urban agriculture in some cities is quite high. Urban and peri-urban food production was found to be 60% in Kampala, Uganda and 80% in Nairobi, Kenya.[24]

Table 2: A wide variety of food products supply valuable micronutrients [23]

Iodine	**Vitamin A**	**Iron**
	Plant foods	
Seaweed, plants from soil rich in iodine	Mango, passion fruit, papaya, puha, avocado, persimmon, sarinam cherry, luquat, sweet potato, pumpkins, carrot, ivy gourd, red pepper, red sorrel, red palm oil, leaf protein concentrate.	Seeds, legumes, leafy greens
	Animal foods	
Marine fish, shellfish, milk	Liver, eggs, whole milk	Blood, meat, liver, fish

The urban poor will not achieve food security if they are dependent on food produced in rural areas.

Urban agriculture has the potential to invigorate the urban economy, possibly eliminating income transfers from food subsidies, which amount to 15-25% of real income in low-income households. In Bolivia, urban food products supply women producers with 25% of their income. In African cities, urban agriculture increased income by 67% in Dar es Salaam, and in Addis Ababa, the incomes of urban cooperative farmers were well above the median, and half were earning more than the city's employed population.

Urban agriculture improves nutritional status

In Nairobi, Kenya urban agriculture has been promoted to help the poor to feed themselves. Evidence from a study in 1994 in the slum of Korogocho suggests that self-produced food increases nutrient intake and improves nutritional status. A small group of farmers was compared to a group of non-farmers on caloric intake and nutritional status.[25] The farming group produced about 15% of their caloric needs, and the nutritional status of children under 5 was consistently better than in the non-farming families. There was less stunting and wasting of children in the farming group.

Nutritional status tends to be better in urban farming families, than non-farming families.

In 1993 investigators in Kampala, Uganda examined levels of malnutrition in children from families involved in urban farming and compared them to levels of malnutrition in children from families that did not farm. Several crops were grown, specifically cassava, plantains, potatoes, cocoyams and maize. Urban agriculture had a positive and significant association with the height of children. There was a difference of nearly 1.5 cm between farming and non-farming children. Eighty percent of those who farmed were women, and mothers of farming families spent an average of 2-4 hours more time in child care than non-farming mothers.[26]

In Vietnam a community nutrition project implemented from 1991 to 1993 indicated that gardening improved the nutritional status of children, in terms of physical growth and intake of micronutrients. Four communes consisting of more than 5,000 households received several interventions (rice, gardening, pond culture, small animal husbandry, demonstration gardens, nursery gardens to provide seeds and seedlings, nutrition education on food preparation, hygiene, contests on growth, and radio spots). A group of control households did not receive the intervention. At follow-up, the intervention communities produced more vegetables, fruit, and fish, and they consumed more vegetables, meat and fish than control households. An additional 125 calories and 4 grams of protein per day were consumed. More Vitamin A (50 mg/day) and iron (1 mg/day) were also consumed. At baseline the intervention children were more stunted than control children (50% versus 46%), but at follow-up intervention children were less stunted (42% versus 48%).[27]

Pilot projects involving gardening, nutrition education and other agricultural activities have demonstrated improvements in the diet and growth of children.

In Bangladesh, a pilot project conducted in the north-western part of the country from 1990 to 1993 tested whether low-cost vegetable gardens accompanied by nutrition education could improve nutritional status of young children and women.[28] The project targeted 1,000 families in 81 villages, while 200 families from other villages served as a control group. Intervention consisted of groups of 10-20 women who chose a leader from among themselves and were provided with technical assistance, seeds, extension staff trained in indigenous vitamin-rich vegetables and in cooking methods to optimise nutritional value of the foods, and nursery women who grew and provided seedlings at subsidised prices. At the end of the project, the total garden area grew in size from 61 m^2 and 3.1 varieties or vegetables at baseline to 138 m^2 and 17 varieties of vegetables. Women in target communities were more than twice as likely as control households to make decisions about garden produce for home consumption or sale (65% versus 25%), and they were also twice as likely to exercise control of the income earned from garden sales (67% versus 31%). Weekly average vegetable consumption increased from 5.8 kg to 7.5 kg, while the control group remained constant over time at about 5.2 kg. Night blindness, an early sign of Vitamin A deficiency, also decreased in the intervention group.

CLOSING THE LOOP

The basic ecological sanitation loop (Fig. 22), generated by one of the workshop groups in an earlier session, includes several repeating steps:

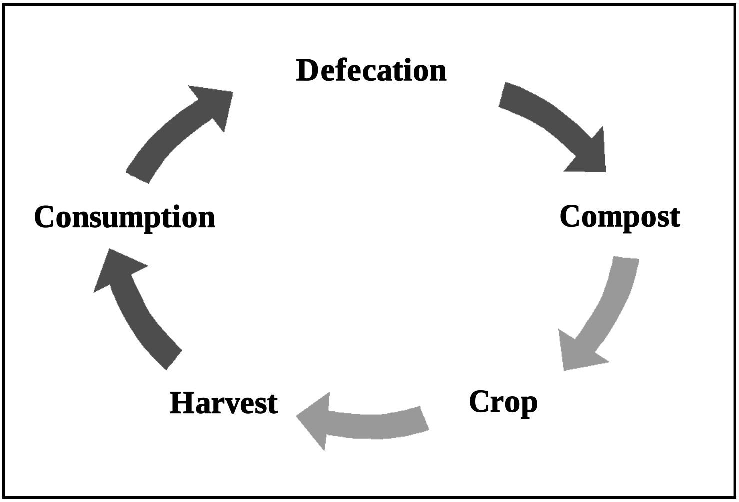


Figure 22:
Closing the loop - Ecological sanitation for food security

Workshop participants were divided into two groups to identify barriers or constraints to implementing a closed loop approach to sanitation at the household level. One group was asked to focus on the loop within a rural context, and the other was asked to consider the urban/peri-urban environment. The groups enumerated and finally grouped the barriers within the cycle.

The major barriers are cultural.

Although certain physical limitations were identified —particularly in urban settings where space is often very restricted and an entire family might be confined to a one-room dwelling, cultural factors were considered to be the major barriers that must be overcome. In many parts of the world, including Latin America, there is strong cultural resistance to handling and using human excrement for agricultural purposes, despite repeated examples of its use in different cultures. Moreover, these cultural barriers are often deeply imbedded within a particular view of one's world (cosmovision), which includes a range of perceptions that make it difficult for ecological sanitation to gain acceptance on a significant scale.

Other barriers include the lack of supportive policies and regulatory structures.

Lack of political will and favourable policy and regulatory structures were also identified as significant constraints. The groups agreed that there is inadequate support and advice available in order to create a cultural environment conducive to a closed loop sanitation approach. Policy makers need to be informed as to what they need to know and do to encourage households to adopt ecological sanitation.

A lengthy reflective discussion took place in plenary. Although there were some initial disagreements, which is to be expected from such a diverse group, the consensus was that:

There is a lot of consensus

The loop exists – and is necessary.

• The loop exists, and has existed in many places for a long time.

The practice of collecting and recycling human and animal manure is not new, and it has been and continues to be a common practice in many cultures throughout the world.

• **The loop is necessary.**

The urgency of our sanitation situation is recognized by only a few.

Business as usual done well, is not the same as doing the right thing. Reference was made to the Parable of the Frog. If you place a frog in boiling water, it will immediately try to get out. If you place a frog in water at room temperature, and slowly heat the water to boiling, the frog will never try to get out. Of course, by then it is too late! This was likened to humanity at this particular juncture in our evolution, and to the lack of recognition and appropriate response to the urgency of our sanitation situation.

"We have outbreaks of cholera in Bangladesh and Mozambique because of sewage discharges, and we still aren't doing anything." (Participant)

This comment is from a health perspective, however the frog parable is equally appropriate in the areas of nutritional deficiency, food insecurity and environmental degradation resulting from linear agricultural approaches.

• **The potential risks...**

Health and environment benefits can be produced by proper management and maintenance of ecological sanitation.

Although there are certain health risks if an ecological sanitation system is improperly managed and maintained, it was pointed out that the same is also true of any sanitation system, where by definition, at the outset we are dealing with a dangerous substance —untreated human faeces. A difference between ecological sanitation and conventional systems is that in ecological sanitation, we try to sanitise and make excreta safe at the place of excretion, whereas this is not the case in conventional systems.

"We've put man on the moon, we transplant hearts, but we still don't know how to sanitise human faeces." (Participant)

When we consider the potential risks of ecological sanitation, we should compare them to other risks, such as the known risks related to the use of agrochemicals.

"Although agrobusiness has been able to package their product well, I can't believe agrochemicals are less harmful than the product of my compost pile." (Participant)

The products of ecological dry toilets have a low content of chemicals and heavy metals, less than chemical fertilisers and much less than urban sewage.

In addition, the management and reuse of excrement at a household level may be significantly less risky than exposing families to pathogens through conventional sanitation systems. There are also risks with animal faeces. For example, the *mixing of E. Coli strains from various animal and human species has created a strain of higher virulence in humans (Participant).*

• Improving and expanding the loop...

It is important to avoid placing too much emphasis on the technical debate.

Although the groups identified specific technical issues (e.g. pathogen management) that will need to be resolved, it was suggested that scientists are often "better at disagreeing than at agreeing." The technical debate can lose sight of the overall objective and in so doing, lose the support of political constituencies.

"We need a common front! Frankly, the public doesn't care about the difference between humus and compost." (Participant)

Related to this comment was the recommendation to avoid being overly research oriented as we move forward. Rather, it was suggested that priority should be given to implementing a range of demonstration projects in different settings, in which research (e.g., on pathogen destruction, growing of food with urine, sociocultural barriers) would be only one component.

Strong emphasis was placed on development of multidisciplinary and holistic approaches. Two examples are especially noteworthy:

In Sweden, knowledge from health, agriculture, veterinary science and the social sciences has been integrated into a multidisciplinary approach.

"We needed background from different stakeholders, got some funding from diverse institutions (brought different departments into funding) and were able to do demonstration projects." (Participant)

The household livelihood security programming approach used by CARE International in Ecuador could be a useful tool for evaluating ecological sanitation. This holistic framework identifies seven interrelated aspects of livelihood security — including health, education, housing, economy, environment, food security and community participation— each with its own set of indicators.

Promoting the loop

It is important to work with and involve national and local governments in order to generate a supportive policy framework and informed civil servants and decision-makers. The Zimbabwe case is strong because there is a broad base of ownership, and ecological sanitation is currently accepted and promoted by health authorities.

Key players for promoting the loop, in addition to those who use excreta for productive purposes, are: governments, NGOs, schools and communities.

NGOs play a prominent role in promotion, awareness, hygiene education and implementation. NGOs act as intermediaries between local authorities and communities/households. In many communities and cultures, schools are also an important link to reaching individual families. Ecological sanitation is suitable for implementation by small-scale contractors and builders. Experiences in Mexico indicate that contractors can successfully promote and introduce both the concept and the technology.

Health/hygiene education is as important (or even more so) for ecological sanitation as for other sanitation systems. Ecological sanitation promotion can be easily integrated with community participation and empowerment approaches. Ecological sanitation and the PHAST approach have been closely linked in Eastern and Southern Africa, as well as in El Salvador in Central America.

Closed loop sanitation provides an opportunity for increased involvement of men.

Specific gender concerns must be considered when developing an effective communication and promotion strategy as much as for other sanitation options. Closed-loop (ecological) sanitation provides an opportunity for increased involvement of men, as they are interested in soil improvement, access to nutrients and increased agricultural returns.

Information and knowledge should be targeted to the needs of each stakeholder.

In order to create a critical mass of supporters for ecological sanitation, it will be necessary to generate enough knowledge to be able to convince the various stakeholders at the different levels. Although all the information should be available at each level, each of the key stakeholders will require targeted information to satisfy their own particular concerns. For example:

- A municipal official might want to see demonstrated evidence that public health safety is assured; and
- A municipal treasurer would need to be convinced of the economic benefits; whereas
- Community members might be swayed when they recognise that the ecological sanitation toilet represents potential savings at the household level and that its products can be a resource for generating income.

Information for policy makers should address:

Finally, policy makers would require a whole package of information, highlighting all or most of the following points:

Myths of water-borne solutions,

- Information countering perceptions that water-borne sanitation is safe and sound, and that commercial fertilisers are safe and productive. At the same time, it will be important to instil the belief that ecological sanitation is safe, sound and convenient —for the user, the farmer, and the consumer.

Safety of ecological approaches,

- Illustrations of the ways in which health aspects can be adequately addressed. With ecological sanitation it will be possible to provide safe sanitation for millions and even billions of people not currently being reached. If users are provided with adequate facilities and follow a few simple do’s and dont’s, faeces can be sanitised before being introduced and extended into the environment.

“Because we are competing with the WC, which is widely believed to be 'sound and safe,' it is important to minimise the health risks! Otherwise, we won't get acceptance. It is more difficult for us than for agrobusiness, because people didn't know about risks at their time of introduction.” (Participant)

Pollution

- Environmental aspects: everyone wants a healthy world, to end pollution, and enrich habitats.

Water security

- Water conservation: we are not using clean water to flush; and we are not mixing contaminated water with clean water.

Costs and

- Infrastructure costs: return on investment is much better in this system vis-à-vis conventional systems.

Value added by ecological sanitation.

- There is value added in the use of urine and faeces for crop production.

Although the closed-loop system with feedback into food production is necessary to achieve the greatest benefits and to assure that the system is sustainable, the other arguments will be of greater initial importance in selling the approach.

"Excreta out of water is a major benefit to water quality.

Excreta onto land is a major benefit to food security."

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AGENDA FOR ACTION

The last session of the workshop was devoted to concrete steps for filling the needs and gaps that have been identified for further expansion of the implementation of ecological sanitation approaches. Three action agendas were developed, addressing needs within regional contexts - the Mexican, the Latin American, and the Global Agenda.

Next Steps: Mexican Group

The Mexico group felt the ecological sanitation agenda could be advanced through tighter collaboration and exchange between groups and co-ordination between local practitioners and funding agencies. Two pathways for further activities were proposed: (1) forming an Ecological Sanitation Network in Mexico, and (2) organising workshops and other initiatives to increase knowledge, awareness, action and learning about ecological sanitation.

Network

A meeting of persons interested in ecological sanitation will be convened. The network will aim to bridge relations between related sectors, practitioners, researchers and funding agencies. The stakeholders (NGOs, multilateral agencies, and private sector) represented at the workshop and interested in participating were: UAEM (*Universidad Autónoma del Estado de Morelos*), UNICEF, UNDP, GTZ, INSP (*Instituto Nacional de Salud Pública*), CITA (*Centro de Innovación en Tecnología Apropriada*), *SARAR Transformación*, SC, *Espacio de Salud, AC*, and CEDICAR (*Centro de Investigación y Capacitación Rural*). The first meeting was planned for early January 2000.

Preliminary work plan:

- Further research on relevance and linkages of ecological sanitation to:
  - Pathogen survival related to use and maintenance of toilets
  - Urban agriculture
  - Sociocultural aspects
- Sharing of research results and lessons learned
- Design of promotion strategy

Workshops

- An *Ecological Sanitation Study Tour* to Mexico could be organised in 2000 for interested organisations in Latin America.

- Interdisciplinary Technical Workshop on Ecological Sanitation proposed by *Espacio de Salud* for the year 2001. Will investigate possibilities.

- Ecological Sanitation Participatory Methodology Workshop ("PHAST-plus") could be facilitated by SARAR Transformación. Funding will be needed to enable ongoing activities to be linked through the Network.

Next Steps: Latin American Group

The participants from other Latin American countries (CINARA, Colombia; CEPIS, Peru; CARE, Ecuador; World Bank El Alto Project, Bolivia) drafted a strategy for ways to improve the implementation approaches of ecological sanitation and to foster the closing of the loop by reusing products as fertilisers and adding to soil.

Strategies and Needs

- In light of sociocultural barriers, solutions are designed together with the community.
- In light of limited economic resources and time:
  - Carry out cost/benefit analyses.
  - Use approaches based on willingness and ability to pay.
  - Create financing mechanisms such as incentives, partial subsidies, credit lines and other possibilities.
- With regard to technological aspects, the proposals are to:
  - Identify gaps in technological issues.
  - Develop applied research involving states, universities, NGOs, and communities.
  - Limit negative external influences.
  - Design a practical strategy of social communication.
  - Promote favourable institutional policies through a strategy of communication and advocacy.

These strategies could be demonstrated through pilot projects and demonstrations, and the results could be disseminated.

Opportunities

- Build ecological sanitation and research into opportunities:
  - "Ecological Sanitation" Pilot Project in El Alto, Bolivia
  - Incorporate ecological sanitation into the School Sanitation Project (SANES), Ecuador
  - Ecuador-Peru binational W&S program, CARE-OPS / PAHO- USAID
  - Incorporate the approach and Pilot Program in Central America with the support of COSUDE (SDC-Swiss Development Cooperation).
- Share research results and lessons learned:
  - Disseminate during the World Water Forum in The Hague
  - A network and website in Peru for the "Promotion of the use of appropriate technologies"
  - Involve AIDIS (Asociación Argentina de Ingeniería Sanitaria y Ciencias del Ambiente) and RRASCA (Red Regional de Agua y Saneamiento de Centro América) in communication network.
- Design promotion strategies:
  - Existence of a community work strategy, Colombia.
  - A World Bank financed "PRAGUAS" program is in its design phase (e.g. Ecuador).

Next Steps: Global Group

The group of participants gathered under the "global approach" was mainly comprised of representatives from bilateral and multilateral agencies working in various regions, global NGO networks, and participants from regions other than Latin and South America. Four issues were identified to create more effective linkages between initiatives and agencies: 1) identification of stakeholders, 2) identification of entry points and opportunities for the introduction and application of ecological sanitation approaches, 3) applied research linked to training and 4) suggested ideas for networks and linkages.

Identify Stakeholders

- Those not served and underserved by sanitation
- Relevant ministries: agriculture, health, forestry, water, public works, education, finance, and communication
- Agrochemical industry
- Local level watershed management, relevant municipal authorities

- Regional authorities with transboundary responsibilities
- Information transmitters: international press and the local media, religious leaders, extension agents, schools
- Civil society, NGOs
- International organisations and donor organisations
- Researchers

Opportunities

Information can be packaged to address different interests and expand ecological sanitation under various conditions:

- High cost of fertiliser
- Water shortage
- Pollution
- Health-cholera outbreaks
- Synergy with new/existing programmes and initiatives
- Involvement of men – gender approach
- Alternative for inadequate infrastructure; e.g. economic and environmental benefits
- Environmentally-conscious segments of society, including home gardeners

Research leading to training

Need to fill knowledge gaps:

- Need benchmark information, situation assessment and problem analysis
  Contingency – changing situations
  Comparative studies
  Longitudinal studies (Economic analysis and health analyses).

- Learning (training, capacity building, etc.)
  Need for a simple and focused message regarding ecological sanitation
  Demonstrations, piloting, participatory programs
  Communication packages targeted at specific stakeholders.

Linkages

- Create an inclusive network for: information-sharing, filling knowledge gaps, lobbying for specific support, acting as a clearing-house
- Thematic networking (pathogen destruction, composting, and urban agriculture)

- Adding ecological sanitation to existing field projects (such as housing initiatives and soil conservation).

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CEIB	Centro de Investigaciones en Biotecnología
CEPIS	Centro Panamericano de Ingeniería Sanitaria y Ciencias del Ambiente
CIB	Centro de Investigaciones Biológicas
CINARA	Instituto de Investigación y Desarrollo en Agua Potable, Saneamiento Básico y Conservación del Recurso Hídrico
CITA	Centro de Innovación en Tecnología Alternativa A.C.
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit
INSP	Instituto Nacional de Salud Pública
PAHO	Pan-American Health Organization
PHAST	Participatory Hygiene and Sanitation Transformation
SARAR	SARAR Transformación S.C.
Sida	Swedish International Development Cooperation Agency
UAEM	Universidad Autónoma del Estado de Morelos
UNDP	United Nations Development Programme
UNICEF	United Nations Children’s Fund
WHO	World Health Organization

GLOSSARY

bacteria Any of a class of microscopic plants found living in soil, water, organic matter or the bodies of plants and animals. Some bacteria cause disease.

chamber A container, above or below the ground, that collects urine or faeces.

composting A biological process by which various living beings (e.g. bacteria, fungi and earthworms) break down organic matter to make humus for fertilising and conditioning land.

decomposition The process by which complex biological structures are broken down into elements or simpler compounds.

dehydration The process of losing water.

desiccate To dry up; dehydrate.

ecological Concerned with the interrelationship of organisms and their environment.

ecological sanitation A sustainable approach to human excreta management that prevents disease, conserves and protects water, and recovers and recycles nutrients.

ecological toilet A toilet, or device, designed to fulfill the aims of ecological sanitation.

ecosystem A community of organisms and its environment functioning as an ecological unit in nature.

excreta Waste matter discharged from an organism, including both faeces and urine.

faeces Bodily waste discharged from the bowels.

night soil Human faeces, sometimes mixed with urine, collected for fertilising the soil.

humus A brown or black material, rich in nutrients, resulting from partial decomposition of plant or animal matter and forming the organic portion of soil.

N/P/K Nitrogen, potassium and phosphorous, which are the principle elements found in urine, and chemical fertilisers.

nutrient A nourishing substance or ingredient.

organic matter A natural substance and potential fertiliser derived from living plant or animal organisms.

parasite An organism living in or on, and depending on, another organism for existence or support without making a useful or adequate return.

pathogen A specific agent (such as a bacteria or virus) that causes disease.

pedestal The elevated fixture where people sit, squat or stand to relieve themselves.

pH A measure of acidity or alkalinity. A pH of 7 is neutral; a pH less than 7 is acidic; and a pH of more than 7 is alkaline.

sanitation The promotion and practice of hygiene and the prevention of disease by maintaining clean conditions.

sanitise To make clean and free of disease causing agents.

sewage Refuse liquids or waste matter (including human excrement, greywater, and potentially hazardous chemical or mineral products) carried by sewers.

slab The platform that separates a pedestal from a chamber. It may be a floor or, in the case of a urinal, a wall.

urine Waste material secreted by the kidney, rich in end products of protein metabolism.

virus A submicroscopic infectious agent causing disease.

LIST OF PAPERS

Environmental Sanitation from an Eco-Systems Approach
Steven A. Esrey (UNICEF, New York) and Ingvar Andersson (UNDP/ESDG, New York)

Nutrition-Food-Based Approaches to Improve Nutritional Status
Steven A. Esrey (UNICEF, New York)

Ecological Sanitation in Zimbabwe - An Overview
Peter Morgan (Mvuramanzi Trust, Harare, Zimbabwe)

Experiences in the Use of Vermiculture in the Treatment of Organic Waste for the Production of Humus for Growing Human and Animal Food
Alfonso Nueva (Water and Sanitation Program/ World Bank, El Alto, Bolivia)

Health Security in the Reuse of Human Excreta from On-site Sanitation
Thor-Axel Stenström (Swedish Institute for Infectious Disease Control and University of Linköping, Sweden)

Integrating Urban and Peri-Urban Agriculture [Ua/P-Ua] and Urban Waste Management
Jac Smit (TUAN, Washington D.C.)

Available in PDF format at Mexican Ecological Sanitation Network–RedSeco web-site: http://www.laneta.apc.org/redseco

WORKSHOP AGENDA

SUNDAY – 17 OCTOBER

18:00 Evening vespers in the Monastery Chapel
19:30 Mexican supper

MONDAY – 18 OCTOBER

7.30 Breakfast
8.30 Introductory Plenary:
Ingvar Andersson – Workshop overview
Ron Sawyer – Workshop process / Participant's introductions
Group work: Mapping excreta flows from different sanitation systems
Presentation:
Peter Morgan – "Ecological Sanitation in Zimbabwe - An Overview"
13:30 Lunch
15:30 Field visit to:
César Añorve's home and workshop in Cuernavaca and
Santiago Tepetlapa in the Municipality of Tepoztlán, to observe functioning institutional and domestic dry toilets.
19:30 Cocktail
20:00 Buffet dinner

TUESDAY – 19 OCTOBER

7:30 Breakfast
8:30 Presentations:
Ingvar Andersson – EcoSan Overview
Plenary discussion
Thor-Axel Stenstrom - "Pathogen destruction and public health issues"
Working groups: Human excreta and health
13:30 Lunch
15:00 Presentations:
Steve Esrey – "Food-based approaches to improve nutritional status"
Jac Smit – "Integrating urban and peri-urban agriculture and urban waste management"

	Reports from recent related Workshops
	Poster session
	Introduction to Field Visit – CEDICAR video
20:00	Dinner

WEDNESDAY – 20 OCTOBER

7:30	Breakfast
8:30	**Field Visit to Mexico City**:
	CEDICAR Urban Agriculture Project
14:00	Lunch at Benedictine Monastery
16:00	Plenary panel discussion: Composting and Nutrition
	Group Work: Barriers to Closing the Loop
	Plenary report-back / discussions
19:30	Dinner
20:30	Special presentations and videos

THURSDAY – 21 OCTOBER

7:30	Breakfast
8:30	Working groups:
	Strategies for Overcoming the Barriers
	Next steps: pilot projects / research / action plans / linkages
13:30	Lunch
15:00	Plenary wrap-up
16:30	Closing Ceremony with Special Guests:
	Conclusions
	Poster session
19:00	Free Evening – Celebration

Sida Publications on Water Resources

This series covers issues on water resources from a development cooperation perspective. Sida's Department for Natural Resources and the Environment believes that the publications will be of interest to those involved in this field of work.

These documents are the results of Sida supported activities but do not necessarily represent Sida's policy. The views expressed are those of the author(s) and should not be attributed to Sida.

Copies may be obtained from:

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Previous publications on Water Resources:

1. *Water and Security in Southern Africa*
   Leif Ohlsson, University of Gothenburg

3. *Study of Water Resources in Zimbabwe*
   Ake Nilsson and Amanda Hammer

4. *A Liquid More Valuable Than Gold*
   Pierre Frühling

5. *Towards an Ecological Approach to Sanitation*
   Uno Winblad

6. *A Gender Perspective in the Water Resources Management Sector*
   Helen Thomas, Johanna Schalkwyk and Beth Woroniuk

7. *Most Worthwhile Use of Water*
   Jan Lundqvist and Klas Sandström

8. *The Mighty Mekong Mystery*
   Joakim Öjendal, Elin Torell

9. *Ecological Alternatives In Sanitation*
Jan-Olof Drangert, Jennifer Bew, Uno Winblad (Editors)

11:1 *Lake Victoria Basin, National Resources under Environmental Stress, Main Report*
Ehlin Consulting

11:2 *Lake Victoria Basin, National Resources under Environmental Stress, Annexes*
Ehlin Consulting

13. *Urban Water Demand Management in Southern Africa, The Conservation Potential*
Peter Macy, Sheldia Associates

14. *Ecological Sanitation*
S Esrey, J Gough, D Rapaport, R Sawyer, M Simpson-Hébert, J Vargas, U Winblad

15. *Water Hyacinth, its control and utilization: A global Review*
G Hill, M Cock, G Howard, CABI Bioscience and UICN

16. *Environmental protection, natural resources management and sustainable development in the Baltic Sea Region*
Bertil Hägerhäll. Ardena Milijö

17. *Swedish Experiences from Transboundary Water Resources Management in Southern Africa*
Jacob Granit

Ecological sanitation offers an alternative solution to the intractable problem of providing sustainable sanitation systems to the still unserved half of humanity, particularly those who reside in urban settings where conventional approaches are neither available nor affordable.

These alternative systems are designed on the cyclical principles of natural ecosystems. External inputs into the system, like water, and "wastes" that exit the system, like nutrients, are reduced to a minimum or eliminated entirely. Ecological toilets are designed to destroy pathogens close to where people excrete them, use no or very little water, and recover and recycle nutrients.

Ecological sanitation helps to solve some of society's most pressing problems - infectious disease, environmental degradation, water scarcity and the need to recover and recycle nutrients for plant growth. In doing so, it also helps to restore soil fertility, conserve fresh water and protect marine environments - all of which contribute toward food security. Ecological sanitation approaches foster local initiatives and leadership, including the establishment of labor-intensive workshops that manufacture urine-diverting toilets, community-based composting centers and home and community organic gardens.

Experts in sanitation, public health, agriculture, nutrition and participatory development gathered in Mexico in October 1999 for a workshop to address the ecosystem approach – Closing the loop - ecological sanitation for food security. This book captures the experiences from Mexico, other parts of Latin America and Zimbabwe in toilet designs, safe reuse of excreta and prospects for urban agriculture and food security.

We hope this publication will inspire others to consider ecological sanitation in their activities related to health, water, sanitation, urban development and food security.

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