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TOWARDS AN ECOLOGICAL APPROACH TO SANITATION

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

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Foreword

Waterborne diseases are the single most important cause of death and illness in the developing world. More than three million people are dying annually in waterborne diseases. Adequate sanitation facilities combined with proper hygiene training is a prerequisite to improving the situation.

About three billion people are today lacking adequate sanitation. Within 20 years from now, it is expected that an additional two billion people will live in cities, mainly in developing countries, demanding hygiene and safe sanitation.

Conventional waterborne sewage system has proven to be inappropriate to solve the sanitation needs in developing countries. Only wealthier upper- and middle class areas are normally provided with those services. Approximately 90% of the sewage in cities in developing countries is today discharged untreated, polluting rivers, lakes and coastal areas. Conventional pit latrines have certain limitations, especially in densely populated areas, with risks of contamination of groundwater etc. Further, there is a need to utilise the nutrients, especially in human urine, rich in nitrogen and phosphates, for agricultural purposes, thereby reducing the needs for fertilisers.

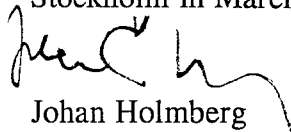
Furthermore, many of the rapidly expanding cities are located in arid or semiarid areas where water scarcity is, or will be, severe, reducing the volume of water available for sanitation.

In summary, there is an urgent need for new solutions in sanitation. In the paper "Towards an Ecological Approach to Sanitation" it is argued that there already exist technical feasible solutions based on dry sanitation¹. Promising pilot activities are briefly presented, both in developing and developed countries.

Social, cultural, organisational, behavioural, financial, economic and gender aspects of ecological sanitation are not fully covered in the paper. Further research, studies and pilot activities are needed to generate more experiences in those areas. We believe that ecological, dry sanitation options always should be considered in water and sanitation projects in order to improve environmental as well as financial sustainability.

We hope that the paper will contribute to a rethinking in sanitation, and we are grateful to Uno Winblad for stimulating the debate in this area.

Stockholm in March 1997



Johan Holmberg

Director, Department for Natural Resources and the Environment, Sida

¹ The Paper was presented at a Symposium in Japan and is published by permission of Japan Toilet Association and WHO

TOWARDS AN ECOLOGICAL APPROACH TO SANITATION

INTRODUCTION

Many of us have a bathroom; we turn a tap and get water, we flush the toilet and get rid of whatever we have put there. We take these facilities for granted. But most people in the world have no piped water in the house and many, according to WHO estimates nearly 3,000 million, lack even the most basic sanitation (WHO 1996).

In my speech today I shall discuss the theme of the Symposium, "the environment and toilets", in this global perspective. My conclusion is that we need a paradigm shift - a shift away from the present non-ecological, "flush-and-discharge" approach, to a holistic approach, taking account of the fact that sanitation is a system where the environment is an important component. What we need is ecological sanitation and to get that we must have ecological toilets. In this paper I shall present a tentative list of criteria for ecological sanitation systems. In the second half of my presentation I shall show examples of ecological toilets from around the world. The basic message of my presentation is: Don't mix!

Definition

I prefer to talk about "sanitation" rather than "toilets". A flush toilet is basically a machine for mixing human urine, faeces and water. Sanitation, on the other hand, is a system. The main components of that system are nature, society, process and device:

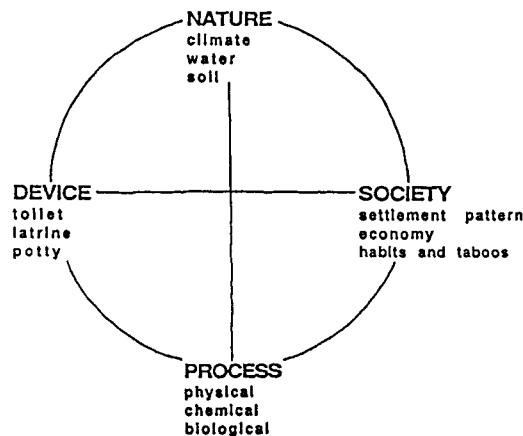


Fig 1: The main components of a sanitation system

When discussing sanitation, and particularly sanitation in relation to the environment, we have to consider all these components. We cannot afford to neglect any one of them.

THE CRISIS IN SANITATION

It is no exaggeration to state that sanitation is a problem that in many places around the world has reached crisis proportions (Black 1994). The main reasons behind this global sanitation crisis are rapid population growth and an unsuitable technological response.

Rapid population growth

The rapid population growth results in ever increasing densities, in urban growth, in the establishment of squatter areas and in a high burden of disease.

Densities

There was a time in history when sanitation was less of a problem - or no problem at all: the human population was small and dispersed over a large area.

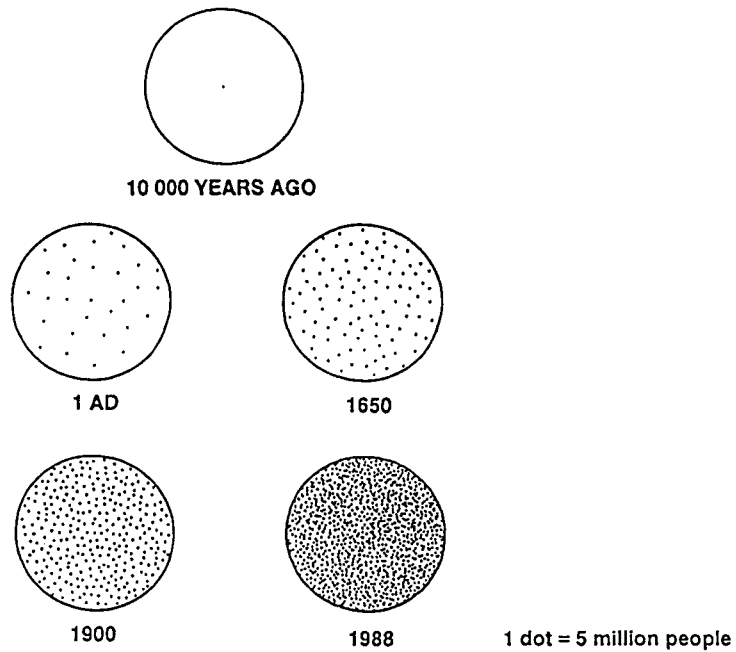


Fig 2: Human population changes over the last 10,000 years (Boyden and Dovers 1992)

But the situation is changing rapidly. The human population is now 1000 times greater than it was 10,000 years ago. Over the past 30 years it has doubled and it may double again in the next 40-50 years. One consequence of this population growth is that we now live closer together, at ever increasing densities, putting higher and higher pressure on the environment. The closer together we live, the more important it is for us to have access to, and make use of, good sanitary facilities.

Urban growth

Today 2,500 million people live in urban areas. Thirty years from now the urban population will reach 5,000 million.

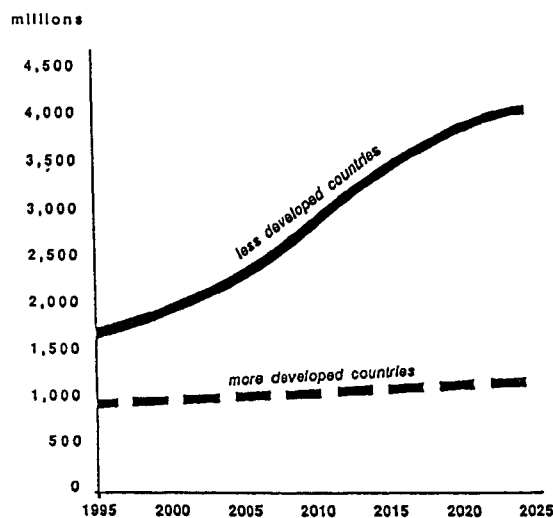


Fig 3: Urban population 1995-2025, less developed and more developed countries (UN 1995)

Squatter areas

If present trends continue the majority of urban dwellers in the world will live in unplanned, unserviced squatter areas in small and medium sized towns. The typical urban dweller of the next century is not going to live in a pleasant, comfortable flat or house, with paved streets, electricity, a sufficient, pure and reliable supply of water, flush toilet, garbage collection and everything else that we tend to take for granted. 20-30 years into the next century the typical urban dweller is more likely to live in a health threatening environment: in a temporary shack along a filthy unpaved lane, water collected from a communal tap with erratic supply or bought from a water vendor, no toilet, no garbage collection.

Disease burden

There is a marked difference in health between those who live in poor and in non-poor areas as reflected in the respective Infant Mortality Rates. Infant Mortality Rates (meaning number of infant deaths per 1000 live births in one year) are far higher in the poor sections of many cities than in better-off sections. The examples in the table below show that the Infant Mortality Rate in poor areas is 3-10 times higher than in the non-poor areas (EHP 1996).

	<u>poor</u>	<u>non-poor</u>
Manila, Philippines	210	76
Sao Paulo, Brazil	175	42
Guatemala	113	33
Karachi, Pakistan	152	32
Delhi, India	180	18

Poor environmental conditions give rise to high rates of diarrhoeal diseases, to helminth infections like Ascariasis and hookworm and to vector-borne diseases like malaria, dengue fever and Japanese encephalitis. More than 3 million people die of diarrhoea every year, most of them infants and young children. 1,500 million people are currently infected with intestinal worms, all of which are spread through human excreta (WHO 1995).

Unsuitable technological response

Conventional sanitation based on flush toilets, sewers and central treatment plants cannot solve these problems. Nor can they, in high density urban areas, be solved by systems based on pit latrines of different kinds.

Flush-and-discharge

Flush-and-discharge systems make the problems of sanitation much worse. Under these systems a relatively small amount of dangerous material - human faeces - is allowed to pollute a huge amount of water. In spite of this, flush-and-discharge is universally regarded as the ideal option for urban areas. Almost without question it is promoted in cities and towns around the world, even in poor countries where people cannot afford it and in arid areas where there is hardly enough water for drinking.

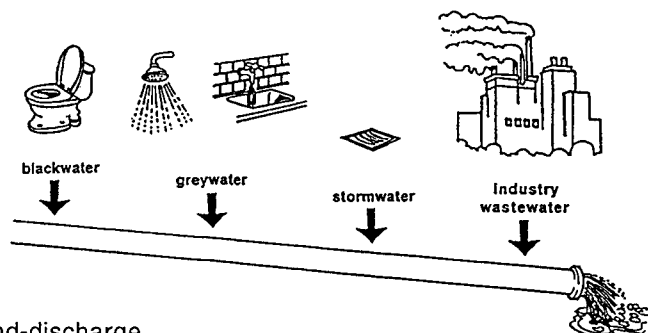


Fig 4: Flush-and-discharge

This glorification of flush-and-discharge is based on a number of assumptions:

- that the problem is one of "sewage disposal",
- that fresh water is an unlimited resource,
- that at the end of the pipe the sewage is treated, and
- that the environment can take care of the discharge from the treatment plant.

However, none of these assumptions is correct:

- the basic problem is the disposal of human faeces and urine, not "sewage",
- outright shortage of water is, or will very soon become, a major problem for most Third World cities,
- only a tiny fraction of all sewage produced in the Third World is treated, and
- all over the world we can find examples of natural ecosystems destroyed by the discharge of untreated or partly treated sewage.

Let me elaborate on each of these points:

Sewage disposal vs management of urine and faeces

A human body does not produce "sewage". Sewage is the product of a particular technology. The human body produces urine and faeces. These are often referred to as "human excreta" but it is important to remember that they are in fact two different substances which leave the body through separate openings and in different directions.

Each person produces about 500 litres of urine and 50 litres of faeces per year. 50 litres of faeces should not be too difficult to manage. It is not a very pleasant product and may contain pathogenic organisms. But the volume is small: when dehydrated actually no more than a bucketful per person per year. The real problem is that in the flush-and-discharge system faeces are not handled on their own. They are mixed with urine. This means that instead of 50 litres of a heavily polluted substance we have to take care of 550 polluted, dangerous and extremely unpleasant litres.

One of the reasons behind the unpleasantness of the mixture of urine and faeces is that they contain a bacterium, *Micrococcus ureae*, which when mixed with urine produces very bad smell (Wolgast 1993).

Water scarcity

A flush system does not work without water. To flush away our 550 litres in a sewered toilet each of us is using something like 15,000 litres of pure water every year. Most cities in the world don't have enough water to provide anything like that amount for each of its inhabitants. The typical Third World city solves this problem by providing flush-and-discharge only to the rich. Which of course means that there is even less water available to the poor.

Globally, some 80 countries with 40% of the world's population are already suffering from water shortages at some time during the year (UN Habitat 1996). Chronic fresh water shortages are expected by the end of the decade in much of Africa, the Middle East, northern China, parts of India and Mexico, the western United States, north-eastern Brazil and in the former Soviet Central Asian republics. China alone has 300 cities facing serious water shortages (UNDP 1996).

Wastewater treatment

95% of all sewage in the Third World is discharged completely untreated into surface waters (World Resources Institute 1992). Many cities do not have any sewage treatment system at all, and of those that do, most serve only a small fraction of the population.

Even where there is treatment, the vast majority of sewage treatment technologies in

use today still contribute significant amounts of pollutants to the environment. Even modern treatment facilities cannot cope with for example phosphorous and nitrogen. Nor are treatment plants designed to detoxify chemical wastes. Primary treatment simply filters out floating and suspended material; secondary treatment facilitates the biological degradation of faeces and urine and other similar material; and disinfection destroys infectious organisms. Most of the industrial and household toxic wastes released into sewers are either discharged into receiving waters, or remain in the sludge.

Ecosystem overload

In the past it was a common assumption that the pollution which results from conventional sanitation technologies can be safely assimilated by the environment. This assumption is not correct. Some chemicals will be decomposed and removed by natural processes, but most will remain in the environment. The inevitable end products of a sewage system are polluted waters and toxic sludge.

The four conventional sludge disposal methods are ocean dumping, landfilling, incineration and application on agricultural land. From an environmental point of view all these methods are unacceptable and from all over the world we have reports of the degradation of the environment due to sewage discharge and sludge disposal.

Drop-and-store

The alternative to flush-and-discharge is “drop-and-store”.

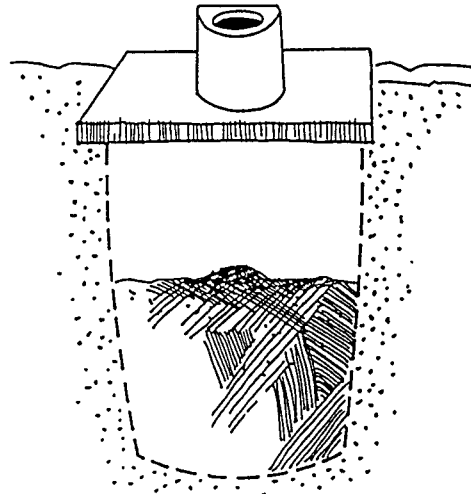


Fig 5: Drop-and-store

Such systems can be simple and relatively low-cost, and they are easy to understand and to operate. But they have many drawbacks: smell, fly breeding, risk for pit collapse, and often a relatively short life. From time to time new pits have to be dug. This may be difficult on crowded sites. In many cases drop-and-store systems cannot be used at all: on rocky ground, where the groundwater table is high and in areas periodically flooded. Recent experiments using biotracers indicate that the risk of groundwater contamination from pit latrines is greater than generally assumed (Stenström 1996).

Drop-and-store systems resulting in large numbers of excreta-filled pits are not feasible in densely built up urban areas. Nor is the Japanese *jokaso* system (“*jokaso*”: a Japanese technology for collection and treatment of nightsoil) a realistic option for poor countries. With manual collection the *jokaso* system is unacceptable for health reasons. With collection by vacuum pump truck as in Japan the system is extremely expensive in terms of initial investment, operation and maintenance.

A NEW APPROACH

Conventional sanitation in the form of flush-and-discharge offers no solution to the global sanitation crisis. We need a fundamental rethinking of the problem. We need a new approach, a new paradigm in sanitation.

The major question in sanitation today is: How can a rapidly growing city short of money and water and with limited institutional capabilities achieve safe, non-polluting sanitation for all its inhabitants?

A new approach to sanitation must be based on *equity, prevention and sustainability*. Sanitation systems of the future should

- ensure equity in the distribution of water
- prevent harm to human health
- achieve zero pollution discharge
- enable us to reuse human urine and faeces for food production
- adjust to small municipal budgets and low-income households
- offer a level of convenience comparable to that of conventional options

This new paradigm we can call *ecological sanitation*. The first principle of ecological sanitation is: *Don't mix!*

Don't mix:

- human urine and faeces
- human excreta and water
- black-water and grey-water
- household wastes and industrial wastes
- wastewater and rainwater

By keeping urine and faeces apart we reduce or even eliminate problems of bad odours and fly-breeding and we facilitate storage, treatment and transport.

Urine, if we don't want to use it, can be infiltrated or evaporated. Better still is to reuse it because urine contains nitrogen and phosphates in forms that are easily absorbed by plants. Urine, diluted with water, can be used directly in the garden or it can be stored and used at a later date.

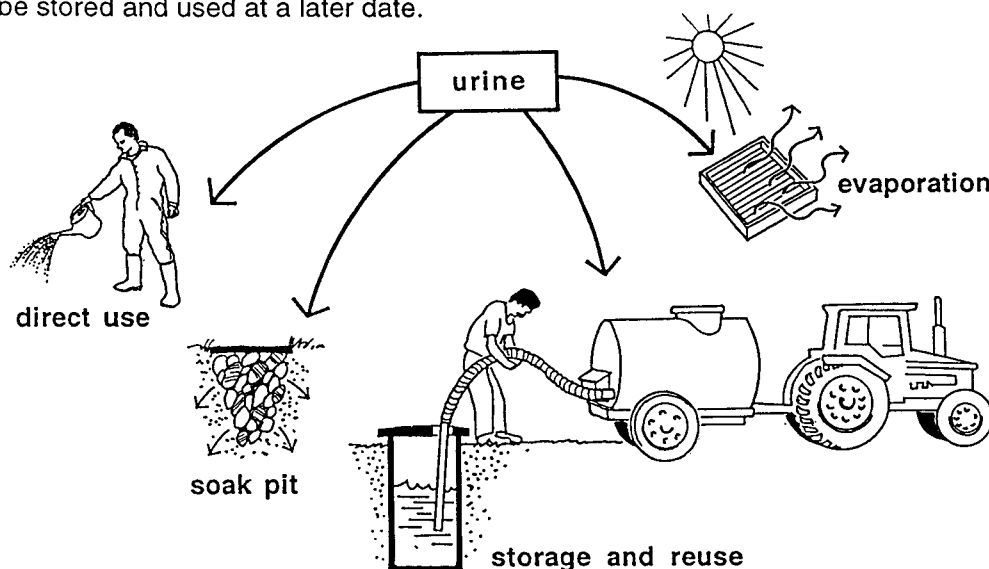


Fig 6: Alternatives for managing urine

Faeces can, if necessary, be processed in several steps before they are reused. In an ecological toilet, that is a dry toilet with urine separation, they are subject to primary treatment, basically dehydration, which also effectively destroys most of the pathogenic organisms. If this local primary treatment is insufficient, the dry output from the toilet can be transported to a neighbourhood composting station for secondary treatment. If a sterile product is required a tertiary treatment could be incineration.

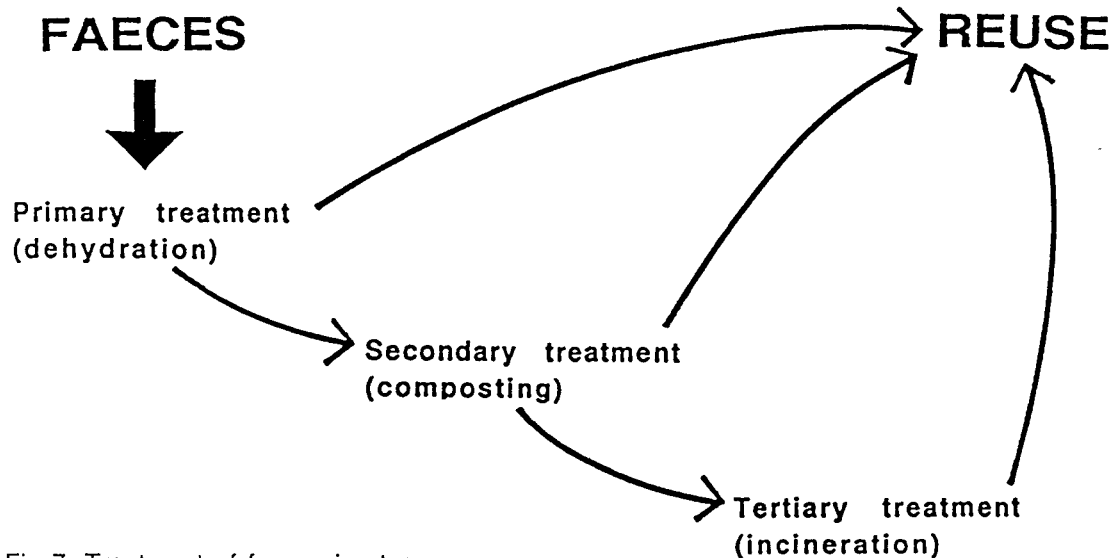


Fig 7: Treatment of faeces in stages

The amount of treatment required depends on the health status of the users as well as on the intended end use of the product. Most pathogenic organisms can be destroyed by the primary treatment taking place on site, usually through dehydration or decomposition. Where intestinal parasites are common, some form of secondary treatment may be required, for example high temperature composting. Tertiary treatment by for example incineration should not be necessary but remains an option in exceptional circumstances.

By not mixing human excreta and flushing water the sanitation problem is limited to managing a comparatively small volume of urine and faeces. We save a lot of water, we save on pipe networks and treatment plants, we create employment and we preserve the environment.

By not mixing greywater and blackwater we can use a number of relatively simple on-site treatment methods for the wastewater generated by food preparation and washing.

By not mixing stormwater and wastewater we can, with relatively simple methods, store, treat and recycle stormwater locally (Niemczynowicz 1994).

Industrial wastewater containing dangerous, poisonous chemicals must of course be taken care of at the source, by the industry where it is generated. All the heavy metals and toxic chemicals used in industrial processes must be retained in closed loops. This can be accomplished by the introduction of the polluter-pays principle. It is not a technical question because it can be done, nor an economic one because prevention is bound to cost less than treatment. The question is political.

EXAMPLES OF ECOLOGICAL SANITATION

“Don’t mix” is central to the new paradigm and to the concept of ecological sanitation. I shall now go through a number of concrete examples, some old, some new, from various parts of the world.

First a few words about the technicalities of keeping urine and faeces apart. The most straightforward method is of course never to mix the two. This way the urine remains relatively sterile and can be reused without any further treatment. Another possibility is to mix and then drain. The third possibility is to mix and then evaporate.

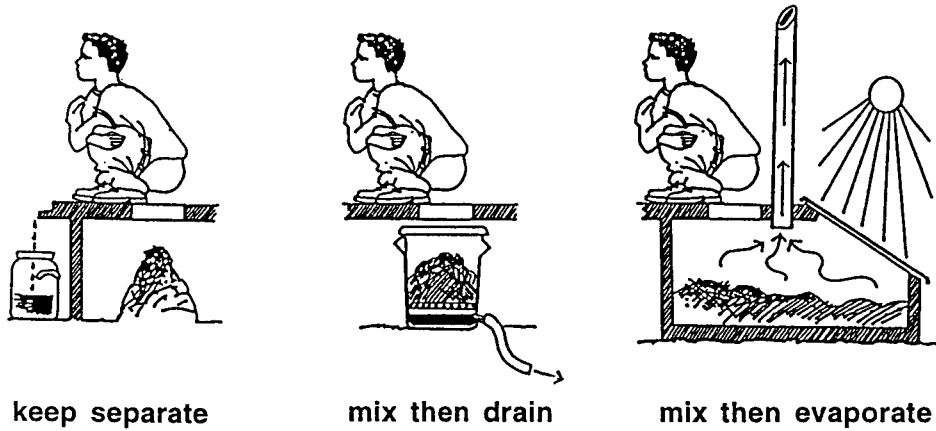


Fig 8: Ways of separating urine and faeces

The first example is from Yemen: a one chamber dehydrating toilet with urine separation placed in a bathroom several floors above street level. In a traditional Yemeni town house the upper floors have toilet-bathrooms next to a vertical shaft that runs from the top of the house down to the level of the street. The faeces drop through a hole in the squatting slab. The urine drains away through an opening in the wall of the house, down a vertical drainage surface on the outer face of the building. Anal cleaning with water takes place on a pair of stones next to the squatting slab. The water is drained away the same way as the urine. As Sanaa has a hot, dry climate the faeces quickly dry out. They are collected periodically and used as fuel. (Winblad and Kilama 1985.)

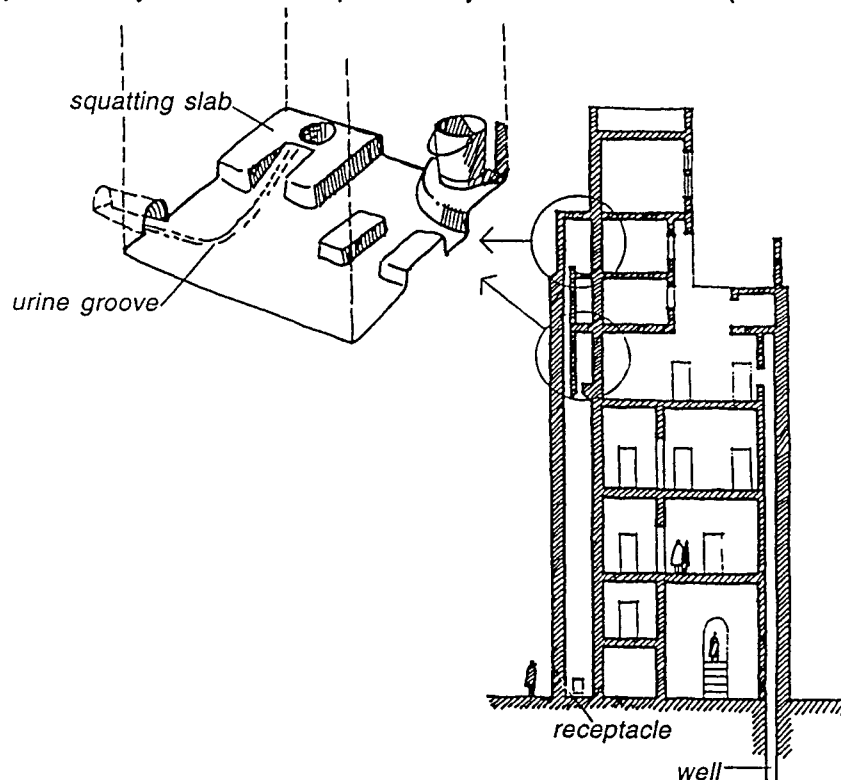


Fig 9: Section through a house in the old part of the town of Sanaa. On the upper floors there are bathrooms with urine separating toilets

The second example is from Vietnam and Guatemala. It is a two-chamber dehydrating toilet with urine separation. The toilet chambers are built above ground. Urine is collected and piped into a container or a soakpit. Faeces are dropped into one of the chambers, the other one is kept closed. Papers used for anal cleaning are put in a metal bucket and burnt.

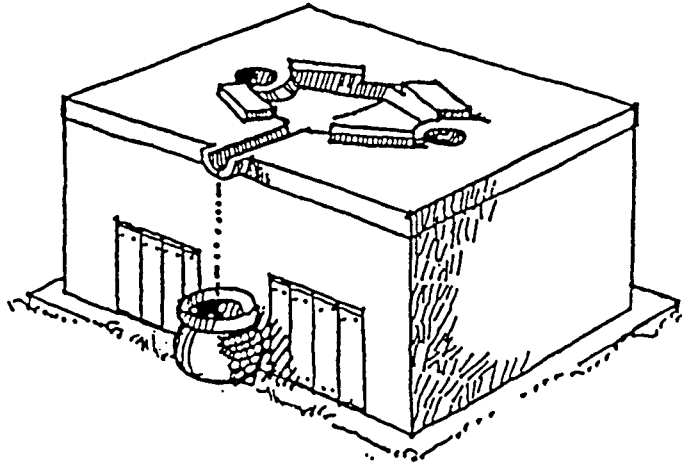


Fig 10: The Vietnamese double-vault, dehydrating toilet, here shown without superstructure. The LASF toilet in Guatemala is of similar design although provided with two seat-risers rather than a squatting slab with two holes.

Each time they defecate people sprinkle some ashes, lime or soil on the faeces. When the chamber is nearly full it is topped up with soil and the drop hole is sealed with mud. (In Guatemala a plastic bag is placed over the seat.) The second chamber is then used. When that one is nearly full, the first chamber is opened and emptied. The dehydrated faecal material is used as a fertilizer and soil conditioner.

This type of latrine is also used in high density urban squatter areas, for instance in Hermosa Provincia, in the centre of San Salvador, the capital of El Salvador.

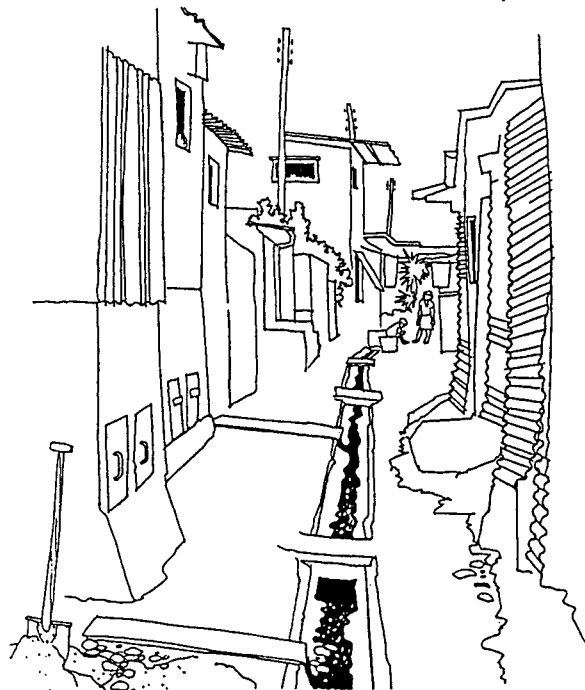


Fig 11: LASF toilets in a densely populated squatter area in central San Salvador

Ecological sanitation is not only for poor countries. In Sweden a number of ecological toilets have been on the market for many years. Here is one example (“WM Ekologen” system) based on urine separation and dehydration. Urine is stored in an underground tank until reused as a fertilizer. Faeces are dehydrated in a bucket directly under the toilet seat. The toilet is placed indoors. The system is usually combined with separate, on-site treatment of greywater.

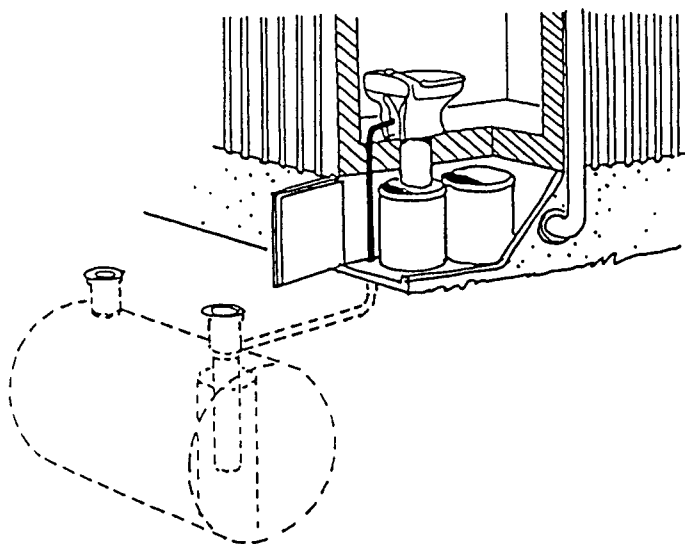


Fig 14: A dehydrating toilet with urine separation, Sweden

Another one, the Clivus Multrum, has no urine separation and is based on decomposition of faeces and organic household wastes. Urine and faeces are mixed with organic household refuse, in this case via a refuse chute from the kitchen. The chamber is placed in the basement, directly under bathroom and kitchen. This system is by now well tested in Scandinavia as well as in north America and has actually been on the market for nearly 50 years.

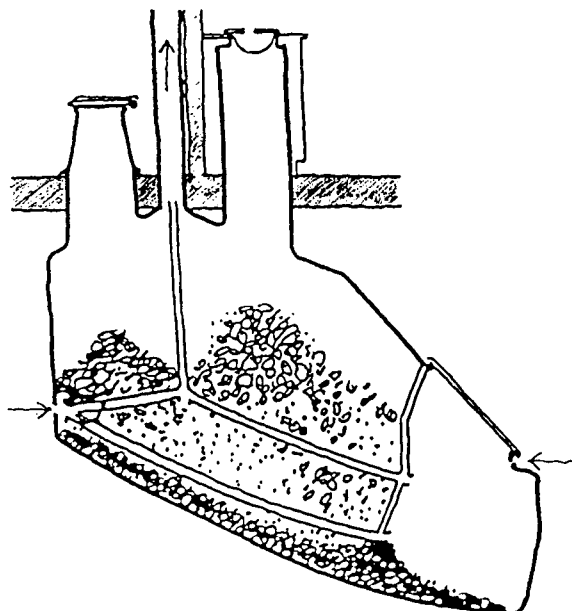


Fig 15: A composting toilet without urine separation, Sweden

The failure of conventional sanitation technologies to prevent pollution is of particular concern in small islands. Nearly every Pacific island nation has identified critical environmental problems resulting from conventional disposal methods. The CCD toilet in Kiribati was developed by Greenpeace in an attempt to achieve zero-discharge. It is a

single chamber composting toilet combined with a greenhouse for evapo-transpiration of urine and water. A nylon fishing net hanging from hooks imbedded in the chamber walls is used to separate solids from liquids. A mat woven from palm leaves sits in the net to catch solid materials deposited through the toilet seat. In some units strips of polyester from old clothing hang from the net to enhance evaporation by acting as wicks to draw up liquids into the airflow generated by the large diameter vent pipe. (Rapaport 1995).

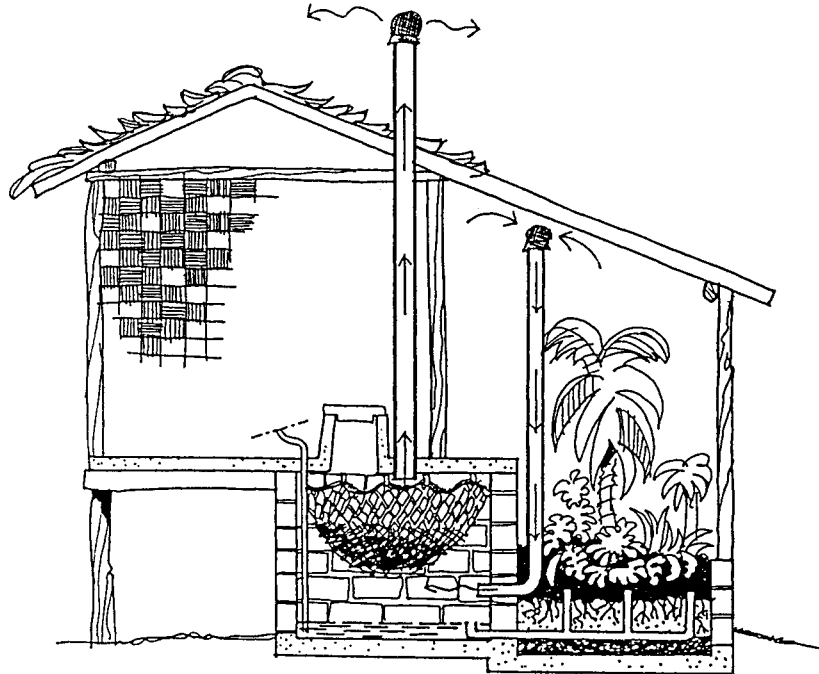


Fig 16: The CCD composting toilet with evapo-transpiration, Kiribati

Finally an example from Ecuador, high up the Andes mountains: a two-chamber, solar-heated composting toilet (Dudley 1993). At this altitude there is no need for urine separation. The natural evaporation takes care of any excess liquid. Although called a "composting toilet" it is more likely to function as a dehydration toilet.

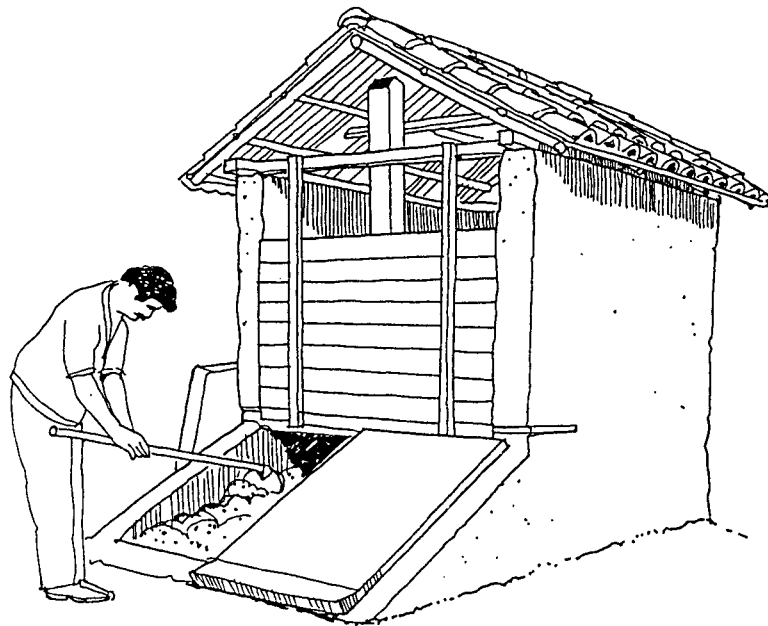


Fig 17: A solar heated dehydrating toilet developed by FUNHABIT in Ecuador.

These examples from around the world show that ecological sanitation exists, that it works and is feasible.

CONCLUSIONS

In this presentation I have raised a number of issues related to the environment and toilets. My conclusions are short and simple: *Don't mix! Don't flush! Don't waste!*

Don't mix urine and faeces - keep separate!

Don't flush away faeces - dehydrate!

Don't waste a valuable resource - fertilize!

For the future of our cities ecological sanitation is not only an option - it is a necessity!

REFERENCES

Boyden, S and Dovers, S (1992): Natural-resource consumption and its environmental impacts in the western world - impacts of increasing per capita consumption. In *Ambio*, vol 21, no 1, Stockholm.

Black (1994): *Mega-slums: the coming sanitary crisis*. WaterAid, London.

Dudley, E (1993): *The critical villager - beyond community participation*. Routledge, London.

EHP, Environmental Health Project (1996): Health and the environment in urban poor areas - avoiding a crisis through prevention. In *Capsule Report*, No 1, March 1996, Cambridge, Massachusetts.

Niemczynowicz, J (1994): New aspects of urban drainage and pollution reduction towards sustainability. In *Wat. Sci. Tech.*, vol 30 no 5, London.

Rapaport, D (1995): Sewage pollution in Pacific island countries and how to prevent it. Centre for Clean Development, Eugene, Oregon.

Stenström, TA (1996): Water microbiology for the 21st century. Paper presented at workshop 3, Stockholm Water Symposium, 7 August 1996, Stockholm.

UNDP (1996): Habitat II, Dialogue III: Water for thirsty cities, Report of the Dialogue, UN Conference on Human Settlements, June 1996, Istanbul.

United Nations (1995): *World urbanization prospects 1994*. New York.

UN Habitat (1996): Water crisis to strike most developing world cities by 2010. *Habitat Press Release*, Nairobi.

WHO (1996): *Creating healthy cities in the 21st century*. Geneva.

WHO (1995): Community water supply and sanitation - needs, challenges and health objectives. Report by the Director-General to the 48th World Assembly, Geneva.

Winblad, U and Kilama, W (1985): *Sanitation without water*. Macmillan, London.

Wolgast, M (1993): *Rena vatten - om tankar i kretslopp*. Creanom HB, Uppsala (in Swedish).

World Resources Institute (1992): *World resources, 1992-1993*. Oxford University Press, New York.

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