IRC International Water and Sanitation Centre -Delft
and
Vrije Universiteit Amsterdam - Instituut voor Milieuvraagstukken (IVM)
European Postgraduate Course In Environmental Management (EPCEM)

Small-scale wastewater and faecal sludges treatment and management in low-income rural and peri-urban communities in developing countries

Participation of small-scale private sector and community based organizations

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1. Introduction

This report is produced as a result of a two-month desk research on small-scale wastewater and faecal sludges treatment and management in low-income rural and peri-urban communities in developing countries. This research was part of internal IRC Water and Sanitation Centre research activities.

Marko Cacanoski, an environmental engineer and a Master student at the European Postgraduate Course in Environmental Management (EPCEM), has conducted the research. The student had to complete compulsory two-month internship.

The objective of this desk research was to make a synthesis of various case studies of relevant field experiences in the area of small-scale wastewater and faecal sludges treatment management, with the focus on the small-scale private sector and community-based organizations. The idea of compiling and analyzing the strong and weak points of the existing field experiences, aimed towards better understanding of the problem and gathering latest updates of the current developments in the field.

As mentioned above, the main target groups in this research were small-scale private sector and community based organizations (CBOs) in developing countries. Therefore, the focus was placed on usefulness of their participation in solving the problems of human excreta issues. The hypothesis is that the small-scale entrepreneurs and the business-oriented CBOs active in these settlements can have a significant contribution to the development of the environmental sanitation coverage and improvement of management of systems and use/re-use of human waste products for productive purposes.

The first part of the report gives to the reader general description of the wastewater treatment and management in developing countries focusing on treatment systems and levels, ways of how to treat wastewater and alternative treatment approaches. Furthermore, the issues related to the faecal sludges are briefly described in chapter 3, followed by introduction of ten selected small-scale treatment options. In addition, 33 various case studies and examples are presented in chapter 4. Several case studies in this chapter tackle the issues of various business opportunities associated with the treatment and reuse options. Chapter 5 focuses on involvement in wastewater and faecal sludges treatment/disposal/reuse through community based organizations (CBOs), small-scale private sector and various donor organizations. There are additional 18 case studies. Based on all the selected case studies and relevant literature, the conclusions are presented in chapter 6. Besides that, in the appendix there are several illustrations and tables referring to the core of the research topic. At the end, the list of sources used and contacts made during the research are included.

2. Small scale wastewater treatment and management

Wastewater management and treatment is costly and their benefit is often hard to be demonstrated. Even if low-cost solutions are being implemented many projects fail to deliver the expected outcome. The selection of an appropriate system for wastewater treatment and management entails a careful process based on technical, environmental, health, social, institutional, economic and financial considerations. The uniqueness of each situation makes it difficult to define universal solutions to the wastewater systems. For that reason, in this chapter, the reader will have brief introduction with general wastewater characteristics and possible types and levels of treatment in small communities.

2.1 What is wastewater?

Wastewater includes liquid wastes generated by households, industry, and commercial sources, as a result of daily usage, production, and consumption activities. Municipal treatment facilities are designed to treat raw wastewater to produce a liquid effluent of appropriate quality that can be discharged to the natural recipient with minimum impact on human health or the environment. The disposal of wastewater is a main problem faced by majority of municipalities in the world, particularly in poor communities in developing countries where treatment facilities are not managed properly or do not exist at all. Consequently, wastewater is considered as a serious health hazard in developing countries.

However, wastewater can be a resource that can be applied for productive uses since wastewater contains nutrients that have the potential for use in agriculture and aquaculture. Wastewater and its nutrient content can be used extensively for irrigation, as an energy source and other ecosystem services. The reuse of wastewater can bring positive benefits to the farming community, society, and municipalities. Nevertheless, wastewater reuse also exacts negative effects on humans and ecological systems, which need to be identified and assessed.

Though the actual composition of wastewater may vary from community to community, all municipal wastewater contains the following wide group of constituents:

- Organic matter
- Nutrients (nitrogen, phosphorus, microelements)
- Inorganic matter (dissolved minerals)
- Toxic chemicals
- Heavy metals
- Microorganisms

2.2 What is treatment, why proper management and treatment?

For every low-income community it is necessary to implement effective and cost-efficient wastewater treatment and management system. The most important reason is providing appropriate conditions for preserving human health. Untreated wastewater effluent contains pathogenic organisms, which include protozoa, bacteria, viruses and eggs of helminthes that are potential health hazard. The term treatment means separation of solids and stabilization of pollutants in the effluent. In turn stabilization means the degradation of organic matter until the point at which chemical or biological reactions stop. Moreover, treatment can also mean the removal of toxic or dangerous substances (heavy metals, nitrogen or phosphorous) that are likely to distort biological cycles, even after stabilization of the organic matter. (Sasse, 1998)

Chemical Oxygen Demand (COD) is the most common parameter to measure organic pollution. COD describes how much oxygen is required to oxidize all organic and inorganic matter found in the effluent. Biological Oxygen Demand (BOD) describes what can be oxidized with the microbial activity. Usually BOD is measured as BOD5 meaning that it describes the amount of oxygen consumed over a five-day measurement period. It is a direct measurement of the amount of oxygen consumed by organisms removing the organic matter in the waste. Furthermore, suspended solids (SS) describe how much of the organic or inorganic matter is not dissolved in water and contain settleable solids that sink to the bottom in a short time and non-settleable suspended solids. It is an important parameter because SS causes turbidity in the water causing obstruction of filters for example.

The management of wastewater can be divided into three (four) main categories:

- wastewater collection
- wastewater treatment
- treated wastewater disposal and/or treated wastewater reuse

2.3 Systems for treatment

Wastewater must be properly managed to avoid public health problems. Three types of wastewater management systems can be used to treat wastewater: on-site systems, cluster systems, and centralized systems. Usually the division of the systems is the following one:

- Onsite systems in outlying areas
- Cluster systems in small residential subdivisions
- Centralized systems in populated urban areas

In this paper, the focus will be on the onsite systems as the most appropriate systems for low-income and small peri-urban and rural communities in developing countries. However, recent studies do not exclude cluster systems as an option in many cases.

Onsite systems

Septic systems handle the wastewater from one house on site. These systems are very frequent in small communities where often homes are not close together. Septic systems consist of a tank that holds the wastewater solids and a drainage field where the tank effluent is distributed. In the leach field, natural processes purify the liquid as it drains through the soil. Conventional septic systems work best on large lot with deep, permeable soils. A variety of alternative onsite system designs are available to accommodate a range of difficult site and soil conditions. The most appropriate system depends on factors such as how permeable the soil is, how high the water table is, and how shallow the bedrock is. Inadequately sited, designed, installed, or maintained septic systems can result in surface ponding in yards. Surface ponding that continues for an extensive period is considered a health hazard and requires corrective action. This is very often a case in many developing areas in the world. Because maintenance is the only factor that can be controlled once an onsite system is installed, a program of inspection and/or pumping is advisable. This approach, combined with public education to ensure that homeowners are putting only appropriate materials down the drain, is the easiest to implement. Repairs and replacements should be done by professionals (e.g. local private companies) with the approval of local authorities, since exposure to inadequately treated sewage and hydrogen sulphide gas presents a health risk.

Cluster systems

In communities where individual onsite systems are inappropriate, either because lots are too small or because land characteristics, make them unreasonable. In this situation, a cluster system might be appropriate option. A cluster system uses *low-cost alternative sewers* to collect wastewater from homes in the area and transport it to a reliable, low-cost, easily operated treatment facility. This system can be suitable for communities up to 100 homes. Several types of alternative sewer systems can be used to collect and transport wastewater from residences to the treatment facility. The treatment facility is usually a larger version of an individual onsite system, such as subsurface soil absorption systems or sand filters. As with any treatment system, a maintenance program is essential to ensure proper operation of a cluster system. Compared with conventional collection and treatment systems, cluster system *requires minimal maintenance*.

Centralized systems

In more densely populated communities, where many cluster systems are needed and onsite systems are not practical, a centralized wastewater system might be required. Constructing conventional sewers to collect the wastewater, however, is almost never practical for small communities because of the *high cost*. Conventional sewers usually account for over three-quarters of the total cost of a conventional wastewater collection and treatment system. Many types of technologies are available for treating wastewater at a centralized plant. Natural treatment technologies use natural processes associated with soils, vegetation, or wetland environments to treat wastewater and include land treatment, lagoons, slow sand filters, and constructed wetlands. These systems generally require larger land areas than mechanical systems. Wastewater must be treated (usually by sedimentation or lagoons) before application to land, filters, or wetlands.

2.4 Possible levels of treatment

Wastewater treatment options can be classified into groups of processes according to the function they perform and their complexity.

Preliminary treatment includes simple processes that deal with solid material. The purpose of preliminary treatment is to remove those easily separable components. This is usually performed by screening (usually by bar screens) and grit removal. Their removal is important in order to increase the effectiveness of the later treatment processes. Primary treatment is mainly the removal of solids by settlement. Simple settlement of the solid material in sewage can reduce the polluting load by significant amounts. It can reduce BOD by up to 40%. Some examples of primary treatment are *septic tanks*, *septic tanks with up flow filters*, *Imhoff tanks*.

In *secondary treatment* the organic material that remains in the wastewater is reduced biologically. Secondary treatment actually involves harnessing and accelerating the natural process of waste disposal whereby bacteria convert organic matter to stable forms. Both aerobic and anaerobic processes can be in use in secondary treatment. Some examples of secondary treatment are reed bed systems, trickling filters and stabilization ponds.

Tertiary treatment is the polishing process whereby treated effluent is further purified to the acceptable levels of discharge. It is usually for the removal of specific pollutants e.g. nitrogen or phosphorus or specific industrial pollutants. Tertiary treatment processes are generally specialized processes. Some examples of tertiary treatment are bank's clarifiers, grass plots, etc.

In the literature we can find so called *advanced or quartiairy treatment* that is applicable only to industrial wastes to remove specific contaminants and it is not in focus of this paper.

2.5 What is important when making wastewater treatment choice?

Effluent quality

The treatment option selected should produce effluent quality that is up to standard with regards to the various quality measurements: BOD, suspended solids, nitrogen, phosphates etc. Different technologies provide different levels of waste treatment, removing contaminants by various methods. All options must be carefully considered with respect to the treatment quality that is provided for by the different technologies. This is an important criterion and is the determining factor in the effectiveness of the different technologies chosen.

Water supply

Water is used in waste disposal mainly for the transport of sewage from one place to the next even though it is used in the biological degradation of organic matter to a certain degree as well. The assumption made is that there is enough water supplied for this use as well as sustained for continuing future use for either purpose. Water is placed here in the criteria because it is a key aspect in differentiating treatment options. It would be difficult to transport the sewerage to another site to be treated without use of water. This allows only one option for on-site treatment, by the use of *composting toilets*.

Land space

The reason for a limited land space requirement is that land issues are always a problem and must be handled carefully. In a rural community, land may be owned by many families each claiming their own piece. Land secured for waste treatment would be difficult to get. This is also placed high on the list because often there is limited land available and this needs to be taken into account when choosing a technology.

Operation and maintenance

It is assumed that a certain degree of maintenance is required and also a skilled personnel to do maintenance and operational duties when required. The maintenance of a wastewater treatment system is then left up to the villagers themselves after implementation where it is assumed that at least one villager has the competence to supervise the operation and maintenance of the system. Although the operation and maintenance of the system may be reviewed from time to time by the relevant parties it is most often left to the villagers themselves in the long run. The proper maintenance of the chosen system would be a limiting factor in terms of the sustainability of the project at the village level, as it has been seen from past experiences that most often maintenance has not been adequate. To overcome this, proper training for maintenance and operation should be made available to people (or companies) who are responsible for this task. Treatment options should be intended towards relatively low maintenance systems.

Cost

Considering the financial position of the inhabitants in the targeted type of communities, support may be provided by various sources. On a village level, funding may be provided by the assistance of local government departments or foreign aid programs. Initially there would be cost of construction after which the running costs may come into effect (e.g. maintenance). Also, in the last chapters of this paper the role of CBO's and private sector will be analyzed. There, the cost issues will be more elaborated.

2.6 Alternatives for wastewater management*

1. Total on-site management of wastewater

    - Greywater and black water (separated): grey water treatment and reuse on-site and blackwater treatment and reuse on-site
    - Greywater and blackwater (combined): treatment and reuse on-site

2. Combination of off-site and on-site management of wastewater

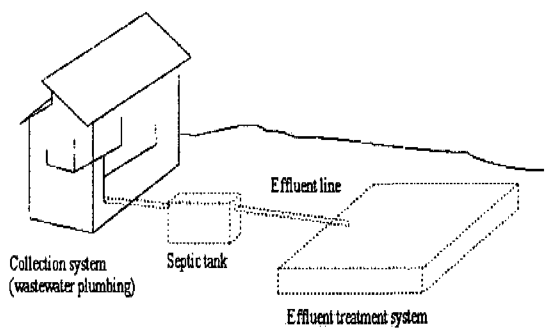
Greywater and black water separated

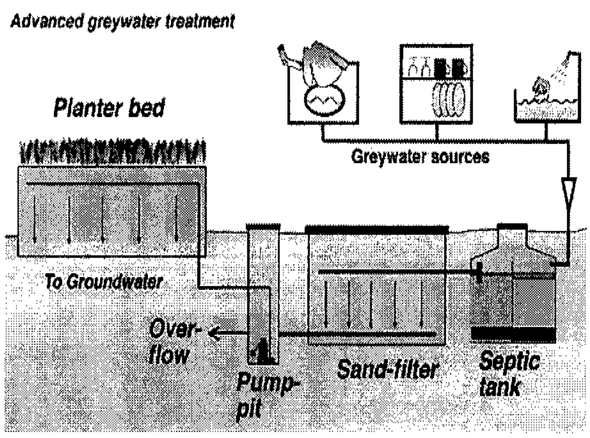
- Greywater and blackwater (separated): greywater treatment and reuse on-site and blackwater primary treatment on-site and further treatment and reuse off-site
- Greywater and blackwater (separated): grey water treatment and reuse partly on-site and partly off-site and blackwater primary treatment on-site and further treatment and reuse off-site
- Greywater and blackwater (separated): greywater treatment and reuse off- site and blackwater primary treatment on-site and further treatment and reuse off-site

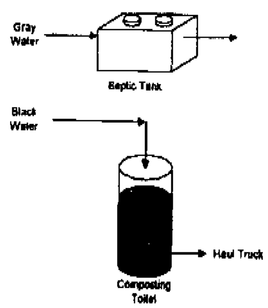
Greywater and blackwater (combined): primary treatment on-site and further treatment and reuse off-site

3. Total off-site management of wastewater

Wastewater collection and transportation for treatment and reuse off-site (conventional sewerage)







3. Faecal sludge treatment and management

3.1 Introduction

In rural and urban areas of Africa, Asia and Latin America, the human excreta disposal problem is serious. On a daily basis, thousands of tons of faecal sludges from on-site sanitation (OSS) systems are disposed into lanes, drainage ditches, onto open urban spaces and into aquatic natural recipients. Faecal sludges are disposed or used in agriculture untreated in the majority of known cases, creating health risks. In many communities, dumping sites are close to formally or informally inhabited, low-income areas where they threaten the health of this growing segment of population. Compared to wastewater treatment technology, the development of options to treat faecal sludges has long been ignored. The sludges accumulating in on-site systems are mechanically or manually collected and then delivered to places of discharge or direct agricultural/aquacultural use. In very few cases, the FS are treated. In general, design and operational guidance for FS treatment options and technologies in developing countries are still lacking.

Urine

Human urine can be used as fertilizer by the producer household or else collected at a communal level and used by commercial farmers. Most of the plant nutrients in human excreta are found in the urine. An adult may produce about 400 litres of urine a year containing 4.0 kg of nitrogen, 0.4 kg of phosphorus and 0.9 kg of potassium. Interestingly, these nutrients are in ideal forms for uptake by plants: nitrogen in the form of urea, phosphorus as super phosphate and potassium as an ion. The total quantities of nutrients in urine are more appropriate when compared with the quantities of nutrients in the chemical fertilizers used in agriculture. The heavy metals concentrations in human urine are lower than those of most chemical fertilizers an important advantage. When urine is collected for use as a fertilizer, it is important to store it in such a way as to prevent odours and the loss of nitrogen to the air. Ammonia loss to the air can be minimized by storage in a covered container with restricted ventilation.

Faeces

The simplest form of recycling human faeces is when the individual household can use the product as fertilizer in its own garden or on its own farmland. Human faeces consist mainly of undigested organic matter such as fibres made up of carbon. The total amount per person per year is 25 to 50 kg containing up to 0.55 kg of nitrogen, 0.18 kg of phosphorus and 0.37 kg of potassium. Although faeces contain fewer nutrients than urine, they are a valuable soil conditioner. After pathogen destruction through dehydration or decomposition the resulting inoffensive material may be applied to the soil to increase the organic matter content, improve water-holding capacity and increase the availability of nutrients. Humus from the decomposition process also helps to maintain a healthy population of beneficial soil organisms that actually protect plants from soil-borne diseases. In urban situations not all householders will have either the land or the inclination to use the product themselves.

3.2 Selected issues on the FS treatment and management

In contrast to sludges from WWTP and to municipal wastewater, characteristics of faecal sludge differ widely by locality (from household to household; from city district to city district; from city to city) (Montangero and Strauss 2002). A basic distinction can usually be made between fresh, biochemically unstable and "thick" vs. "thin" and biochemically fairly stable sludges (Heinss et al. 1998). Unstable sludges contain a relative large share of recently deposited excreta. Stable sludges are those, which have been retained in on-plot pits or vaults for months or years and which have undergone biochemical degradation to a variable degree (e.g. septage, which is sludge from septic tanks).

FS are sludges accumulating in septic tanks, aqua privies, family pit or bucket latrines and unsewered public toilets. Proper FS treatment, either in combination with wastewater or separately, is being practiced in a few countries only (e.g. Argentina, Ghana, Benin, Botswana, South Africa, Thailand, and Indonesia). *Treatment options* used comprise batch-operated settling/thickening units; non-aerated stabilization pond; combined composting with municipal organic refuse, extended aeration followed by pond polishing. However, FS is a highly concentrated and variable material. This implies that *FS cannot be considered as a kind of wastewater.* Treatment thus calls for specific treatment schemes and design criteria. Because of the high variability of this material, the design of a treatment system should not be based on standard characteristics but rather on the results obtained on a **case-to-case basis**. While substantial resources have been invested into the development of wastewater technologies, both low and high-cost, sustainable FS treatment technologies still require large inputs of field research, development and testing before they may be propagated as "state-of-the-art" options.

FS management has not kept up with the rapid pace at which household-level sanitation became upgraded through the installation of septic tanks. Traditionally, most FS was manually collected for use in agriculture. Replacement of bucket latrines by septic tanks calls for a different mode of FS collection, both technically and organizationally, if the uncontrolled dumping of septage is to be avoided. The need to devise improved FS collection management and appropriate treatment for septage has been recognized by city authorities. FS treatment will be based on physical decentralization, using modest- scale treatment works strategically located at the city outskirts.

The use of double-pit latrines should allow eliminating pathogens before pit emptying and hence to reduce potential health risks related to sludge handling and disposal or reuse. Sludge transport to a treatment site would not be necessary anymore; it could be used directly as soil conditioner on the nearest agricultural plots. However, the principle of alternate use of pits requires a change in behaviour. All projects involving the construction of double-pit latrines must therefore allow for a prolonged support program (Franceys et al, 1992).

Using small to medium-size, semi-centralized FS treatment plants may help to minimize faecal sludge haulage volumes and mileage. As an example, the plants might comprise solids-liquid separation and dewatering. The separated liquid either might be treated at the same site or be transported away in solids-free sewers for centralized treatment. Sludge volumes are inversely proportional to the solids content. Assuming that the dewatering process (e.g. by sludge drying beds) yields a reduction of the water content from 98 % to 75 % (equivalent to an increase of the solids content from 2 % to 25 %), the dewatered sludge volume to be transported would be 12 times smaller than the raw FS volume. These treatment systems could also include co-composting of faecal sludge (separated solids) and organic solid waste.

4. Available small-scale technologies

4.1 Introduction

This overview of available small-scale *treatment* options for low-income communities in developing countries does not aim to be complete. The options were selected from the web pages of several leading companies and organizatioOns who are involved in this business, and numerous randomly selected case studies and other types of reports. This part does not aim to illustrate the mechanisms of collection of wastewater or faecal sludge or advantages and disadvantages linked with the cost, construction and maintenance issues. Both wastewater and faecal sludges treatment options are presented in this part of the text. Some of the options are supported with examples from the field. For example, during the literature search, I found the following information. Known faecal sludges treatment plants in developing countries are several:

Indonesia has implemented approximately 100 plants (pond schemes, some of which are preceded by Imhoff tanks). Many plants reportedly are under loaded or non-functional. In *Jakarta,* there are 2 plants including extended aeration followed by facultative and maturation ponds. In *Thailand* there are several known low-cost schemes (digesters + drying beds + ponds) in provincial towns and high-tech plants (physical-chemical treatment followed by activated sludge) in metropolitan Bangkok. In the city of *Ho Chi Minh* (Vietnam) there is a known case of existing drying ponds with existing sale of bio solids. In Nam Dinh (Vietnam), there are plans for implementation of constructed wetlands.

In *Ghana,* there are two treatment plants in Accra and one in Kumasi. Additional smaller faecal sludges treatment plants - FSTP (all pond-based) exist. Furthermore, there is one pilot co-composting scheme in Kumasi. In Bamako (*Mali*) there are plans for two FSTP (constructed wetlands and ponds). In Ouagadougou (*Burkina Faso*) there is one plant for co-treatment in ponds (under construction). In Tanzani *(Botswana)* there is a know case of co-treatment with wastewater in ponds. In *South Africa* there is existing co-treatment of FS with wastewater in activated sludge plants.

This data are taken from several SANDEC publications. The authors of the publications are not aware of any FS management scheme or initiative, where responsibilities and tasks would have been devolved to community based organisations (CBOs) or individual beneficiaries. Exceptions are reported by Muller (1997) and Rijnsburger (2002) for places where MAPET, the manual pit emptying technology, has been developed and introduced (in Dar es Salaam, Tanzania, in the early nineties; in Barumbu, Democratic Republic of Congo, in 2001). This case will be presented later in the text.

4.2 Brief overview of the technologies

4.2.1 Arborloo

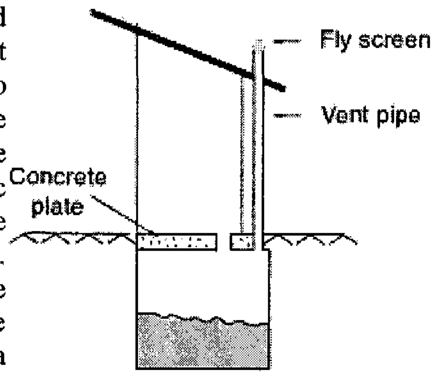
Source: Peter Morgan (Harare 2000)

The arborloo is a simple pit latrine built over a shallow pit. The slab and superstructure are portable and move on a never-ending journey from one shallow pit to the next. Soil, wood ash and leaves etc are regularly added to the pit as well as excreta that assist in the formation of soil-like humus in the pit. Full pits are topped up with soil and planted with young trees. The end result is a "sanitary orchard," "wood lot" of fruit and other trees scattered around the garden. The concept of the *arborloo* is being promoted and tested in countries like Kenya, Mozambique, Malawi, South Africa as well as Zimbabwe, where it is thought to have **considerable practical application**. The potential for its use throughout Africa is enormous.

Because the method and concept is simple and yet retains the basic elements of ecological sanitation, it is thought of as a good first step along a route of increasing sophistication within the realm of ecological sanitation. It is, for instance, possible to upgrade the *arborloo* and make a *Fossa alterna,* moving quite simply from a series of single pits into a permanently sited alternating double pit system (*Fossa alterna*). By slight modification or replacement of the latrine slab (making a vent pipe hole), the system can be upgraded further to a VIP latrine.

4.2.2 Pit latrine

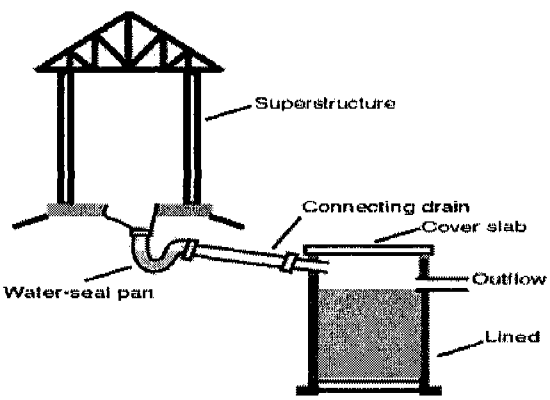
Source: UNEP



A pit latrine collects excreta in a pit dug in the ground beneath the toilet structure. If the soil is loose the pit needs to be lined with, for example, loose bricks to prevent the wall from collapsing. During storage in the pit decomposition of the organic substances takes place under anaerobic conditions. The anaerobic decomposition releases gases (carbon dioxide, methane and sulphuric gases) and reduces the volume of sludge. Seepage of water into the surrounding soil takes place through the sides and bottom of the pit. During seepage further decomposition of organic matter by soil bacteria takes place reducing the BOD of the water. The pit will eventually fill with faecal sludge and needs to be emptied. The period between emptying depends on the size of the pit and its usage. It is desirable to design the pit to store at least one year of sludge production. Emptying requires mechanical suction of the sludge. The sludge requires treatment prior to re-use or disposal. Two adjoining pits can be used alternately. Further decomposition of sludge in a full pit takes place while the adjacent pit is in use. Its content after further decomposition can be manually removed. An alternative way of dealing with a full pit is to dig another pit and relocate the sanitary platform and toilet housing to the new pit.

4.2.3 Pour flush toilet

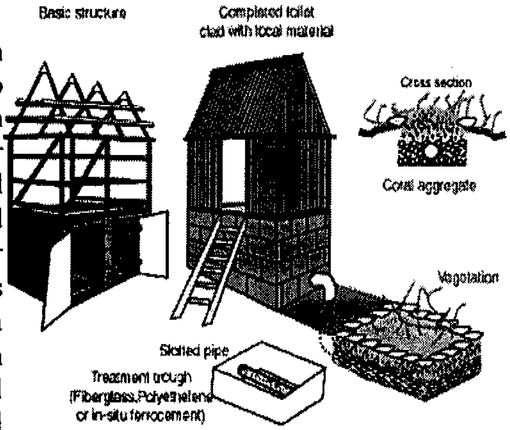
Source: UNEP



A pour flush toilet has a water seal. The problems associated with odor and insects are avoided by having the water seal. Excreta deposited in the latrine pan are flushed by pouring 2 to 3 l of water into it. The mixture is directed into a pit in the same way as for a pit latrine. The processes of biodegradation of the organic wastes in the pit are exactly the same. More water percolates through the soil surrounding the pit, and the potential for groundwater pollution is higher. A pour flush toilet with a pit is therefore not suitable when groundwater table is close to the surface. Sludge has to be regularly emptied from the pit. The use of two adjoining pits alternately enables the sludge in a full pit to undergo further decomposition while the other pit is being used, and enables manual sludge emptying after further sludge decomposition. With the use of the pit latrine, composting toilet and pour flush latrine, greywater has to be separately treated. Greywater can be reused directly or after treatment. Disposal of greywater on-site is by use of a leach pit or trench. Limitations of disposal of greywater by leach pit or trench are similar to those applicable to septic tank.

4.2.4 Composting Toilets

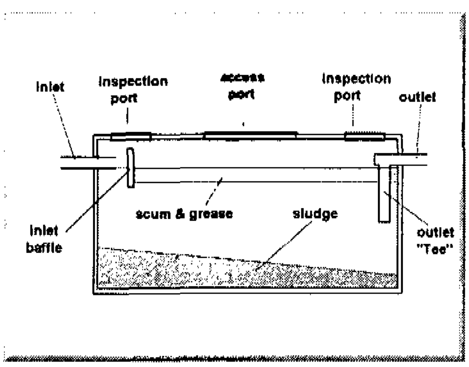
Source: Rotaloo Composting Toilets



Composting is a natural process through which organic material is decomposed and returned to the soil, which is then acted upon by organisms in the soil producing a valuable soil conditioner (humus). In a composting toilet, no water is used and human waste and other organic material (dried leaves) are deposited into a digestion chamber where aerobic bacteria decompose solid portions and liquids are left to evaporate through a specially designed ventilation system. Digestion chambers will take a certain period of time to fill up depending on the particular system and finished compost can be carefully removed avoiding contact with hands and can be buried in a shallow hole or trenched around roots of trees. This system requires manual removal and disposal of finished composting material after a period of time. Finished compost can still be contaminated with pathogens and should always be handled with care.

4.2.5 Septic Tank

Source: Sasse, L. 1998



Septic tanks are designed for **on-site** treatment of domestic sewage and are small, rectangular chambers situated just below ground level where sewage is retained for 1-3 days. They usually consist of 2 compartments with the first larger then the second. Solids settle to the bottom of the tank where they are digested anaerobically. A thick crust of scum is formed at the surface and helps maintain anaerobic conditions. Some sludge accumulates at the bottom of the tank that needs regular *desludging*. Biogas is produced in a septic tank as sludge decomposes and gas rises to the surface as bubbles. The gas then accumulates on the surface above the liquid from where it should allow escaping into the air. This is rough primary treatment prior to secondary or tertiary treatment. Septic tank effluent still contains pathogenic bacteria, cysts and worm eggs. In addition, both greywater and blackwater can be flushed through the septic tank system. Since only accepts liquid waste must be connected to a flush toilet. Therefore, it is not suitable in the regions where there is inadequate water supply.

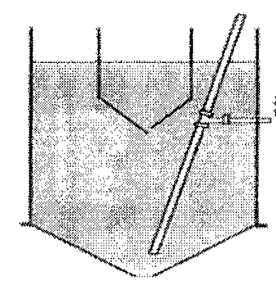
4.2.6 Septic tank with up flow filter

Source: Septic tank with up flow filter, Mara, D

This is essentially a septic tank with an Up flow Filter that is incorporated directly after the second chamber of the septic tank. Effluent after leaving the second chamber of the septic tank is directed upwards through the bottom of the filter before exiting to be disposed of either in leach fields etc. It is also mainly designed for on-site treatment of domestic sewage. In the up flow filter the effluent enters at the base and flows up through the layer of coarse aggregate, which is then discharged over a weir at the top. Anaerobic bacteria grow on the surface of the filter material and oxidize the effluent as it flows past. Disposal of the effluent may be into a stream or into soakage pits etc. Filter may be expected to operate without maintenance for 18-24 months. Need to then drain filter and wash it with freshwater. Septic tank needs regular desludging. Filter and the septic tank can be cleaned together.

4.2.7 Imhoff Tank

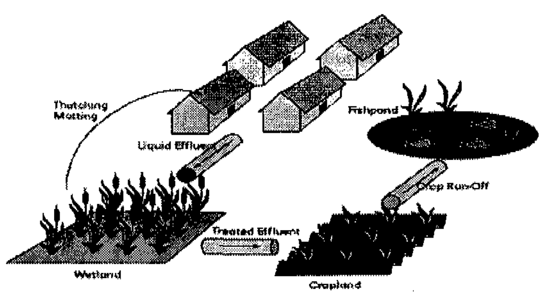
Source: Sasse, L, 1998



Imhoff tanks are used for domestic or mixed wastewater flows where effluent will undergo further treatment. The Imhoff tank is divided into an upper settling compartment in which sedimentation of solids occurs. Sludge then falls through opening at the bottom into the lower tank where it is digested anaerobically. Methane gas is produced in the process and is prevented from disturbing the settling process by being deflected by baffles into the gas vent channels. Effluent is odourless because the suspended and dissolved solids in the effluent do not come into contact with the active sludge causing it to become foul. When sludge is removed, it needs to be further treated in drying beds or such for pathogen control. Since they only accept liquid waste it must be connected to a flush toilet. Not suitable where water supply is scarce or unreliable. Both greywater and blackwater can be flushed through the system. It requires removal of scum and sludge at regular intervals.

4.2.8 Constructed wetlands

Source: SANDEC



Constructed wetlands usually consist of gravel/sand/soil filters planted with growing plants such as reeds, bulrushes or cattails. Three pilot constructed wetlands planted with cattails have been studied since 1997 at the Asian Institute of Technology (AIT) in Bangkok. The 25 m2 pilot plant treats the septage from around 3,000 people. The infiltrate is collected and pumped into an attached-growth waste stabilization pond system. The objectives of the project were to assess the suitability of this option for the treatment of septage and establish design and operational guidelines. Open questions remain, in particular with regards to the agricultural reuse of treated sludge and infiltrate. A pilot project is planned and should allow obtaining answers to several questions as well as to confirm the recommendations.

4.2.9 Co-treatment of faecal sludge and wastewater

Source: SANDEC

In cities of Latin America, the majority of households that benefit of sanitation systems are usually served by sewered sanitation. Many small towns, however, are largely or even fully served by on-site sanitation systems. In Alcorta (Santa Fé), a town of 4,000 inhabitants, 35% of the population is connected to a sewer system whereas 65% use septic tanks and cesspools that are emptied by vacuum trucks. A series of two stabilization ponds was put in operation in 1987 to treat both wastewater and septage. A monitoring program of the system discovered that the capacity of the first pond had been reduced in half due to the high solids content of septage. Based on these investigations conducted by the University of Rosario, a septage pre-treatment consisting of two sedimentation ponds was constructed in July 1998. The two ponds are operated alternatively: one pond is loaded while the sludge accumulated in the other one is drying. The idea is that the settled sludge should be easy to handle and partly mineralized/hygienized at the end of the drying cycle. The effluent of the sedimentation ponds is co-treated with wastewater in a series of two waste stabilization ponds.

4.2.10 Settling tanks and waste stabilization ponds for the treatment of faecal sludge

Source: SANDEC

Field studies were conducted at the Achimota Faecal Sludge treatment plant in Accra/Ghana from 1993-97 to assess the performance of two parallel sedimentation/thickening tanks and a series of four ponds treating the supernatant from the solids-liquid separation step. The treatment plant receives around 150 m3 FS/day; 20 to 40 % of which originate from unsewered public toilets and 60 to 80% from septic tanks. The first treatment step consists of a solids-liquid separation in two parallel, batch-operated settling/thickening tanks. The intensive anaerobic degradation of the fresh public toilet sludge which has been stored for 1-2 weeks only prior to collection taking place in the settling tank causes the solids to rise to the surface and thus obstructs effective settling. Results of 4 years of monitoring reveal that the performance of the sedimentation tanks strongly depends on the plant's state of maintenance and operation. The loading and resting periods should not exceed 4 to 5 weeks each. In practice, the tanks are emptied every 4 to 5 months, only. This reduces the efficiency of the solids-liquid separation process considerably.

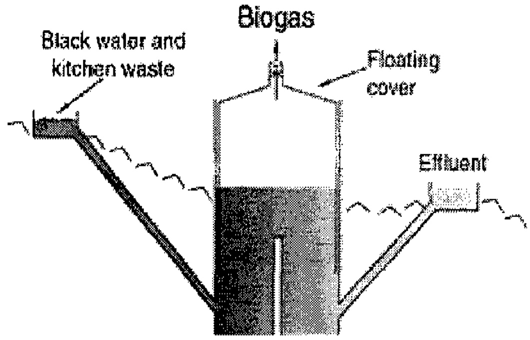
4.2.11 Composting with Organic Solid Waste ("Co-Composting")

Source: SANDEC

Co-composting, i.e. the combined composting of faecal matter and organic solids waste is practiced all around the world, usually in small, informal and uncontrolled schemes or on a yard scale. Apparently, most of this proceeds at ambient temperatures, are with concomitant inefficient inactivation of pathogens. In contrast to this, thermophilic composting, i.e. the composting at 50-60 °C, is an effective process for pathogen destruction while stabilising organic material and creating a valuable soil conditioner- cum-fertilizer. Co-composting of sewage treatment plant sludge with organic solid waste is widely practiced in industrialized countries. The SANDEC staff is not aware, though, of any thermophilic co-composting scheme treating FS and organic waste, except for one scheme in South Africa, which was operational from 1992-96, and in which bucket latrine sludge was co-composted with municipal waste. The scheme was closed down when the bucket latrines were replaced by a sewerage system. SANDEC, in collaboration with IWMI-West Africa and the Municipality of Kumasi (Ghana) have recently started investigating FS and organic solid waste co-composting on pilot scale. FS, which is composed of high-strength sludge from unsewered public toilets and of septage, is dewatered to the required solids content by sludge drying beds or, alternatively, thickened in a primary settling pond. The FS-organic waste mixture is windrow-composted for a period of 1 month (thermophilic phase) followed by a maturing phase of 1-2 months. The raw mixture is composed of 1 part dewatered FS vs. 3 parts sorted waste. Matured compost, produced at a rate of 1 ton/month, will be tested in comparative planting trials to ascertain its marketability.

4.2.12 Anaerobic digestion with biogas utilization

Source: SANDEC



This option may, in theory, be perfectly suited to treat higher-strength FS, which have not undergone substantial degradation yet. Such sludges may comprise the contents of unsewered public toilets, whose vault contents are emptied at relatively high frequencies of but a few weeks. There exist, in practice, two types of digestors, viz. fixed and floating dome units. Although, where urine is mixed with faeces, the C: N ratio of the FS is too low to generate maximum gas yields, the option might nevertheless proof technically and economically feasible under specific local conditions. The only biogas systems known to the authors, who are operated on FS as exclusive organic feed are plants attached to public pour-flush toilets operated by Sulabh, an Indian NGO, for municipal authorities. There are, reportedly, approx. 70 such plants in operation. NEERI (India) conducted applied research on FS-fed biogas plants in the sixties and seventies. Biogas plants processing FS mixed with cattle dung are presumably being operated in many developing countries as small, decentralised schemes serving one or several households or institutions. Yet, the authors do not avail of and have not collated information on such schemes. Gaps-in- knowledge pertaining to FS-fed anaerobic digestion pertains to supernatant post- treatment, settled solids evacuating and hygienization; costing and affordability, mainly. Although anaerobic digestion with gas utilization has been an option widely proposed for sludge treatment and energy recovery, the number of respective schemes implemented in developing countries has remained rather low. A possible reason might consist in the relatively high investment cost of such plants and the concurrent low affordability by target users. Further to this, removal of accumulated solids from the digestors appears to be a difficult task, which has caused many such plants to turn unexploited.

4.3 Case studies (disposal, treatment and reuse of wastewater and faecal sludge)

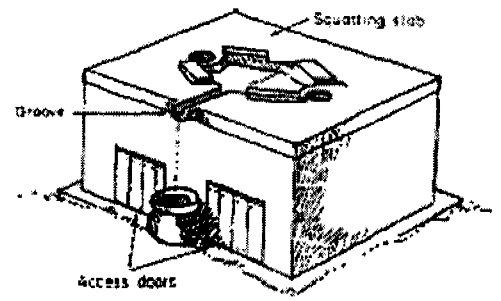
Kumasi (Ghana)

One of the most critical waste disposal problems of the city of Kumasi is the disposal of nightsoil and septage from public latrines, household bucket latrines, and septic tanks. The current system of human waste management in Kumasi is inadequate; waste removed from the public and bucket latrines end up in nearby streams and in vacant lots within the city limits creating an unhealthy environment. Many government offices, schools and private institutions require improved sanitation facilities. The Kumasi Metropolitan Assembly (KMA) with the assistance of the UNDP/World Bank Water & Sanitation Program (now the World Bank Water & Sanitation Program) produced a Strategic Sanitation Plan for Kumasi (SSP-Kumasi) for the period 1990-2000. The SSP-Kumasi recommended the use of simplified sewerage in the high-density area, latrines in the medium-density areas and WC/septic tanks in the high-cost/low- density areas. The city and beneficiaries on a 50:50 basis would share the cost of household latrines equally. The construction of new public sanitation facilities was encouraged in markets, schools and light industrial areas, while existing public bucket latrines were phased out. Two faecal sludge treatment plants were planned, one of them is built and ready to be commissioned, the construction of the second one in ongoing. (Source: SANDEC)

The double-vault dehydrating toilet in Vietnam

The classic example of an ecological sanitation system based on dehydration is the Vietnamese *double-vault toilet.* It is widely used in northern Vietnam and over the past 20 years the concept has also been used successfully in Central America, Mexico and Sweden. In northern Vietnam it used to be common practice to fertilize rice fields with fresh excreta. As this was a dangerous practice the health authorities in 1956 started campaigns to construct double-vault dry toilets. Long and persistent health education programmes followed the campaigns. The objective of the new toilet design was to *kill pathogens before the faeces were spread on the fields.* The Vietnamese toilet consists of two processing chambers each with a volume of about 0.3 cubic metres.

The toilet is built entirely above ground with the processing chambers placed on a solid floor of concrete, bricks or clay.



Vietnamese double-vault latrine

Source: Rybczynski et al. 1982

The toilet is often placed at the back of the garden, sometimes next to a pigpen. People excrete in one of the chambers. Before the vault is used for the first time, the household members cover the floor with a layer of powdered earth. The purpose of this earth is to absorb moisture from the faeces and to prevent them from sticking to the floor. After each use people sprinkle two bowls of ashes over the faeces. The ashes absorb moisture, neutralize bad odours and make the faeces less attractive to flies. Urine drains away through the groove in the slab and collects in a jar behind the toilet. Paper used for anal cleaning is dropped in box or jar and burnt. Thus in the receptacle there are only faeces, ashes and soil. The contents are therefore fairly dry and compact. The jar for collection of urine can be placed in position either empty or partly filled with water, lime or ashes. The urine or the urine-soaked ashes are used as a fertilizer. In Vietnam the experience of this system is mixed. There is no doubt that the system, when properly used, does function very well. A retention time of 2 months seems, however, rather short for total pathogen destruction. The real problem in northern Vietnam though is that *some farmers tend to empty the processing chambers whenever they need fertilizer*, regardless of the retention time. (Source: SIDA)

Decentralized wastewater treatment - new technologies for Vietnamese conditions

In this case study the decentralized schemes of wastewater management are proposed for medium and small cities of Vietnam. The decentralized approach is a new means of addressing wastewater management needs of sewered and unsewered areas in a comprehensive fashion. The basic idea of that is to treat the wastewater (possibly together with refuses) on-site by means of low-cost treatment systems, and make direct use the treatment products (water, compost, and biogas). This alternative can meet a sustainable wastewater management requirement and has a promising future, especially for developing country of Vietnam, where the water and sanitation issues are becoming a more and more important issue and are under new period of infrastructure development. Nowadays there are 571 cities and towns in Vietnam. The country is under rapid urbanization and industrialization process, with positive indicators in socio-economic development. However, there is an increasing problem of water pollution. There is very low ratio of population served by adequate sanitation, especially in rural, peri-urban and poor urban areas. Urban sewerage and drainage systems are still poor and under degradation. In most of cities and towns, flood and inundation often occur in rainy season. Existing sewer networks (if any) in cities have been built for surface water drainage only. Mainly domestic wastewater from houses is directly discharged to the common sewerage network and then flows to the canals, lakes and ponds without any treatment. In consequence, self-purification capacity of receiving water bodies is overloaded and it causes surface and ground water pollution, impacting directly to the health of community, reducing the value of environment. More than ever, development of urban sewerage and drainage systems in Vietnam has become an urgent need. In Vietnam, the septic tank is the most common on-site treatment facility in urban and peri-urban areas. In Hanoi, there are about 10,000 septic tanks in operation for treatment of the domestic wastewater. In urban centres the ratio of households equipped with septic tanks is nearly 50-80%. In the rest parts of the city the ratio is 20-30% (Hanoi PC, 1998). Desludging of septic tanks is not often followed. There is still subsidizing form of management of public utilities including wastewater management, without or with very poor public involvement. Thus, looking for the appropriate solutions for wastewater management is becoming very hot issue and is to be paid adequate attention, especially in this period of increasing urbanization, industrialization, improvement and development of water supply and sanitation facilities.

In Vietnam, most of septic tanks are often extremely outdated and damaged. They are not repaired and regularly overloaded, while sludge is not emptied regularly. Surveys and analyses carried out by CEETIA in the period 1998 - 2001 showed that most of septic tanks were under designed, and are operated with rather low treatment efficiency. In case of land availability, stabilization ponds in chain and constructed wetlands could be economically appropriate alternatives. For on-site wastewater effluent improvement, additional chambers could be constructed for individual household or group of households treating wastewater after existing septic tanks. (*Source: 5th Specialised Conference on Small Water and Wastewater Treatment Systems Istanbul-Turkey, 24-26 September 2002*)

Dry sanitation in Morelos (Mexico)

This case study is experience of Cesar Anorve who promotes a modified version of *Vietnamese double-vault toilet* in Mexico. The innovation includes up-scale urine diverting toilet seat. In addition, urban gardening project where human urine is used is described. The major accomplishments include the design of the toilet seat. The constructor advocated squatting (as the original) rather then seating for health reasons. The vast majority of the toilets were made of cement and sand. This technology is adaptable to several climates. Several applications were explored in rural areas, suburban zones, cities and apartments. Most of the demand for dry sanitation comes from low-income rural communities without access to water. It is impossible to identify a precise figure for the number of dry toilets in Mexico, but he sold more then 6000 toilet seats. His vision of project's self-financing capacity is interesting. They have chosen to limit the project to small-scale production, where producer of the toilet has to promote the product's use through workshops. The most important objective is to strengthen local economies by creating local jobs, using local materials, requiring minimal investment and using simple technology. The author's opinion is that the market should respond positively. The separated urine has been used in family scale gardening. ANADEGES project involves 1200 families who are producing vegetables in reused containers with worm-composted kitchen waste, urine and leaves. The following case study illustrates the most interesting moments of this project. (Source: UNDP/SIDA)

Growing vegetables (Mexico City)

In response to rapid inflation, high unemployment and inadequate nutrition in Mexico City, Anadeges (a network of CBOs), has perfected a method of growing vegetables in containers using human urine as a fertilizer. The project was launched in Mexico City in 1988 and more than 1,200 urban households are currently participating. The technology used was selected and adapted to fit the local circumstances, which include no land available for conventional kitchen gardens, participants unable to afford the required investment in containers and fertilizers, and the need for growing containers of lightweight materials to allow rooftop cultivation. Vegetables are grown in containers. This soil is made from the bottom layer of plant material from previous year's containers, which has composted into rich humus, and household garbage, which has been composted with worms. Urine, which has been stored in containers for 3 weeks, is applied to the containers after dilution with water on a 1:10 ratio. The problem of how to provide adequate space to grow root crops or very wide leafy vegetables was solved by using discarded car tires. The Anadeges experimental centre in Mexico City is now testing a prototype machine for cutting and turning used tires inside out to form wide-mouthed containers that have sufficient room for crops of this type. After several years of study, certain conclusions are now obvious from this low-cost urban production of organic vegetables. Plants fertilized with urine grew more rapidly, larger and healthier than those grown with conventional agricultural techniques and less water was needed. Plants that produce edible leaves (for example spinach, Swiss chard, parsley, as well as nopal, a nutritious, widely available cactus) performed particularly well. Leaves were big and dark green in colour. Some fruit-bearing plants grew well and produced abundantly, particularly chillies, the hot peppers essential in the Mexican diet, although they were not as hot as those conventionally grown. Other fruit-bearing plants, such as tomato, tomatillo (green tomato), squash, bean, cauliflower and cucumber, responded well during the early stages, but did rather poorly in terms of fruit yield. All plants did particularly well in their early stages and proved remarkably resistant to insect pests and diseases. Anadeges sells a kit to each family. A kit consists of 10 containers; three tyres turned inside out, a wide variety of plant seedlings, and a kilogram of worms (*Eisenia foetida*), to assist with garbage composting. About 80% of the cost of the starting kit is covered by a loan from a revolving fund. Fed on kitchen scraps, the worms reproduce quickly. After only a few months, 2 kilograms of worms, worth more than the family owes, are returned to Anadeges, thus paying off the loan with interest. (Source: SIDA)

Dry sanitation in El Salvador

The Letrina Abonera Seca Familiar (LASF) toilet is based on the Vietnamese double vault toilet. Approximately 100,000 toilets have been built so far. This type of sanitation system has been built in low income rural as well urban areas of El Salvador. As a result of excellent community organization and adequate education, all units are functioning well. The dehydrated faeces are used to reclaim wasteland and in the gardens. The project demonstrates that careful management of a toilet, resulting from high motivation of the families involved, can make simple technology working well. (Source: SIDA)

Chicuma experience: urine diversion in pit latrines

This case study emphasizes the importance of urine separation in pit latrines as a precondition for successful application of the excreta to the land. Chicuma is low-income rural community. However, 50% of the installed pit latrines had no proper urine diversion, owing to poor construction. Other 50% were reasonably successful but geological conditions did not allow complete dryness. (Source: ?)

Zero discharge sanitation for Pacific islands

The CCD is aerobic double-valut composting toilet in which faeces are transformed into humus and the urine is evaporated. Excreta are deposited into one of the two chambers, which are used alternately to provide an extended period of composting time before the humus is removed for use as a soil conditioner. In 1996 a CCD toilet was built in Fiji in a pilot project sponsored jointly by the South Pacific Commission and the Fiji School of Medicine. All of the demonstration units have achieved zero discharge of pollutants for at least a half-year of use. Because relatively little compost is generated, it may not be the most appropriate option in areas where the reuse of nutrients is expected to be a primary motivation for using dry sanitation. Another option is an integrated CCD toilet and wastewater garden where nutrients in the wastewater are more readily available to plants in the garden bed. (Source: SOPAC)

Small-scale wastewater treatment plant project (The Kingdom of Tonga)

The sanitation situation in Tonga may deteriorate rather then improve. An exception may be the island of Hapaii where an AuAID project seems to be successful with the introduction of locally produced composting toilets. Sludge removal from septic tanks is the responsibility of the owner of the dwelling who has to pay Public Works Department to dispose the sludge. The sludge is then discharged into drying beds located close to the rubbish dump. Public Health department claims that all the sludge is properly stored, but it is hard to believe that because the capacities of the drying beds in not sufficient. Apart from the very common septic tanks, more advanced wastewater treatment plants exist in few resorts. Successful example is the Nuku'alofa Hospital and the Mormon Church settlement with well-maintained oxidation ponds and skilled personnel. (Source: SOPAC *Report 109, visit to the Kingdom of Tonga 1999*)

Nightsoil collection and treatment in Japan

The treatment of nightsoil (human urine and faeces) is unique to Japan. The Japanese experience of nightsoil treatment may provide useful suggestions to other countries intending to introduce new sanitation practices. Each household in dry deposits in a tank stores human excreta. No water flushing is practised. Once a month, there is a vacuum truck collecting the excreta. Disposal is at the nightsoil treatment plant operated by cities and towns or public corporations. Japan has other alternatives for sanitation: tandoku jokaso and gappei jokaso. Tandoku jokaso means a simple treatment facility provided for WC's in each household. Treatment is basically dilution with water and sedimentation of suspended solids. Effluent leaves the household and enters the nearest water recipient. Gappei jokaso is rarely used household based compact biological wastewater treatment facility. Both of the systems need periodic disposal to the treatment plants nearby. The treatment is: incineration, reuse in agriculture (rarely in Japan) or application into municipal landfill. (Source: SIDA)

Case of Rufisque (Senegal)

Success of a locally developed ecological wastewater purification system using water hyacinth/water lettuce has resulted in multiplier effects. Maintenance and operation staff has been able to gain skills allowing them to assist other districts and towns in upgrading their services (Malick and Diallo, 1997). Dissemination of this locally managed and low-cost sanitation technology has stimulated a growth sector of the local economy while increasing public awareness of the issue and improving the environmental health of the community. (Source: Gregory Rose 1999)

Community-based wastewater treatment in castor (Senegal)

The use of water hyacinth in wastewater treatment is an age-old technique utilised over 1,000 years ago in Sudan and is being re-visited today in this system (Malick and Diallo, 1997). In Castor, Senegal, the local NGO, ENDA-Tiers Monde, has built a wastewater collection and treatment system serving most of the communities inhabitants. The project has been successful in gaining support from community members, creating employment opportunities and treating wastewater to a standard high enough to use it directly for the production of food. The system consists of a grease trap, two septic tanks, followed by a small-bore sewage system. The sewage enters a large decanting tank/sedimentation basin that gets covered by a sludge blanket where most of the sludge is retained. From this point, the secondary effluent flows to a series of 4 aerobic concrete tanks. The tanks are approximately 1 metre deep and are narrowly designed to prevent wind from layering the plants to one side of the ponds. Water hyacinth/water lettuce comprises the active wastewater treatment at this point in the process. As water passes from tank to tank, the effluent quality is progressively increased. Effluents recovered from the process are being used to irrigate bananas, apples, papaya, peppers, corn, zucchini, okra and a variety of other vegetables. Additionally, a number of tree species are raised on treated effluents recovered from this system. The water hyacinth biomass produced though the treatment processes are harvested regularly. This biomass is formed into compost for use in local market gardens (Malick and Diallo, 1997; Mougeot, IDRC Trip Report May 1998).

Wastewater treatment in Pena Blanca (New Mexico)

Peña Blanca is an unincorporated community, located approximately 25 miles southwest of Santa Fe, New Mexico, in Sandoval County. The community is bounded on the south by the Santo Domingo Pueblo Grant and lies within the Pueblo De Cochiti Grant. The community consists of approximately 185 homes and businesses, extends for about two miles along the Rio Grande valley, and is located about one mile east of the river. Cochiti Lake is about five miles to the north. The community sits in an alluvial valley with riparian vegetation typical of the high desert in New Mexico. Perched ground water exists at depths as shallow as five feet. The land has been farmed for centuries and the land use patterns contain the levelled fields and irrigation ditches associated with this activity.

Wastewater from households in Peña Blanca had been discharged to septic tanks and cesspools and then to soil dispersal systems. The community recognized problems with cesspools and inadequate septic tank systems as early as 1977. In 1984, Delta H Engineering, LTD. prepared a generic facility plan for Peña Blanca as part of the process to obtain Federal Environmental Protection Agency (EPA) grant money for wastewater treatment and disposal. The plan considered the following alternatives.

- Decentralized collection and on-site treatment
- Small diameter variable grade gravity collection and artificial wetlands treatment
- Small diameter variable grade gravity collection and facultative pond
- **Small diameter variable grade gravity collection and centralized on-site treatment**
- Small diameter variable grade gravity collection and total retention pond
- Conventional gravity collection and activated sludge treatment
- Small diameter variable grade gravity collection and slow rate land treatment
- Conventional gravity collection and centralized on-site treatment
- Conventional gravity collection and centralized on-site treatment
- Small diameter variable grade gravity collection and controlled discharge pond treatment

The option 4 was selected but the state review disregarded it because of the found insufficiencies. Another company, Molzen-Corbin completed the final wastewater facility plan for Peña Blanca in September 1986. The report states that after rejection of the facultative pond alternative, rehabilitation of failed systems and construction of new on-site disposal systems were the only alternatives left to the residents of Peña Blanca. Thus, on-site management was a last resort for the community to minimize adverse health effects associated with wastewater disposal after two years of studies and two rejected facility plans. Some of those associated with this project consider it a failure because the community was unable to acquire a collection and treatment system. (Source: *On site wastewater management* *in New Mexico – A case study of Pena Blanca water and sanitation district by Richard P. Rose*)

Pilot project eco-Village in Kimberly (South Africa)

The village is made out of 12 medium-income households with environmental friendly management. As it is a pilot project, housing will be free as long as inhabitants are happy to live with these alternative systems. The complex includes:

- UD Sanitation system: Urine is collected in a big tank towards the end of the compound and will be given out to Forestry department as fertiliser. Dry matter is collected just behind the toilets and will be collected regularly and given out as compost
- Grey water is collected: getting out of the house it is diverted through a series of soak pits and later collected in a dam/pond at the very end of the compound. No use is envisaged for grey water.
- Solar and Wind energy will be tried out; gas will be available as an alternative mean.

If the pilot project works out, the City Council will expand the experience to first 300 then 3000- inhabitant complexes. These trials and examples are generally expensive for any community project, but it is interesting how high cost systems are done. (Source: *Ecosan Study Tour in South Africa September 2002, Michael Köttner and Heinz-Peter Mang*)

Dehydrating toilet with urine separation (Yemen-Vietnam-Guatemala)

Dehydrating toilet with urine separation pilot project was implemented in Yemen. Hot climate helps quick dry out of the faeces. The faeces are collected periodically. No treatment options are detected through the literature. Use of the dry faeces as a bio fuel is recorded (Winblad and Kilama 1985). Similar system is implemented in Vietnam and Guatemala. The difference is that the faeces are used as a fertiliser and soil conditioner. No other data are available for this case. Source: *Towards an ecological approach in sanitation* (Uno Winblad, SIDA 1997)

Eastern Europe experience

Two interesting cases were found in the region of the Balkans. The first one is in the municipality of Velgosti (peri-urban area of the city of Ohrid, Macedonia). There, the majority of the people use septic tanks as a way to collect human excreta. The person I made an interview with has septic tank for more then 15 years and according to him, only twice in this period the excreta was removed from the underground tank. There is no existing urine separation system (not existing system in the region at all). The excreta are not used for any of the possible purposes. What I found as improper management is the collection and disposal/treatment system. Officially there is only one company who has permit to collect and dispose the excreta. I was told that the company should deliver the excreta to the local aerobic treatment plant, but very often because of the high cost, they discharge the excreta in various known and unknown locations. No official fee exists for the collection/disposal/treatment and very often the owners of the septic tank pay (unknown) private companies who own a truck with a tank to do the work.

Second case is in the rural areas of the continental part of Croatia. The case I am familiar with is more or less average model of the most rural and peri-urban areas in Croatia. There the people use pit latrines and the excreta is mixed with the animal excreta. After certain period of time, the excreta are applied on agricultural fields. There is no control of the quality and no actions are taken to educate the people how to manage properly the excreta.

On-plot ecosan systems for the treatment of faeces, urine and greywater (Mali)

Koulikoro (Mali) has a central potable water supply system dating from the 1970s, but as yet no sewage system. In an arid sub-Saharan countries like Mali, where financial and water resources are scarce, a water-carrier sewage system resembling those used in Europe would be inappropriate and too expensive. Mali is also faced with the steadily worsening problem of soil degradation, up to and including desertification, chiefly as a result of agricultural overuse and insufficient return of nutrients. An affordable means of proper wastewater disposal is needed. GTZ is developing an on-plot household ecosan system in which faeces, urine and greywater are separately collected and treated. This offers major advantages over conventional latrine based systems, as it enables the hygienic recovery of soil amending substances from faeces and of nutrients from urine and purified greywater. The ecosan system is also in harmony with local traditions. In 2002, the National Sewage and Solid Waste Department at the Malian Ministry of the Environment incorporated the greywater gardens and separating toilets developed by the ecosan initiative into its program. Together with GTZ, the department is now examining their suitability for widespread introduction. However, the success of greywater gardens depends only on the degree to which local women accept this system for growing vegetables, bananas and papayas. (Source: GTZ)

Current research in Mozambique

A field research programme concerning the application of ecological sanitation products to agriculture in rural and peri-urban areas is underway in the province of Niassa, Mozambique. The research is being implemented by ESTAMOS, DAS – Niassa and WaterAid. The Niassa Province project will run a rural and a peri-urban pilot project with 50 farmers. The District of Mandimba represents the rural area and the City of Lichinga (the provincial capital) will provide the peri-urban context. Niassa Province is politically and socially isolated with poor infrastructure and a weak, cash-based agricultural economy. As the concept of ecological sanitation spreads, awareness about the necessity of reliable research to substantiate the proposed benefits is emerging. Although those within the field believe firmly in the idea of closing the loop, it is important to establish quantitative and qualitative data to prove the validity of the theory. The study also aims to test the cultural acceptability of using ecosan products in agriculture by surveying the farmers who will use the sanitized human excreta as well as those not directly involved in the project, such as potential eco-crop consumers. (Source: EcoSanRes web page)

Situation in Hebron (Palestine)

The ecological sanitation pilot project in Palestine is a success, particularly in the areas of capacity building, sustainability, local adaptation and social adaptability. The project, undertaken by Sida and the Palestine Hydrology Group (PHG), demonstrates the feasibility of household ecological sanitation (based on urine diversion) in the Hebron area. The hot, dry climate of the West Bank, combined with a serious freshwater shortage and an abundant supply of limestone powder, creates an ideal situation for ecosan implementation. Water scarcity in the region is aggravated by untreated black and greywater discharge and unsanitized sewage being released into the environment. Of an original goal of 75 eco-toilet installations, 28 households have been fitted. Although the project has been deemed successful in the fundamental areas of ecological sanitation, some improvement is needed to complete the cycle of returning nutrients to the environment. Some households are using the urine to fertilize tomato and olive trees, but many households have not yet emptied their chambers or are using septic tanks to dispose of the urine and anal cleaning water and dumping dehydrated faeces with household waste. (Source: EcoSanRes web page)

Example of a small onsite treatment plant in Palestine

Mustafa (1996) has built a small onsite treatment plant entailing a septic tank-trickling filter pilot plant for the treatment of gray wastewater from one house with 13 persons. *The effluent from the plant is used in the garden.* It was found that gray and black wastewater has about the same strength with regard to the COD concentration but the ratio of nitrogen in gray to black wastewater is about 1:22 sufficient for biological growth in the trickling filter. (Source: *Wastewater Management for Small Communities in Palestine by Prof. Dr Rashid Al-Sa'ed Palestinian Hydrology Group*)

Possibilities to reuse treated effluent in Palestine

Palestine is among many countries of the Middle East, where the annual withdrawal of water is already exceeding the renewable amount and waster scarcity increases with the rapid population growth and increasingly domestic and agricultural demands. Therefore, reuse of treated effluent and utilization of biosolids (stabilized sludge) is an essential element of an integrated water resources management. Large urban projects of reuse of treated effluent are still lacking; however, small pilot scale projects have failed. Among the reasons behind are of legal, technical and socio-cultural nature. Nevertheless, it seems clear that hygienic concern related to sanitation and reuses schemes and the need to demonstrate safety of these schemes should be investigated. Small rural onsite projects are successfully implemented where wide public awareness campaigns and environmental education programs were made. Environmental awareness is a key task of most NGOs, like PHG, where lectures, workshops, environmental educational materials and environmental week were organized and conducted (Daoud, 2000). PHG has realized the benefits of reuse of treated wastewater in agricultural irrigation as a resource recovery in terms of offsetting some of the costs of community sanitation. Among the benefits are: conserve limited water resources, expand irrigated areas and produce more food, fodder, or industrial crops, cost savings of expensive fertilizers and increase in soil fertility. It is estimated that, the agricultural component of Beny Zaid regional project will double the total revenue from \$4000/ha to about \$8000/ha through treated wastewater reuse in olive trees irrigation. Lack of data will make it very difficult to quantify the amount and judge the quality of produced sludge from present rural onsite sewage treatment plants. However, based on the technology applied, it can be said that sludge handling and management as reliable, simple and cost effective concerning the hygienic quality and quantity of biosolids produced. (Source: *Wastewater Management for Small Communities in Palestine by Prof. Dr Rashid Al-Sa'ed Palestinian Hydrology Group*)

Zimbabwe

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. The urine-diverting toilets in Zimbabwe are similar to those used in other parts of the world. There are homemade as well as commercial varieties of urine-diverting pedestals. These toilets divert urine either to seepage is or the urine is collected and stored for later use as a fertiliser. (*Source: CLOSING THE LOOP Ecological sanitation for food security (Steven A. Esrey, Ingvar Andersson, Astrid Hillers, Ron Sawyer) 2000 by SIDA)*

Vertical gardens in Gaberone (Botswana)

A Swedish horticulturist, Dr Nilsson, has developed a small-scale *container gardening system* for dry areas. It is based on walls with built-in growth boxes made of hollow concrete blocks. When building the wall some of the blocks are turned through 90 degrees and the protruding hollow part is provided with a floor and a small hole for drainage. The core of the wall is filled with a weak concrete mixture. The protruding containers are filled with sand on top of a layer of fertilizer. The containers can be arranged in various patterns and the wall can be provided with containers on one or two sides. On the walls surrounding the demonstration homestead in Gaberone, Botswana, there are 2,000 containers. A variety of vegetables and ornamentals are grown in the containers. Dr Nilsson is able to produce 2 kg of tomatoes per container four times a year. The retail price of the tomatoes produced on 1 square metre of wall during one year is roughly equivalent to the cost of building 1 square metre wall so cost is recouped quickly and *profit can be made*. (Source: SIDA)

Re-use of urban wastewater for irrigation (Pakistan case study)

The main health risk in relation to wastewater irrigation is an infection with intestinal helminths (Mara and Cairncross 1989). In addition, if the wastewater contains industrial effluent, chemical pollutants such as heavy metals can accumulate in the soil and crops and thereby, pose a health hazard. These health risks can be greatly reduced by treating the wastewater before re-using process. On the other hand, many of the existing technologies are prohibitively expensive for low-income communities. In addition to the high cost of building treatment plants, the cost of utilizing peri-urban land for treatment plants and sewage collection costs are also high-priced factors. A further disadvantage is that many of the conventional treatment methods remove the nutrients in wastewater reducing economic benefits to the users. There are alternative lower-cost treatment technologies such as *wastewater stabilization ponds*, which are used extensively in mid and low-income countries, particularly in the Middle East region. However, the reality is that two-thirds of the wastewater generated in the world receives no treatment at all (Mario and Boland 1999). A large number of wastewater treatment plants dealing with the other one-third are not properly operated and maintained. For example, more then 90 percent of the existing wastewater treatment plants in Mexico are estimated to be operating inadequately (Mario and Boland 1999). Under conditions of water scarcity and weak enforcement of legislation, the use of untreated wastewater is an unplanned, often spontaneous activity, which is practiced by poor farmers in urban and peri-urban areas in many countries around the world. Wastewater remains and will continue to stay a low-priced and reliable resource of water and nutrients. The common point of view of researchers, decision makers, and service providers is that the use of untreated wastewater is unacceptable and can provide benefits only when treatment is provided.

The situation in Pakistan is good example of the written above. The case study in the town of Haroonabad shows how untreated urban wastewater has been used for irrigation. In most towns, which have a sewage disposal system, the wastewater is used for irrigation. In those cases where wastewater is not used directly, it is disposed of in the most convenient surface water recipients, which often are irrigation canals that serve as the source of drinking water for people further downstream. However, the quantities of wastewater disposed of and used are unknown in most cities. The municipal committee of Haroonabad town is in charge for the provision of a supply of water and waste disposal services to its citizens. Unfortunately, the responsibilities of the municipal authorities end at the disposal station, from where the farmers take over the management of wastewater. The municipality is not responsible for the delivery of wastewater to farmers' fields, and therefore, only farmers whose lands are located in the vicinity of the disposal stations are able to irrigate their fields. Using untreated urban wastewater is undesirable and even unacceptable to many, but it is a reality for many poor farmers who are not likely to benefit from wastewater treatment facilities any time soon. The Haroonabad case study suggests that it is possible to further increase benefits of urban wastewater in small towns even when treatment is not a feasible option. *(IWMI Research Report 64, Use of Untreated Wastewater in Peri-Urban Agriculture in Pakistan: Risks and Opportunities)*

Wastewater management for small communities in Palestine

In Palestine, many non-governmental organizations (NGOs) exist to provide technical and financial services to small Palestinian communities as they struggle with their wastewater problems. These NGOs are qualified to assist small rural areas in identifying the most cost-effective solutions to their problems. One of such organizations is the *Palestinian Hydrology Group (PHG),* which traditionally work with many donor agencies to provide valuable technical and financial assistance to small rural communities suffering from various environmental and public health problems. The selected sanitation case studies discussed in this paper illustrate the best use of cost-effective technologies and available technical and financial assistance.

The sanitation system that is proposed for implementation in the village of Artas, Palestine is based on the collection of sewage by small-bore gravity sewer system and biological treatment in parallel up flow anaerobic sludge blanket (UASB) rector. During the first phase, the system will serve about 9300 population equivalents (PE) by the year 2005. The effluent of the anaerobic stage is post-treated in agricultural facultative ponds. The effluent is reused for agricultural irrigation. Septage from interceptor tanks near the houses and excess sludge from the anaerobic tanks is treated in a vertical flow wetland system. The system is designed tom treat sewage of Artas village, the Salmons Pools Report, and the village of Al-Khader. The use of small diameter gravity sewers (SDGS) is one of the introductions, for although the SDS has been suggested for the village of Taffouh in Hebron district. Artas will be the first location in the Middle East to have such a system implemented. This option requires the use interceptor tanks near the houses. The probability of having low sewage flow at least occasionally, due to low water consumption, further justifies the choice for this system. The interceptor tanks bring about certain degree of pre-treatment which is favorable to the process in the anaerobic tank. Small diameter gravity system is developed for flat areas, and so it will be the first time that SDGS system will be constructed in a mountainous environment with very steep slopes. Therefore, the project will contribute to develop and test new standards that can be used else where in similar situations. In particular, the characteristics of collected wastewater from Artas will be useful to design other decentralized rural sanitation projects.

Another first step is the use of the up flow anaerobic sludge blanket (UASB) reactor, which will be the first sort in Palestine. A similar pilot treatment plant has been built in Jordan and involved scientists are anxious to exchange performance results and other practical information to enhance the understanding and functioning of this cost effective primary treatment technique for further use in the Middle East. The UASB reactor has been designed a pre-treatment stage and to reduce the strong biological loaded wastewater to a level were it could be further treated in facultative ponds. Another aspect of this project, the *constructed vertical wetlands*, will also be new to this region. This project is considered as an urban sanitation one and only the sewerage systems have been implemented by now. The main treatment system is being modified and still not yet erected. Therefore, no practical experience can be reported. (Source: *Wastewater Management for Small Communities in Palestine by Prof. Dr Rashid Al-Sa'ed Palestinian Hydrology Group*)

Re-use of human excreta for biogas (China case)

The Chinese fixed-dome reactor has been widely used. Reports of built biogas digesters range from five to seven million (Nazir, 1991; Henderson, 1998). The cost in China to build a family size reactor from locally derived materials is approximately $US 80 (Henderson, 1988). The government has actively promoted the technology since the 1970s - mainly in rural areas. ISAT (1998) reports that in 1992 there were 1.7 million plants in operation in the Szechuan province. It is common that the latrine and livestock waste collection system gravity feeds into the biogas reactor, thus reducing labour and human contact with the waste and labour. Often, the reactor is located directly under the flooring of livestock enclosures and pigsties, where animal wastes can easily be washed, swept or drained into the reactor (Chen, 1997). *Increases in general sanitation have occurred where biogas reactors are used*, and has resulted in hygienic and convenient toilet systems being implemented very close to living quarters. (Source: GTZ)

Municipal ecosan concepts in a Chinese suburb

Located in one of Beijing's three river basins, Yang Song covers a little more than three square kilometers and is home to some 21,000 people. With its intensive livestock farming and grain and vegetable production, the region is a major source of food for the city of Beijing. The community currently produces roughly 15 tonnes of solid waste each day. Less than 10 % of the town's wastewater is treated prior to being discharged into the rivers or groundwater. Within the scope of a local ecosan project, the community is to be provided with a modern, material-separating disposal and recycling concept for wastewater and organic wastes that is in line with the principles of closed-loop wastewater management and sanitation. GTZ, Chinese and German scientists and companies are working together to analyse and compare different sanitation, wastewater treatment and recycling options in various harmonized systems. The cost-effective recovery of useful materials and energy is the main objective. There are also plans to use water-saving vacuum technology and urine separation systems. Organic waste from kitchens and markets will be collected, shredded and, finally, fermented in a bioreactor system. The resultant fertilizer and hygienized urine will be suitable for use in growing flowers and vegetables. Greywater will be used for watering public parks and gardens. (Source: GTZ)

Ecosan as an element of sustainable regional resource management in Botswana

In many countries of Africa, including Botswana, conventional forms of wastewater disposal have drawbacks for the general population. Most households located outside of the major urban centres are not connected to any existing waste management and sanitation system. Droughts and inadequate water resources make an already unsatisfactory situation even worse. Over the next five years, a project devoted to sustainable regional resource management will be cooperating with local authorities, the International Union for the Conservation of Nature (IUCN) and the German Development Service (DED) in developing, testing and demonstrating sustainable no centralized wastewater management and sanitation systems and methods. Initially, private households in the districts of Ghanzi, Gaborone and Serowe are to be tied into the research activities. Later, the approach will be extended to the municipal level. One of the aims of this GTZ-project is to recover nutrients and trace elements from domestic wastewater, faeces and urine for use in agriculture. This not only contributes toward long-term food security, but also provides the people with an opportunity to earn extra money. (Source: GTZ)

Sludge reuse in Egyptian agriculture

Sewerage and wastewater treatment is currently being extended to 13 million Cairo residents under the Greater Cairo Wastewater Project. Sludge production is expected to increase to 0.4 million tonnes/year of dry solids over the next 10 years (Hall, 1996). The *Cairo Sludge Reuse Study* was initiated in 1995 to demonstrate that urban wastewater sludge recycling schemes can be established to link urban waste generation with agricultural production and poor soil reclamation (Hall and Smith, 1997). In addition, because Egyptian farmers are willing to pay for organic soil amendments, there is the opportunity to recover cost (Hall, 1996; Hall and Smith, 1997).

Ecosan research into non-centralized applications in Cuba

All over Cuba, and particularly in urban areas, the wastewater management and sanitation systems lack capacity and are in urgent need of rehabilitation. Most notably in peri-urban areas with considerable agricultural activity, the soil, groundwater and watercourses are heavily polluted. As a result, health conditions and odor-nuisance levels are critical in many places. Moreover, many households do not have access to electricity. This forces many people to use ecologically questionable forms of fuel for their everyday needs. To address the situation, a GTZ-supported ecosan research project is conducting field tests on various household sanitation systems and looking for appropriate-technology solutions that generate cooking-energy yields. For example, on several city farms in two different project regions, the disposal or utilization of household sewage and organic waste is being integrated into the in-house production of fertilizer and cooking energy. In a third region, prefabricated components are being designed and developed for diverse decentralized disposal systems, and in a fourth region, different ecosan systems are being implemented in urban centres. The four regions in question are located in different parts of the island to ensure the study is representative of the island's diverse climatic, structural and social conditions. (Source: GTZ)

Ecosan systems in Ouagadougou (Burkina Faso)

The climatic and social conditions in Ouagadougou, the capital of Burkina Faso, are typical for a country in the sub-Saharan savannah belt: surface water, which represents the city's major source of drinking water, is stored in open reservoirs and therefore extremely vulnerable to pollution. The limited groundwater resources are very important, both as a relatively uncontaminated source of water and as a reserve supply in particularly dry years. The simple pit latrines used by 93% of the population infiltrate into the groundwater. Once discarded, they contaminate the receiving water body and contribute to the high levels of water- related diseases. Thus, conventional sanitary systems have created a dilemma between the need for sanitary disposal of human excreta, the protection of water resources, and the increased agricultural activity needed to meet the rising demand for food. That dilemma can be addressed if human excreta are recognized as a potentially valuable resource. The extent to which ecosan sanitation systems can be introduced in Ouagadougou as part of a closed-loop, or material-flow oriented recycling process is currently being investigated by GTZ. The findings are expected to be on hand this year. (Source: GTZ)

The Tunisian national strategy for sanitation and wastewater management in rural areas and small communities

According to 1994 national census, only 1.8% of rural households are connected to sewers network, 23.6% have septic tanks and 74.6% have inadequate wastewater management facilities. After developing the urban wastewater sector, the Tunisian government entrusted the National Sewerage Agency (ONAS) to prepare a national rural sanitation strategy. The study included four phases:

- diagnosis of current situation and basic data collection
- identification of technical solutions
- national strategy elaboration
- pilot program design

The strategy was developed on the basis of existing data and a survey of 322 households in 84 rural areas. The diagnosis phase concluded that the rural communities are characterized by a great variations in terms of : the housing standards; demography and population density; standards of income and living; and water supply services.

The strategy recommends the following wastewater management practices for the various rural settings:

Wastewater system (a) and conditions of application (b)

a) Conventional sewers with treatment or connection to the sewer network of a neighbouring city
b) Densely populated communities with piped water supplies and high water consumption.

a) Small diameter gravity with pre-treatment in interceptor tanks and post treatment facilities
b) Grouped housing with piped water supplies; impervious soil; high water table; high risk of water pollution

a) Septic tanks with subsurface infiltration
b) Scattered housing; served with piped water or public stand posts; permeable soil; deep water table (more than 4 meters).

a) Septic tanks with sand filtration
b) Grouped housing with piped water supplies; impervious soil; high water table; high risk of water pollution

a) Seepage or infiltration pits
b) Can only be used for effluent disposal from a septic tank or a sand filter

The development and dissemination of simplified sewerage in Brazil

Simplified sewerage generally known as condominium sewerage in Brazil was developed by the R&D Division of CAERN, the water and sewerage company of the northeastern State of Rio Grande do Norte, and its engineering consultant José Carlos de Melo, It was field tested in the low-income areas of Rocas and Santos Reis in Natal, the State capital in the early 1980s. CAESB, the water and sewerage company of Brasília and the Federal District, started implementing simplified sewerage in poor areas in 1991 and now it considers simplified sewerage as its "standard solution" for rich and poor areas alike. CAESB has over 1,200 km of condominium sewers in operation – the largest example of simplified sewerage in the world. Simplified sewerage is now used in many states in Brazil. Many schemes have been successful, and some have been failures – mainly due to poor construction and/or poor institutional commitment, and especially due to poor maintenance. Whatever the successes and failures of individual projects, what can be said is that simplified sewerage has been successfully adopted into mainstream Brazilian sanitary engineering. The reasons for this success have been (1) the ease of dissemination of innovative technologies at the biennial

ABES Congresses which are attended by all the state water and sewerage companies, (2) the relatively small number of leading Brazilian sanitary engineers who have been committed to, and have been excellent advocates of, the technology, and (3) the keen interest shown in the technology since its beginning by the World Bank and UNDP which has acted within Brazil to give the system a seal of international approval.

5. Involvement in wastewater and faecal sludge treatment/disposal/reuse of CBOs, NGOs and small scale private independent providers

5.1 Introduction

Peri-urban communities in developing countries are the last to receive services from water and sanitation utilities. However, their residents must every day defecate and urinate. Even where piped water and sewerage networks do reach into poor neighbourhoods, home connections are often high-priced. Municipally operated public standpipes, public toilet facilities, and public baths are usually poorly maintained. When such facilities are privately owned and operated, however, they must be clean and affordable to attract customers and bring in a profit. Therefore, that the majority of peri-urban residents buy water and sanitation services from **small private providers** who deliver what public providers are unable or unwilling to provide. Small private providers are already the main operators in this market, delivering services to the urban poor in particular.

In addition, **NGOs and CBOs are facilitating the organization of communities** to improve water and sanitation provision on a self-help basis. Scaling up of activities to extend and sustain coverage to the urban poor means that small providers, whether community-based or commercial entrepreneurs, must acquire the credibility and standing necessary for negotiating with formal legal and bureaucratic systems, particularly when neighbourhood systems need to be connected with primary public networks. Current planning for service delivery by water authorities, municipalities, and the donors who support them ignores existing small providers as well as working systems constructed by the communities themselves.

Pioneers who build their own tertiary and secondary sewerage systems and get them connected to the sewer companies are found in the literature. Some of them are:

- Community-financed and -managed small-bore sewerage systems in Karachi, Faisalabad and few cities in Pakistan
- Owner/operator/franchisers of public toilet and bathing facilities in Sulabh centers all over India
- Public baths in Lima
- Septage treatment plants in Cotonou, Benin, and Manila, Philippines.
- Community-managed latrines in Addis Ababa and community-managed water system in Dhulikel Nepal

In this section, several different case studies and other experiences are summarized. Please note that in the previous section there are cases where CBOs and private sector role is mentioned. Therefore, these cases will not be repeated in this section.

5.2 Case studies and other examples

Example of Kumasi (Ghana)

Kumasi is one of the few cities where emptying enterprises discharge their loads at a designated site even though they have to pay a discharge fee. The Kumasi Metropolitan Assembly (KMA) licenses private contractors. The competitive market between private operators and the fact that KMA can withdraw the licenses in case truck drivers do not discharge their loads at the official site seem to be the reasons for the successful KMA policy (Mensah, 2002). In contrast to Kumasi, *emptying enterprises in Cotonou (Bénin) have founded an association*, resulting in the absence of competition between the enterprises and very high emptying fees (CREPA Bénin, 2002). Kumasi Metropolitan Assembly (KMA) moved from direct provision of sanitation services, and started promoting and establishing active involvement of both communities and the private sector in their delivery. The private sector should be involved in the faecal sludge collection and haulage, operation and maintenance of the facilities (public toilets, sewerage systems, treatments systems for sewer and faecal sludge) including the collection of user charges (Kumasi Metropolitan Assembly 1995). Holding workshops to which entrepreneurs as well as service users are convened has meanwhile become established practice in Kumasi. Faecal sludge (average 500 m3 per day) is currently disposed of at the site with reasonable degree of cooperation in terms of payment of tipping fees and emptying at the designated site. Private truck operators have to pay a tipping fee of 1.5$. The Kaasi pond system was built as temporary treatment system in January 2000 (Africa Cup). The desludging of the system is not feasible; ponds have been filled with solids resulting in inadequate treatment of the effluent that flows into the Subin River. Ponds will soon be taken out of operation as a new treatment facility has been built at Buobai, 14 km north east of the city center under the Urban Environmental Sanitation Project (UESP/world Bank) and is yet to be commissioned. The Buobai plant consists of two settling ponds followed by facultative and maturation ponds and is designed to treat approximately 200 m3 sludge a day. Trucks will have to pay a tipping fee, probably a bit higher than in Kaasi due to the fact that operational and maintenance costs will be higher. KMA trucks will not have to pay. According to the experience gained in Kaasi there is indication that truck drivers will not discharge their load indiscriminately but transport it to Buobai and pay the discharge fees. The Waste management and the Environmental Health departments of the KMA have been warning truck drivers through letters and meetings regarding the need for high environmental protection standards. Moreover they risk loosing their license if they are caught discharging at an illegal site. Operation and maintenance will be handled by the private sector under franchise scheme. However the waste management department will manage the plant during the first 3 months of operation in order to determine the surtax to be paid by the private contractor to KMA based on FS inflow and cost for operation and maintenance. The contractor will also be responsible for biosolids management. Drying beds were planned to dewater the settled solids desludged from the settling ponds but could not be built because of shortage of funds (Mensah 2002 b). The Environmental Sanitation Policy states among others that recycling of waste for industrial, agricultural and other uses shall be practiced wherever it produces a net cost reduction or positive environmental impact and also that the promotion of waste reduction shall be an integral part of waste management. A pilot co-composting plant (composting of organic solid waste and dewatered faecal sludge) has been put in operation at the beginning of 2002. The plant is located at the Buobai FS treatment site. Investigation of the system just started and will deliver information on the sustainability (marketability, etc.) of this treatment option in the Ghanaian context. The pilot project is coordinated by IWMI in collaboration with the University of Science and Technology in Kumasi, the KMA and SANDEC. Results of the investigation will help the WMD (Waste Management Department) develop its biosolids management strategy. A new landfill will be built in the South of the city (Dompoase). Another FS treatment plant will also be built at the landfill site and serve the southern section of the city. Besides faecal sludge landfill leachate will also be treated in the plant.

Untreated faecal sludge reuse in agriculture as it is practiced in Tamale (northern Ghana) is apparently not common in Kumasi. A preliminary study aiming at assessing farmer's perception with regard to faecal sludge reuse (compost produced with organic solid waste and faecal sludge) as well as their willingness/ability to pay was conducted among 90 farmers in 2001. The results indicate that 2/3 of the farmers are willing to pay for the compost. The main factor that could motivate the farmers is field trials (IWMI 2001). However, the study was carried out before the operation of the co-composting plant started. The study will therefore be repeated once compost will be available.

Efforts to improve on Kumasi's sanitation are dating back to the late eighties and have in its nature been a top-down approach with initial decisions taken on the central, municipal level. Hence, the decision to improve the cities FS management through an array of measures comprising the household-level and public toilet installations, FS collection and FS treatment was taken at the top. However, elements of decentralization were introduced from the early stages: by devolving parts of the decision-making to local stakeholders, by promoting private entrepreneurship for public toilet management, FS collection and FS treatment, and by devising two FS treatment plants to cater for the sludge loads currently being collected.

Case of Dhaka (Bangladesh)

PRISM-Bangladesh, a non-government organization based in Dhaka, Bangladesh, has developed a highly successful Duckweed cropping system for both domestic wastewater treatment and the production of fish protein (Skillicorn *et al.*, 1993). PRISM has standardized and optimized the duckweed management and cropping system to treat the wastewater generated at the Kumandini Medical Complex in Mirzapur. Experimental trials and data collection undertaken between 1989 and 1991 resulted in a strategy to optimize the production of duckweed for the cultivation of carp and tilapia and treat wastewater to a high efficiency.

Small entrepreneurship in Bamako (Mali)

The City of Bamako, Mali, is the country's capital. It straddles the river Niger and has a population of 1.2 million. The City is administratively truncated into 6 districts each comprising from 10-12 wards. Sanitation systems in use in Bamako encompass private and public latrines of various types, septic tanks and a low-cost sewerage scheme covering a small zone of the City. The emptying of pits and vaults is accomplished by 25 vacuum trucks and 4 collection vehicles with manual suction pumps (33 tractors and 1 donkey-drawn). Urban agriculture plays an important role, with some 6 % of the population involved in vegetable, flower and tree growing (Visker 1998; Towles 2001). FS are widely applied in vegetable, cereal and tree growing, usually after some type of processing (storage upon mixing with organic solid waste, plant residues or cattle dung). The fact that excreta are traditionally used in agriculture should render it fairly easy to sell a finished treatment product (biosolids or compost) to farmers.

Starting in the early nineties, small enterprises (groupes d intérêt économique GIE economic interest groups) became established in response to the Malian government's reduction in hiring for civil posts. In order to help many of the unemployed graduates affected by this decision, the government offered small loans to these private enterprises. They started rendering services in the public needs sectors such as sanitation. A group or enterprise called Sema Saniya was the first of the GIE to be founded in 1991, with others been established meanwhile. Sema Saniya is currently (April 2002) preparing plans for a faecal sludge treatment plant (FSTP) to treat FS collected from the City's Communes V and VI. CEK-Kala Saba, an NGO working in the environmental sanitation sector as facilitators, project coordinators and technical-managerial consultants, are developing plans for another FSTP to treat FS from Commune IV. Sema Saniya started with a few donkey carts to dispose of garbage and has now advanced to two tractors with a biweekly collection serving over 1,500 families. They have also acquired two vacuum trucks in the process. The company has reportedly other satellites in other areas, but due to some governmental regulations is not in direct control of them. Sema Saniya has built and operates many public toilets in other districts of Bamako area and is planning to expand on these services. Their main source of revenue, however, is the removal of faecal sludge from septic tanks (septage) and public toilet vaults. Government currently plays but a minor role in the sector of FS collection and haulage to date. Emptying, collection and haulage services are largely privatized. There are no contracts or regulations governing the locations served by a particular company. Sema-Saniya frequently empties latrines throughout the city, as it is currently the largest and most dependable sanitation company. Citizens of Bamako wait to empty their toilets until they are completely filled, in the interest of saving money, generally over 2 years though this time depends on the number of people using the toilet. Public toilets can require evacuation on monthly basis or more frequently during periods of great population passage. The sludge is being dumped in fields in and outside of Bamako. Government does not exert any control. The Bamako case shows that and how, in the absence of government support, initiative and policy, small entrepreneurs and NGOs can move in and set up FS management in a largely sustainable and socially and environmentally responsible manner. Contrary to Kumasi, the approach, which developed in Bamako, is bottom-up. Yet, the two contrasting examples show that, apparently, both the top-down and the bottom- up strategies may, in principle, lead to sound and largely sustainable solutions.

Slum Sanitation Program in India

Municipal Corporation of Brihanmumbai (MCBM) launched the Slum Sanitation Program (SSP) as an integral part of the Bombay Sewage Disposal Project (B.S.D.P.). The main aim of S.S.P. is to provide sustainable sanitation facilities in slums located on Municipal lands. The S.S.P. is a participatory program involving communities in entire implementation process right from the beginning from forming a community based organization and collecting contribution for operation and maintenance of proposed toilet blocks, involving them from the planning stage to the completion of the work and handling over the facilities to the communities for future operation & maintenance. A significant departure from the earlier approach & supply driven to demand driven approach is made in the SSP Project. The S.S.P. will help to alleviate harsh living conditions of about one million slum dwellers occupying municipal owned land by providing sustainable sanitation facilities for safe excreta disposal. Recently in view of large demand expressed by the slum dwellers in the slums located on other lands, the scope of S.S.P. is proposed to be expanded on lands other than municipal lands also. To know the present status of sanitation facilities all over Mumbai, a detailed survey is being conducted under S.S.P.

Program publicity through NGOs: The publicity of S.S.P. was carried out by four contracted NGOs in four Municipal Wards covering 55 slum colonies. As an outcome of program publicity only 32 CBOs were registered but the contribution from these CBOs was very meager. There was much resistance from the community to pay the up front contribution as they were getting free services from MCGM and MHADA.

Only two toilet blocks have been constructed and handed over to the community. Two more toilet blocks have been virtually completed except for water and electric connection and will be handed over to the community shortly. Work of construction at three more sites is in progress. Recently contracts have been awarded to construct 20 toilet blocks in each ward except in city wards where slums are very less. With the experience gained from the construction of toilet blocks and publicity given to the community in respect of these toilet blocks, the response from other communities is encouraging and it is expected that about 400 toilet blocks will be constructed within the next two years. Two movable toilet units and two mobile toilet units are also being installed at selected sites with CBOs consent.

Ouagadougou (Burkina Faso)

A group of masons in Ouagadougou (Burkina Faso) has chosen to move into a new market niche by specializing in the construction of an improved latrine design proposed by an innovative program to promote household sanitation, introduced as part of the city's Strategic Sanitation Plan. The program was designed to open the market for sanitation infrastructure to individual artisans and micro-enterprises, rather than structuring it so that only large international companies could respond. Households wishing to take advantage of the program, which subsidizes 20 to 30 percent of the construction cost, must hire masons registered with the water company. In this way, participating masons have embarked on a new commercial strategy based on an innovative product. (Source: *Independent Water and Sanitation Providers in African Cities Full Report of a Ten-Country Study by Bernard Collignon and Marc Vézina, Water and Sanitation program April 2000*)

Kampala (Uganda)

Kampala (Uganda) City Council simultaneously encourages and discourages private management of public toilets. Three private operators signed contracts with the Kampala city government to provide municipal public toilets. There is a high volume of business: in the city center, 70 persons an hour use an eight-toilet facility, eleven hours a day. But at the same time, the expansion of toilet facilities is hindered by the high cost of repairing the existing facilities, the high cost of water delivered by the water company (US$2 per cubic meter of water for a facility where 16 cubic meters is used per day on average), and the imposition of a monthly municipal tax of US$1,000 after three years of operation. And then there are the frequent cuts in water provision. The owner of one of the private operators, KKM All Services Ltd., decided to rehabilitate a borehole near his facility in order to have access to water supply from a more reliable source than the city network. He bought a pickup truck fitted with a water tank to transport water from the borehole, and undertook to maintain the drains. He earns about $15,000 a year from his business, 70 percent of whose clientele are poor households. (Source: *Independent Water and Sanitation Providers in African Cities Full Report of a Ten-Country Study by Bernard Collignon and Marc Vézina, Water and Sanitation program April 2000*)

Dakar's Fass Delorme district

Teamwork reduces the workload for this pair, whose regular customers include about a thousand residents clustered around the hundred-odd courtyards of this small district, plus the occasional client from outside who has heard about their work by word of mouth. They also do some drain cleaning as a sideline, and do a lot of business repairing caved-in or damaged latrines. Clients hire them for two types of service: annual pit emptying for about CFAF 15,000 for an 8 cubic meter pit, or a partial dig out for CFAF 3,000 every two or three months. Waste is generally reburied on-site, if there is room and the courtyard is unpaved, or in the roadway nearby, which gives rise to protests from the neighbors and sometimes a visit from the municipal sanitation authorities. But this pair usually escapes any penalty by taking the fellows out for a drink. (Source: *Independent Water and Sanitation Providers in African*

Cities Full Report of a Ten-Country Study by Bernard Collignon and Marc Vézina, Water and Sanitation program April 2000)

Bamako

The Sema Saniya GIE operates a number of sanitation business ventures. They began with the collection and sorting of household waste for resale and recycling and then added the sale of trash cans, operation of a public toilet and shower facility at the main train station, and septic and latrine pit emptying. In July 1995, they bought a second-hand suction truck with a CFAF 10 million grant from ACCT (Cultural and Technical Cooperation Agency). Within two years, the success of this operation convinced them to buy a second truck, using CFAF 6 million of their own earnings and a CFAF 5 million loan from BMCD (Malian Bank of Development Credit), which they reimbursed within a year. Business is still booming and there are plans for the purchase of a third truck in 1999. Sema Saniya's customers are mostly individual households, who pay CFAF 8,500-15,000 in cash for a complete pit emptying; the price varies with the distance the truck must travel. A significant number of clients are referred by agents called coxers (after the English term for coxing a sculling crew) who receive a commission for each successful referral. The founder of EMAPROHY started work as a construction worker. Seeing the heavy demand for septic tank cleaning, he bought a suction truck in 1991. He has reinvested his profits and now operates four trucks. Since 1995, he expanded his business into the construction area, which now accounts for two-thirds of his annual turnover. (Source: *Independent Water and Sanitation Providers in African Cities Full Report of a Ten-Country Study by Bernard Collignon and Marc Vézina, Water and Sanitation program April 2000*)

A group of young people managing a standpipe in Dakar

A group of 30 young people from the Fass Delorme neighborhood in Dakar got together and created a cultural association. In order to earn money, they built a standpipe with funds put up by a local leader and had it connected to the water company mains. The group's members take turns manning the standpipe and invest most of their profits in equipment they use to start other moneymaking ventures (sound system, video camera). (Source: *Independent Water and Sanitation Providers in African Cities Full Report of a Ten-Country Study by Bernard Collignon and Marc Vézina, Water and Sanitation program April 2000*)

Private Network Investment in Dakar and Operators in Kampala

In Dakar, more than half the water distribution network has been built by independent private land developers. Their private investment is automatically transferred to the national water authority, SONES, with a promise of compensation. In Kampala, private standpipe operators are managing small networks with several standpipes serving an entire peri-urban community, under contract to the water users' association that invested in network extension. Because the water corporation, NWSC, discourages such extensions, five wholly freestanding borehole networks have been built by Kalebu Limits, founded by an engineer and his wife, a marketing specialist. Starting with a single network, fed by water pumped from a well with an electric motor, they financed the second one from the profits on the first. The company also manages a group of eight coin-operated standpipes connected to the city network. (Source: *Independent Water and Sanitation Providers in African Cities Full Report of a Ten-Country Study by Bernard Collignon and Marc Vézina, Water and Sanitation program April 2000*)

Mapet – Hand-Powered Pit Emptying Technology

Mapet stands for Manual Pit Emptying Technology, a low-cost, decentralized emptying technology developed by WASTE in collaboration with the Dar es Salaam (Tanzania)

Sewerage & Sanitation Department, pit latrine emptiers (scavengers), local leaders and technicians, and residents in the late eighties/early nineties (Muller 1997). The project comprised the technical as well as organizational development of a locally adapted and rooted technology enabling the traditional scavengers to depart from their humiliating and risky job of having to enter latrine pits for scooping out the faecal sludge. Further to this, the new emptying option came in response to the inaccessibility of many residential areas by normal vacuum tankers; the inadequacy of the municipal emptying service organization, and the non-affordability of emptying prices charged by the municipality. In the former pilot area in Dar es Salaam, where the system was developed, a MAPET team consists or consisted of three workers, all self-employed. The team is autonomous in organizing its work and regulating the sharing of cost and income. The team operates in a service territory assigned by elected neighborhood leaders. The neighborhood or ward office serves as a booking office for residents who require pit emptying. The municipality supports the MAPET micro-entrepreneurs by providing technical assistance for major repairs. The emptiers can turn to local workshops for minor repairs. The MAPET-based FS handling in Dar es Salaam is reportedly still operational to some extent, yet with equipment partly dysfunctional. There is, reportedly, a strong demand from community-based organizations (CBOs) to procure equipment and introduce non-formal pit emptying services (Rijnsburger 2002). Meanwhile, MAPET has also been introduced in the town of Barumbu, D.R. Congo, through a CBO. Informal emptiers paid by a directly negotiated customer fee operate the system.

Tanum municipality (Sweden)

The municipality has the ultimate responsibility for emptying, storage, and reuse of urine and it signs agreements with farmers or entrepreneurs. Five examples are given of how the municipal responsibility for handling of urine can work.

1. In duty areas, where the technical committee is responsible for urine pipes and tanks, the municipality arranges for collection of urine and reuse on arable land according to a signed agreement with an entrepreneur/farmer.
2. Property owners may opt for an individual arrangement with an approved entrepreneur or farmer who collects the urine. The fee is stipulated in the agreement.
3. The Environment and Building Committee issues approval according to para 23 'Instructions about treatment of waste' for private handling of urine and the task is carried out by assigned farmers/entrepreneurs. The environmental committee keeps record of the households who arrange for urine collection and submits a list to the assigned farmers and entrepreneurs. The entrepreneur or farmer marks the date of collection and reports back to the committee once a year.
4. Property owners who arrange collection with other than the approved farmers or entrepreneurs shall submit an application to the environmental committee. The approval serves as a mutual agreement.
5. It is also possible to treat and apply urine on the private property if the given requirements are fulfilled and an agreement is signed. This is often the case with dry toilets with urine-separation in summer cottages. The environment and building committee gives approval and this serves as an agreement.

(Source: *Gregory D. Rose Community-based technologies for domestic wastewater treatment and reuse: Options for urban agriculture*)

WASH pilot project in Manila

Source: IRC Delft

Isla Puting Bato is a squatter community around the breakwaters of the North Harbour and the adjacent land owned by the Philippine Ports Authority. Community dwellers have no adequate access to safe water. Water merchants sell what little water that is available at a very high price that many poor people cannot afford. Environmental pollution and the presence of garbage and raw sewage contribute to the deteriorating health and hygiene situation of slum dwellers. People in the community are calling for better living conditions and the basic right to human dignity. In response to the challenges posed by the impending water and sanitation crisis, and inspired by the launch of the global WASH campaign, the WSSCC South-East Asia Coordinating Office set up a WASH Pilot Project in early 2002 involving a Community Centre in an urban slum area of Isla Putting Bato, in the Tondo District of Manila. The project is addressing the problem of inadequate water supply, lack of hygiene and sanitation facilities through improving infrastructure, informal education, advocacy and community organization. The WSSCC Regional Coordinator in South-East Asia, Mrs. Lilia Ramos, set up the WASH Pilot working out of Appro-TECH Asia, the NGO she heads in Manila. Appro-TECH Asia serves as the WASH Coordinating Office for the Region. The NGO has been active in promoting and advocating the principles of Vision 21 'Water for People' and the goals of the Iguacu Action Program of Water Supply and Sanitation Collaborative Council. Vision 21 pictures a world in 2025 where every man, woman and child on the planet has safe and adequate water and sanitation and lives in a hygienic environment. The WASH Pilot Project provides appropriate technologies for a safe human waste disposal system that will not harm the environment, and a rainwater catchment tank to help with the Centre's activities. These activities include nutrition programs, health, hygiene and sanitation education and advocacy, and assistance to improve the livelihoods of community members. Once the water and sanitation technology is in use, the Community Centre will collect rainwater and so reduce its expenditure by about 40%. Savings will be used to purchase water from vendors. This can also contribute towards lessening future burdens on other water resources. The Pilot Project will become an entry point to address the community's concerns of wastewater and solid waste management.

Case of Benin

Source: Small scale providers (typology and profiles) Suzanne Snell 1998

The Société Industrielle d'Equipement et d'Assainissement Urbain (SIBEAU), Cotonou, Benin was started as a small private initiative and received help from government in finding a suitable site and obtaining permission from village residents to allow the private sludge treatment plant, to be built. With a permanent staff of 3 managers, 3 supervisors, 6 assistants and 54 workers, plus about 200 temporary staff depending on work program, SIBEAU processes septic tank waste and maintains its own collections vehicles and equipment, Since then the company has carried out World Bank-financed works under contract to the municipality (drain cleaning, road paving, solid waste collection and disposal; may include composting of household organic waste). SIBEAU receives 240Ð300 m3/day of sludge for processing at a plant with capacity of 180 m3/day. The treatment plant was designed to handle waste for 300,000 residents; it is currently seeking to respond to a market twice that size by expanding its plant from three to six ponds. Land is available for adding another four in the future. Those of other septic collector enterprises bring in sludge by SIBEAU's own collection vehicles and. SIBEAU carries out natural processing by lagoon treatment: waste is first pretreated and then held in an anaerobic pond, followed by transfer to two other ponds and dried. The ponds are lined with concrete to ensure containment. SIBEAU was started with entrepreneur's own funds. Customers pay collectors for service at the time their waste is picked up. SIBEAU and ten other sludge collectors have formed an association, which has standardized collection procedures and prices charged to consumers. The firm handles about 60 percent of the latrine waste coming from urban areas within a 50-km radius, including Cotonou (600,000). In these areas, about 70 percent of households use a private latrine, 20 percent a latrine outside their own compound, and 7 percent use individual toilets with a septic tank.

The following selected case studies were taken and adapted from the publication ***Water and sanitation services for the urban poor: Small-Scale Providers: Typology & Profiles by Suzanne Snell (1998)***. This publication gives an excellent overview of the possibilities how small scale private sector participates successfully in resolving human excreta and wastewater issues in developing countries. Therefore, it is highly recommended to use this book as a reference in the further research.

Addis Ababa (Ethiopia)

Provider name: Community operated and managed latrines, Addis Ababa, Ethiopia

Key features

The six similar case studies summarized here focused on building new community-owned latrine blocks for previously unserved and often inaccessible communities of the poorest of the poor. In all cases, latrine user committees were organized for each latrine to clean and maintain them and collect fees for emptying the latrines. The communities are furnished labor to build the latrines and usually were paid either in cash or with food (wheat and oil). In one case, a contractor provided skilled labor and supervision; in other cases, the NGO's own staff supervised works and also recruited skilled labor from the community. Three of the six projects also built standpipes and all of the projects built storm water drainage ditches. Other works included sullage soakway, access roads and a bridge.

Two of the six projects involved building about 50 blocks with a total of 250 seats to serve about 2,000 users; one built 22 blocks with 103 seats, and one 90 blocks with 252 seats to serve 3,200 users; two involved building only four or five latrines for a few hundred users, but also one or two standpipes to serve 1,000 to 1,500 users. One of the 50-block projects also involved building 16 standpipes, wash stands, and a shower house.

The technology was the same for all six studies. VIP latrines were constructed with stone pits half mortared with cement, concrete foundations, local wood frames, concrete block walls, PVC vent pipes, and corrugated iron roofs and were furnished with padlocked sheet metal doors. Vacuum trucks empty latrines. Most drainage ditches were masonry lined; some were earth ditches and some were concrete pipe.

Only one of the CARE projects did the community directly contribute cash for the construction costs; in the other CARE project, a cash contribution came from the local elected administrative unit (Kebele), which depends on government and donor funds. The community and NGO signed agreements that the community would pay for operations and would manage the latrines. Monthly fees range from about Birr 0.25 per person to Birr 1.0 per household (average 5 persons). For one latrine block, users who earn their living by selling local beer contribute Birr 2.20 per household per month because their customers are using the latrine. The other households contribute Birr 1.10 for its use. The study team estimated that the minimum required for emptying and maintenance costs comes to about Birr 0.50 per person per month, or Birr 2.50 for a household of five, two to ten times the amounts actually being requested. Not all households actually pay. In one case the Edirs (traditional funeral associations) have played a major role in convincing people to pay and in collecting money.

Key innovations

The one project managed by an international NGO (Daughters of Charity) the latrine user committees and other types of community representatives to mediate, monitor, and enforce environmental rules. The latrines were being maintained two years after they had been handed over to the community and the problem of open field defecation had been solved. Another ongoing project (Redd Barnis taking a similar approach and is establishing a coordinating committee, elected neighborhood groups and Health Scouts, and is recruiting salaried grassroots workers from the community.

In the Ethiopian Aid project where the NGO employs the water seller at the standpipe, the arrangement works well even though the water fees are too low to cover maintenance costs.

Key constraints

- Obtaining permission from public and private owners to contribute land needed for building latrines and drains was time-consuming. Some residents were unwilling to donate land for drainage.

- The fact of community ownership is not sufficient to ensure community maintenance when there is no effective neighborhood governing structure. This applies to standpipes as well as latrines: In one of the CARE projects where a single standpipe was constructed, no one is in charge of it and the fittings for all but one tap have been stolen. In the Redd Barna project which includes 16 standpipes, each with four taps, and intensive community organization, fittings have been stolen from one.

- Cost recovery was planned for all six projects and user committees were responsible for collecting money for vacuum emptying and maintenance (especially lock and door replacement) but it was not implemented because users did not contribute regularly or it was unclear how much they owed. In several cases households were unhappy with charges being set on a household rather than a per capita basis, which created a hardship for smaller households.

Market characteristics

The existing sanitation system in Addis Ababa, a city of over two million residents, comprises limited conventional sewerage and on-site systems for excreta disposal, piped and open ditches for storm water drainage, and some dump trucks for waste disposal. Since 1981 a limited sewerage system has served the central part of the city and less than 10 percent of its residents. It is operating at less than a third of its design capacity of 175,000 people. On-site sanitation includes various types of dry-pit latrines, used by about 1.6 million residents, and septic tanks, used by 175,000; some 700,000 people have no access to any sanitation facilities. There is no system for household collection of solid wastes so only those living near the few dozen dumpsters use them. Waste water and solid waste are commonly disposed of in storm water ditches.

Background

The CERFE study brought together city officials and other stakeholders to inventory all 118 recent community-based environmental sanitation projects in the city and prepared in-depth case studies of 12 projects. This summary is based on 6 of the 12 case studies. The study found that the combined impact of the projects constituted a significant response to the sanitation crisis in the city, building latrine blocks to serve a total of about 100,000 people and constructing a total of 1,170 km of drains. The impact of such projects could be greatly extended by integration of efforts across the spectrum of environmental sanitation needs in a given area, rather than targeting provision of one or two services such as latrines or water.

Sustainability

In the Daughters of Charity project, one of CARE projects and the Redd Barna project, where the latrine user committees are supported by other authoritative structures which play an active role in convincing people to use the latrines and pay for their use, the organizational conditions for sustainability may be met. But not all user committees are collecting the fees owed and in no case are the fees high enough to cover periodic emptying and maintenance costs as estimated by the study. In the Ethiopian Aid project, the cost recovery system is not clear to all participants despite a signed agreement and there is not a consensus to pay for the latrine. The study indicates however that a cost recovery system based on regular payments of small amounts in the context of an integrated environmental sanitation initiative including income-generating activities can work.

Malang, East Java (Indonesia)

Provider Name: Bpk. Agus Gunarti (local resident), Indonesia, Malang, East Java

Key features

A small bore reticulated neighborhood sewerage system with off-site primary/secondary treatment, initially serving 70 households plus trucked-in septage sludge (probably up to 20 cubic meters per day), planned, implemented (i.e. 100% self-financed), managed and maintained by the community. Has been replicated in approximately 10 (ten) other neighborhoods, totaling around 1,000 households.

Key innovations

In addition to the 'home grown' nature of the initiative, and the use of small bore technology, a notable innovation is the high level of revenue supplementation from growing and selling aquaculture products from the treatment ponds, from the treatment of imported sludge, and from selling dried sludge.

Key constraints

- The approach presents a potential threat to existing institutionalized informal incentives structures, which favor more traditional 'end-pipe' sanitation projects in the Indonesian urban development sector.

Background

The first project was initiated in 1987 by a local resident, an otherwise unskilled bemo driver (small public transport road vehicle). Out of a personal concern for the poor environmental state of his neighborhood, he and a few 'colleagues' designed the system, negotiated to obtain a treatment facility site within the local cemetery next to the river, and marketed the idea to the local citizenry. He received no financial nor technical assistance for this first scheme - "I'm not an engineer, so I read a few books, and designed the system". In 1989, Pak Agus joined the City Sanitation Office, where he has been responsible for replicating his initiative throughout the city. He has followed much the same model, but with some financial support coming from neighborhood women's associations (PKK). This expansion program is ongoing.

Sustainability

The system built in 1987 is still operating as conceived and designed. Sustainability appears to be high. There are no operating subsidies provided.

Orangi Pilot Project in Karachi (Pakistan)

Provider Name: Orangi Pilot Project (OPP), Karachi, Pakistan

Key features

OPP is an action research institute that has developed model program for low-cost sanitation, housing upgrading, home health, family enterprise credit, school, women work centers, and rural development. OPP provides community organization for self management; it does no construction but offers technical assistance to the community that carries out the construction. Since 1988 its work has been carried out by four autonomous institutions: OPP Society to channel funds, OPP Research and Training Institute to manage the Sanitation, Housing and Social Forestry Program and its replication, Orangi Charitable Trust to manage credit programs, and Karachi Health and Social Development Association (KHASDA) to manage the health program.

OPP oversaw installation of the latrines, sewers and drains in about half of the Orangi settlement. BCCI Foundation, OPP's sponsor, invited UNCHS (Habitat) to start a sanitation project in the other half of the settlement in 1982. As of November 1993, Orangi residents in the OPP and UNCHS areas had built a total of 76,000 sanitary pour flush latrines, 236 miles (1,243,954 feet) of underground sewerage lines, and 30 miles of secondary sullage/sewerage drains at a cost of Rs. 57.2 million. About 80 percent of the drains and two-thirds of the latrines and sewerage lines were build in the OPP area.

Households installed individual sanitary pour flush latrines in their homes. Underground sewerage lines were built to connect these to the city sewerage system

Costs were lowered to less than a quarter of what contractors would have charged by using simplified designs for latrines and standardized steel moulds for manholes, and by providing free technical guidance to lane managers. The owners desire to improve their real estate, protect their children's health, and reduce heavy expenditure on medicines to treat sanitation-linked diseases proved powerful motivations for investing in sanitation. When the communities realized that by investing Rs. 1,000 (average one month's income they could get these benefits, they took on the responsibility for sanitation (Rs. 300 for a latrine, 200 for the house connection, and 500 for their share of lane and secondary drain line).

Key innovations

OPP took the research and extension (R&E approach that had been extremely successful in the case of small farmers and applied it to the low-income house owners in the katchi abadi. They successfully developed and introduced methods for building their own low-cost sanitation and housing. In this case OPP's R&E activities included simplifying latrine designs and methods of construction, surveying and mapping, preparing models and instructions, finding activists and training them to be lane managers, providing plans and loaning tools, and supervising work.

OPP designed a new kind of organization meant for constructive work, in contrast to the existing anjuman associations that are effective at lobbying and canvassing. After OPP's technicians had surveyed and prepared maps and estimates, the social organizers found an activist who was trained to become a lane manager. The lane manager then held more meetings, created consensus, settled disputes, collected money, and supervised work.

Key constraints

According to OPP's analysis, there were four key constraints:

- Psychological: residents initially believed that official agencies would provide sanitation and sewerage for free.
- Economic: the conventional cost was beyond the paying capacity of low-income families.
- Technical: residents did not know how to build underground sewerage lines.
- Sociological: construction of sewerage lines requires social organization for collective actions that did not exist in 1980.

OPP overcame each one of these constraints by convincing residents they would be better off doing it themselves, developing innovative low-cost models and methods, training, and innovative organizing.

Background

The unplanned settlement or katchi abadi of Orangi began in 1965 and grew rapidly after 1972. The settlers bought land from dalals and built their own homes. The dalals, who occupied, subdivided and sold land from the 1950s, provided roads and plot markers. Official agencies provided some main roads, water lines, electricity, and a few schools, hospitals and banks. In 1980 bucket latrines or soak pits were being used for the disposal of human excreta and open sewers for the disposal of waste water. Typhoid, malaria, diarrhea, dysentery and scabies were rampant and medical expenses high, conditions OPP calls medieval sanitation. Poor drainage was causing water logging and reducing the value of property. Along with the individual household sanitary pour flush latrines, the streets, houses, and private schools have been built by the residents.

Sustainability

Lane sewerage lines and sanitary latrines built with their own money and under their own management are being maintained by the lane residents at their own cost. They have become accustomed to a higher standard of sanitation for which they are willing to pay. They have also gained a high level of skill in both organizational and technical skills and have become less dependent on OPP for guidance.

Example in Lahore (Pakistan)

Provider Name: Qadri Social Welfare Society (QSWS), CBO, working with Youth Commission for Human Rights (YCHR), independent NGO, Qadri Colony No. 1, Qadri Colony No. 2, and Farooq Colony, Kot Lakhpat area, Lahore, Pakistan.

Key features

Lane sewers, septic tanks, and latrines constructed and managed by community. Sewer lines were laid in 25 out of 27 lanes (92 percent) during the first two years of construction. Once all

27 lanes were completed in Qadri Colony No. 1, the program was extended to Qadri Colony No. 2 and Farooq Colony, where, so far, 4 out of 33 lanes and 7 out of 30 lanes respectively have been constructed..

Total population of Qadri Colony is about 3,500 people living in 27 lanes. Qadri is a mixed ethnic
and economic status community with average monthly household income ranging from 700 to 2,000 Rs. Total population of Kot Lakhpat, which includes Qadri Colonies Nos. 1 and 2, Farooq Colony, and others, is about half a million residents. To date, 22,409 feet of lane sewers in 97 lanes have been laid in the three communities with a total population of about 10,500.

Designs for small-bore shallow sewers, pour-flush latrines, and septic tanks are provided by YCHR, based on work done by the Orangi Pilot Project in Karachi (see separate profile). Manhole design was modified based on feedback from the community: it was found that better access for maintenance could be provided with cone shaped manholes which allow use of bamboo poles to clean clogged pipes. Sewer design also had to be modified to cater for storm water flows not provided for in the original Orangi designs because of differences in annual rainfall in the two cities.

Key innovations

Social motivation and mobilization are key components of YCHR sanitation programs. Mobilization of women became a new activity after YCHR realized that the initial focus on men as lane managers and lane committee members reduced the potential for success by excluding the participation of women, who are a crucial group for operation and maintenance. Community motivation is greater than before the project. Pressure from the community welfare society, QSWS, overcame initial resistance by the cantonment board, LCB, which agreed to lay a 100-meter secondary sewer to link the lane sewers to the trunk.

Key constraints

- The cantonment board may not always build the primary and secondary sewer lines as indicated in the plans, and lack of interagency coordination can lead to problems.

- Lane managers sometimes became overloaded with responsibility and found themselves supervising construction on a full-time basis because other committee members failed to contribute their time once contributions were collected; some lane managers could not complete their assignments.

- Lack of involvement by women was discovered and corrected during the construction stage.

The low-income communities of Lahore (pop. 7 million), provincial capital of Punjab, lack proper sanitation and sewerage systems. Most of the drains in such localities are open and spilling of sewage is not uncommon; stagnant ponds of liquid waste and heaps of solid waste emit foul odors and foster diseases. YCHR is concentrating its efforts in Kot Lakhpat, an industrial area located in the suburbs of Lahore, and neighboring cantonment Lahore, and is also facilitating introduction of similar programs elsewhere in Punjab by training other CBOs and NGOs from Okara, Kasur, and Faisalabad.

Background

YCHR is a non-profit, non-partisan development organization formed to help the low-service areas of Lahore develop as pressure groups to allow them to participate in the policy- and decision-making process. YCHR is also providing consulting services to the Water and Sanitation Agency Sewer Cleaning Directorate for an awareness campaign and a solid waste management project in a target area of Lahore of more than half a million residents (Bilal Gunj and Walled City). YCHR also runs health education, home school education, and solid waste management programs. Qadri Colony was selected for a low-cost sanitation project by a social organizer from a neighboring colony that had a successful sanitation project because of Qadri Colony's proximity to trunk service. After obtaining basic training from the Orangi Pilot Project, YCHR set out to replicate OPP's low-cost sanitation model in Lahore. Meetings with slide shows were held to mobilize the community and explain the rules for lane committee formation. YCHR carried out surveys, prepared cost estimates and detailed designs, provided technical assistance, supervision and training, and lent tools and equipment – including shuttering for manholes. The community formed lane committees and selected lane managers. The committees collected funds for construction, hired the labor, and supervised the works.

Sustainability

Contributors of funds and labor develop a sense of ownership, resulting in sustainable operation and maintenance. Lane sewers continue to be community-maintained.

6. Conclusions

In rural and peri-urban areas of Africa, Asia and Latin America, the human excreta disposal problem is alarming. On a daily basis, thousands of tons of faecal sludges (FS) from on-site sanitation (OSS) systems are disposed into lanes, drainage ditches, onto open urban spaces and into aquatic natural recipients. Faecal sludges are disposed or re-used in agriculture untreated in the majority of the cases. In many communities, dumping sites are close to formally or informally inhabited, low-income areas where they threaten the health of this growing segment of population. Moreover, uncontrolled disposal and reuse of untreated wastewater and faecal sludges is potential hazard to the quality of the living environment through pollution of groundwater, inland waters, marine environment, soil and air.

Wastewater and faecal sludges management and treatment are costly and their benefit is often hard to be demonstrated. Therefore, community based organizations (CBOs) and international non-governmental organizations (NGOs) are often ideal for promoting ecological sanitation and other low-cost approaches, mostly during the early pilot phases. And certainly, the case studies in this paper clearly show that the decentralized ecological sanitation systems often depend on community based organizations through promotion, building, monitoring and assessing of the facilities. Their knowledge of local conditions is essential for promotion and management of the concept. Furthermore, these organizations often have the enthusiasm to bring in new practices, survey household habits, mobilize local resources and influence the conduct of community members. However, general conclusion is that the activities in relation to human waste issues and carried out by the CBOs and NGOs are rather limited in number and capacity. NGOs can and do act as intermediaries to provide a wide range of support services but the limitations, as well as the advantages of using NGO's to provide support needs to be fully recognized by the donors, community and local authorities.

In relation to the small-scale private independent providers, the conclusion is that promising transformations have been identified like progress in emptying services, establishment of a competitive market among small-scale private independent providers, licensing or contracting systems between local authorities and enterprises. Furthermore, several local initiatives are detected in the presented case studies aiming at implementing improved management schemes and faecal sludges and wastewater treatment systems. These companies need loan money to expand service area and to improve the services. Many cases show that after the collection of faecal sludges, the treatment and re-use remain a problem and in fact that should be the focus of interest of the companies. Often it is difficult to create appropriate treatment system that will suit both technical and financial requirements on the long-term basis. Treatment and disposal tariffs have to be structured that long term services would be available at minimum cost and sufficient to recover the full cost of services. Additional obstacle is that skilled personnel are needed to operate and maintain the systems/services on a daily basis.

There are several very successful local stories but with limited impact on other parts of the evaluated countries. General conclusion is that this business is still in the early stages and in many places the community and private sector involvement does not exist. In many cases there are no sound written contractual agreements with the city authorities, consultations among the interested parties are limited, and the stakeholders do not appear to be motivated. Moreover, very often the case is that the legislation on sanitation is lacking or it is not enforced.

In addition, general feeling from the case studies is that often the formal institutions are not prepared to distance from standard technology and approaches (which are in many cases inappropriate) and accept creative solutions and alternative technologies. One good example for this case is example of Indonesia where traditional end-of-pipe sanitation projects are the only supported option in their urban development sector.

In Eastern Europe lack of the management of faecal sludges and wastewater systems and proper legislation are the main reasons why the citizens are not fully pleased with the services, even if appropriate aerobic treatment plant is in function.

Sometimes when the appropriate systems exist (Zero discharge sanitation for Pacific islands) but the quantity of the materials for reuse is not sufficient, we cannot talk about it as an option in areas where the reuse of nutrients is expected to be a primary motivation for developing small-scale business.

Additional constraint occurs when the infrastructure is not adequate. In Vietnam many septic tanks are outdated and damaged. From another hand, positive side of this is that improving the damaged infrastructure might create many local jobs and be an excellent starting point for implementation of new technologies. In Chicuma, 50% of the installed pit latrines had no proper urine diversion, owing to poor construction.

Very often local residents believe that official agencies would provide sanitation and sewerage free of charge (Source: Orangi Pilot Project). This should not be the case if we consider the fact that the financial and technical sustainability of the services is the driving force.

Further failure factor can be that the costs are beyond the paying capacity of low-income families, and I consider this as one of the main constraints for radical changes in the sanitation sector in the world, especially if we accept the theory that local independent private providers would support the actions only on the basis of visible profit.

However, there are many success factors from the field experiences. For example, in Senegal, distribution of locally managed and low-cost sanitation technology has stimulated a growth sector of the economy while increasing public awareness of the issue and improving the environmental health of the community. (Source: Gregory Rose 1999).

The well-known biogas reactors in China should be used as much as possible because the case showed that the increases in general sanitation have occurred where those reactors are used. There are no reliable data on biogas usage in other parts of the world.

Cesar Aorve from Mexico has suggested that one of the keys to longer term sustainability of eco-san systems is to support the link that exists between the small scale community oriented workshops that construct the urine-diverting toilet seats and the people who build the toilets. His vision of project's self-financing capacity is interesting. The main idea is to limit the project to small-scale production, where producer of the toilet has to promote the product's use through workshops. The most important objective is to strengthen local economies by creating local jobs, using local materials, requiring minimal investment and using simple technology. The author's opinion is that the market should respond positively.

Another successful example is when a network of CBOs called Anadages (source: SIDA) has perfected a method of growing vegetables in containers using human urine as a fertilizer. Also, excellent community management and motivation of the local families in El Salvador is good example how simple technology can work well.

Successful factors can be to offer easy payment plans to the customers, which means that the price of the services should be appropriate to the average household budged and the local or national governments should participate in the financial part of the services. Getting in touch with other operators through combining the businesses and exchange of expertise might be also one of the ways to approach the problem. In addition, work with governments and international or local organizations can be beneficial in relation of establishing sound environmental sanitation rules, and sharing knowledge and expertise.

Re-use of urine as a fertilizer is strongly suggested option according to the "Eco-San: Closing the loop" conference in Germany in April 2003. Also, experts from Waste in Gouda are in favor of this system as a promising support mechanism in faceal sludges treatment. Double-vault dehydrating toilet in Vietnam case shows that new toilet design allows removal of pathogens before the faeces were spread on the fields. In addition, there is no doubt that the system, when properly used, does function very well.

All available small-scale technologies presented in this paper are good. However, sometimes specific local conditions do not favor certain technology. The conclusion is that the technology has to fit local circumstances (Growing vegetables case in Mexico City) and all the decisions has to be made on case-to-case basis, even if we are talking about two different peri-urban settlements of the same city.

The Mormon Church settlement with well-maintained oxidation ponds demonstrates how important is to have skilled personnel and motivation to make a change (Source: SOPAC).

The Kumasi Metropolitan Assembly (KMA) licenses private contractors, and the competitive market between private operators and the fact that KMA can withdraw the licenses in case truck drivers do not discharge their loads at the official site seem to be the reasons for the successful KMA policy. Also, in northern Ghana, the results indicate that 2/3 of the farmers are willing to pay for the compost, which creates additional space, and motivation to make investment in local composting plants.

In the frames of the famous Orangi Pilot Project development of innovative low-cost models and methods, training, and innovative organization management seem to be the main success factors.

At the end, the final conclusion is that no matter if top-down or bottom-up approach is applied, through good organization, transparency in choosing treatment options, strong political will at all levels, awareness of the local population, supporting local private independent providers with micro credits and many other technical, financial and social inputs, can lead to success in low-cost sanitation sector in developing countries.

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Appendix

Case study: the Eco-Guide project

The aim of the Eco-Guide project has been to develop and apply planning and evaluation tools for wastewater systems. In the project two different urban areas were studied: Bergsjön, a suburb of 13,000 inhabitants in Göteborg, and Hamburgsund, a small coastal village of 1100 inhabitants. In each area three different wastewater systems were studied: the existing system with conventional piping and treatment, a local alternative with sand filter beds and wetlands, and a system where wastewater is separated into urine, faeces and grey water. The different wastewater systems have been compared and evaluated using different approaches: analysis of direction, environmental impact assessment and life cycle assessment. Conclusions were drawn concerning the environmental effects of the chosen system and the application of different evaluation methods.

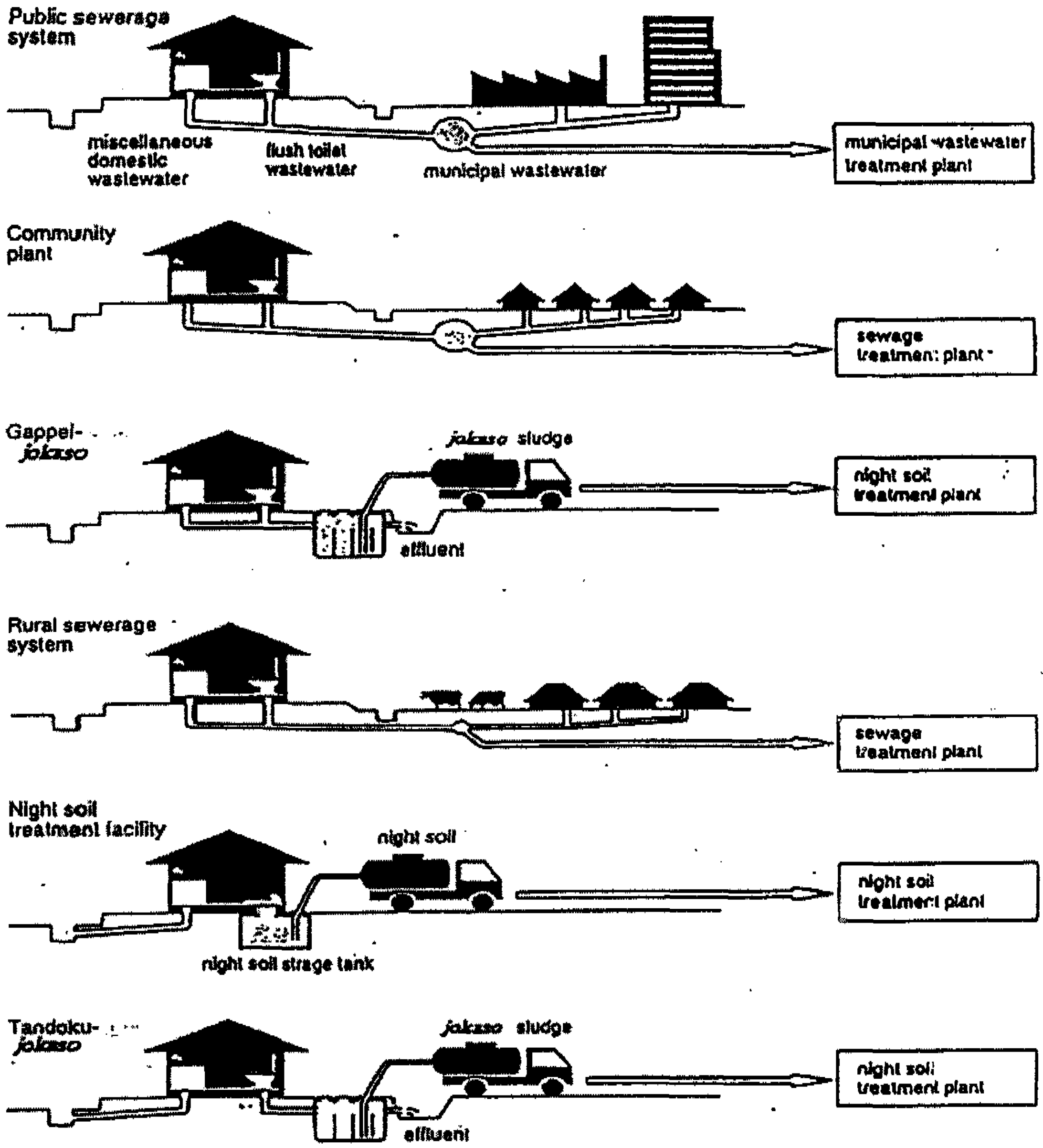
Concerning the environmental effects the separating wastewater system turned out to be the best choice both in Bergsjön and in Hamburgsund. Discharges of nutrients and polluting substances to air, water and land were minimised and the nutrients were recycled. From an energy point of view the existing system in Bergsjön was favourable owing to the recovery of heat and the production of biogas. In Hamburgsund there were no economical or technical prerequisites for energy recovery. The investment costs per capita were lower in the existing system in Bergsjön than in the alternative systems. The costs of operation were, on the contrary, lower in the alternative systems. In Hamburgsund the costs for both investment and operation were lowest in the local wastewater alternative.

The results are to a great extent dependent on the choice of area to be studied and the chosen technical solutions. However, some general conclusions were drawn.

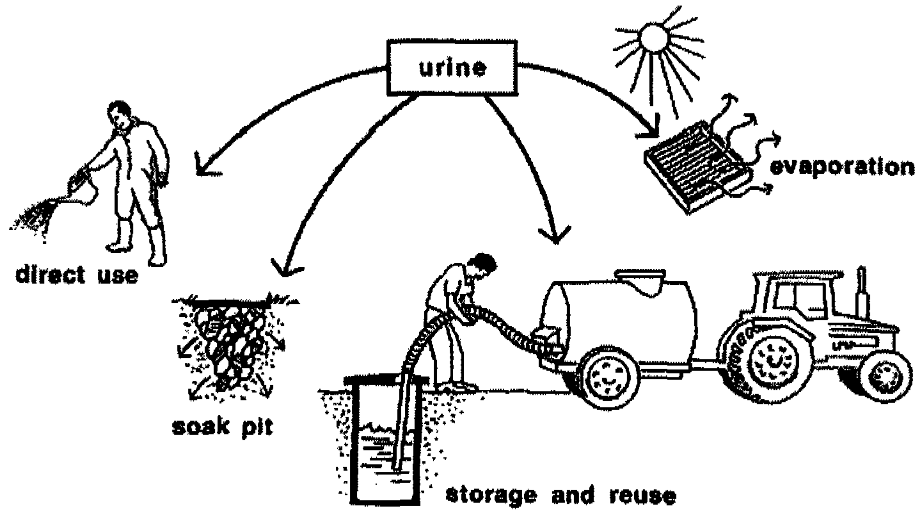
* Importance of the scale. Large wastewater systems (like Bergsjön) use less energy per capita than small systems (like Hamburgsund). Investment and operation costs are also lower in a large-scale system.
* Importance of use of energy. Recovery of energy is an important factor for environmental considerations. Heat pumps, for example, use the large amounts of heat in wastewater. Energy consumption during the operational phase is larger than that for the manufacturing of components in the wastewater system (investment phase). The energy use for investments is, however, not negligible when studying systems with many components.

Within the project three evaluation methods have been compared. An LCA is applicable especially when studying energy use and environmental impact on a global level. An EIA is useful when describing environmental impact on a local level. The results from the simplified analysis of direction produced similar results to the more comprehensive evaluation methods.

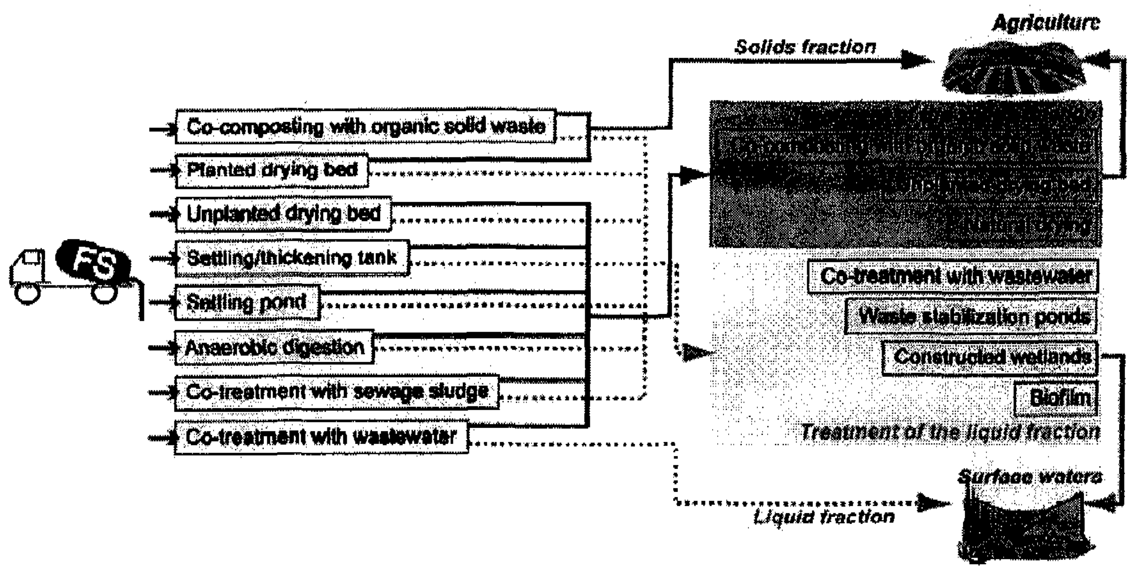
This article is entirely copied from: *Ecological alternatives in sanitation* (Drangert, Bew, Winblad SIDA, 1997)



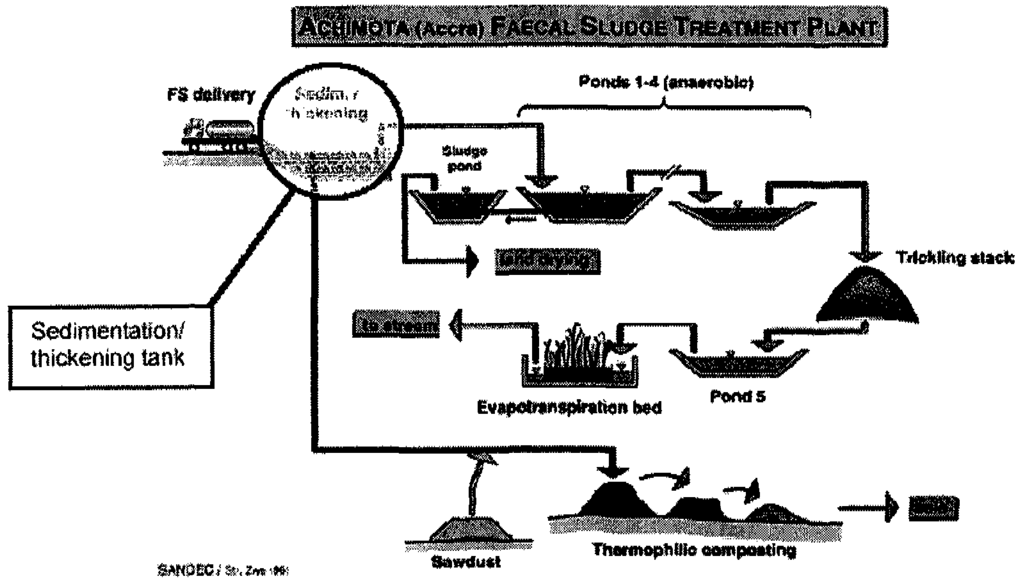
Systems for treatment and disposal of human excreta and wastewater in Japan (source: SIDA 1997)

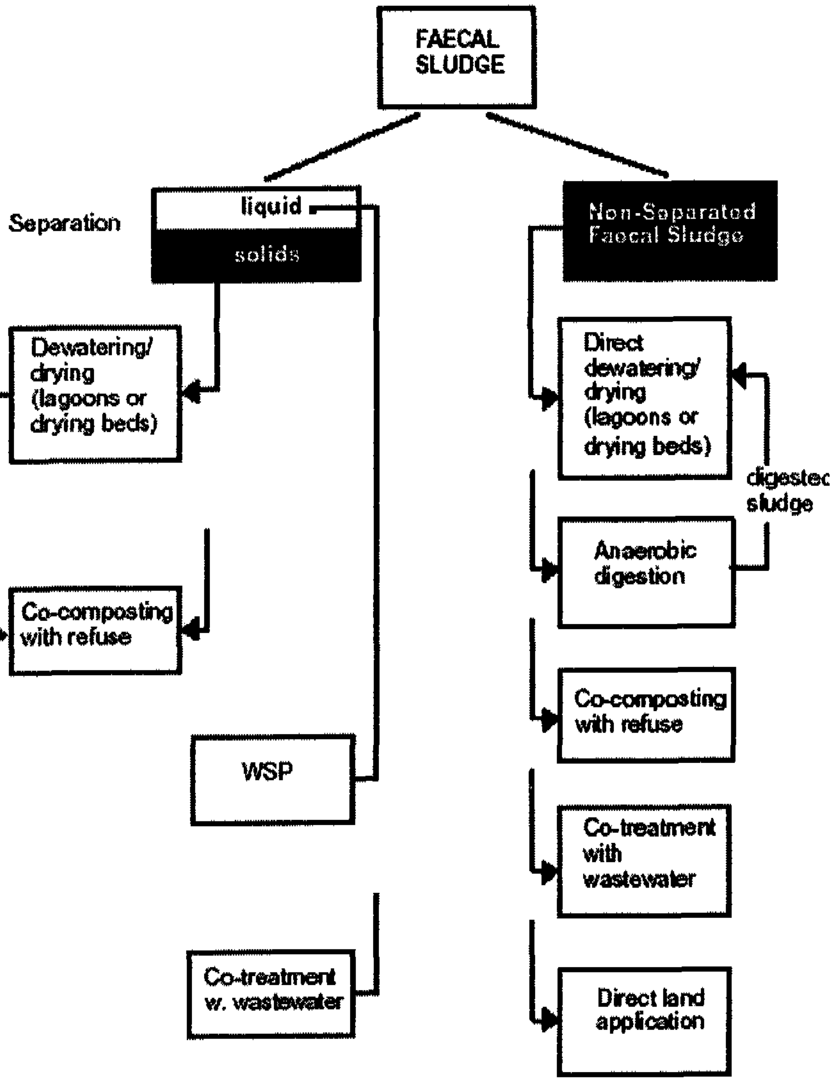


Urine re-use and disposal options (source: SIDA)



Overview of potential, modest-cost options for faecal sludge treatment (source: SANDEC)


ACHIMOTA (Accra) FAECAL SLUDGE TREATMENT PLANT
FS delivery
Ponds 1-4 (anaerobic)
Sludge pond
Trickling stack
Sedimentation/ thickening tank
to stream
Evapotranspiration bed
Pond 5
Sawdust
Thermophilic composting
SANDEC



Theoretical Options for treating faecal sludges (FS) source: SANDEC

Examples of Faecal Sludge Disposal, Use and Treatment Practices

City/country	Disposal / use without treatment	Separate treatment	Combined treatment
Latin America			
• Province of Rosario (Argentina)		Stabilisation ponds	Stabilisation ponds for septage + wastewater
Africa			
• **Gaborone and Lobatse (Botswana)**	-----	-----	Co-treatment with wastewater in WSP
• **Kumasi (Ghana)**	Discharge into streams	Pond system being commissioned 2002	-----
• **Accra (Ghana)**	Sea disposal (for excess sludge)	Settling/thickening followed by ponds; composting of separated solids with sawdust or solid waste	-----
• **South Africa**	-----	-----	Mostly co-treatment in act. sludge treatment plants
• **Grahamstown (South Africa)**	-----	-----	Co-composting with municipal refuse
• **Maseru (Lesotho)**	Trenching ground	Drying lagoons	-----
• **Dar Es Salaam (Tanzania)**	Sea disposal through wastewater outfalls	-----	Co-treatment with wastewater in WSP
• **Cotonou (Benin)**	-----	Stabilisation ponds	-----
Asia			
• **Manila (Philippines)**	Mostly unaccounted for; discharge into drains + outfalls	-----	Minor quantities: co-treatment with wastewater in WSP
• **Jakarta (Indonesia)**	Storm drains and canals; mostly unaccounted for	Extended aeration followed by ponds; drying beds for separated sludge	-----
• **Hanoi (Vietnam)**	Agricultural or aquacultural use	-----	Combined compostingof faecal sludges and municipal solid waste
• **Ho Chi Minh City (Vietnam)**	Agricultural or aquacultural use	Drying ponds	-----
• **China (unsewered parts of urban areas)**	Agricultural or aquacultural use	Some field-side storage by farmers	-----

source: SANDEC

Provider type	Profile examples	Steps towards success
(1) Permanent partners with water utilities whose water they distribute at kiosks or standpipes	Kenya Mali Haiti Senegal Bangladesh (has already undertaken steps to success listed at right)	• Improve interface with utility with regard to metering and billing and installment payments for hookup charges. • Develop sound written contractual agreements with utility/city. • Develop forums for regular consultation among stakeholders. • Build more holding tanks. • Test UV Waterworks treatment unit as backup or substitute for unreliable utility water supply.
(2) Pioneers who bring water in advance of utility expansion (3) Pioneers who build sewerage systems and have them connected	Paraguay Argentina Guatemala Philippines Pakistan (has already taken steps to success)	• Find loan money to expand service area and invest in larger and more durable pipes and wells. • Establish agreements with utilities on standards to allow future connectivity. • Contracting market pipelaying and other specialized funtions to utility. • Consider change of legal status to ensure a stronger bargaining position during contract negotiations with utility.
(4) Mobile water truckers, carters and water carriers	Senegal Haiti Peru	• Find loan money to expand service area. • Offer easy payment plans (small individual payments) to keep customers connected and happy.
(5) Owner/operator /franchiser of public toilet and bathing facilities and of *septage treatment* plants	India Benin Peru Philippines	• Find loan money to expand service area. • Get in touch with other operators and exchange expertise. • Conduct financial analysis to set prices fairly (raise tariffs to cover LRMC), get loans to expand service, and improve *quality over time.* • Work with governments to establish sound environmental sanitation rules. • Increase public awareness of benefits of sanitation services.
(6) Community-managed latrines and water systems	Ethiopia Nepal Mali	• Build effective community governing structure, or hire permanent outside accountant, so that money is efficiently used to maintain system. • Increase tariffs to generate funds to attract good accountants and supervisors.

Future scenarios by small-scale provider type (Small scale providers: typology and profiles) by Suzanne Snell 1998