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Water & Sanitation in
Developing Countries

SANDEC News

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Dear Reader,

This SANDEC News gives you an overview of the recent results and developments of our research projects conducted in close collaboration with partners in Africa, Asia and/or Latin America. We recently also embarked on new research activities. In the field of water treatment, a simple method for arsenic removal by solar irradiation is now under investigation. In the field of sanitation, a research project has been initiated, focusing in particular on the potential and limitations of decentralised wastewater treatment/management in peri-urban areas. In the field of solid waste management, we are presently in the process of defining a new research focus which will be directed either on landfill or decentralised composting. Let me also take this opportunity to inform you about some changes in our staff. Chris Zurbrugg, who has taken over from Serge Abramowski, is now in charge of solid waste management. Swen Vermeul has replaced Bernhard Sommer as research assistant in water treatment projects. Agns Montanger o joined our team most recently as new research assistant in the SOS project. She replaces Udo Heinss who will act as project officer in decentralised wastewater treatment. I warmly welcome our new colleagues and wish them success, satisfaction and fun in their work with the SANDEC team and with our partners abroad!

Roland Schertenleib
Director SANDEC

Enhancing Community Motivation and Participation in Solid Waste Management

by Christian Zurbrugg and Rehan Ahmed

Abstract

The collection of waste generated by the rapidly expanding cities in developing countries is increasingly beyond the capacity and financial means of the municipal administrations. A promising approach to improve collection coverage is the introduction of community-based management schemes involving the local communities in proper waste storage, collection, sorting, and recycling activities. Research has shown how such schemes can be implemented under different conditions (Pfammatter & Schertenleib, 1996). SANDEC initiated a pilot project study in an urban slum in Karachi, Pakistan, in collaboration with a local NGO, Association for Protection of Environment (APE). Its objective is to field test a community information and education approach to enhance motivation and participation in the establishment of a primary collection scheme. The project activities included development of alternative information and awareness material disseminated by informal methods, including community meetings with target groups of different genders and ethnic backgrounds. The project greatly contributed to enhancing motivation and participation among the various target groups of the community. The community members were involved in all stages of the project, as well as in the assessment of the existing situation, planning, design, implementation and even evaluation of an alternative collection scheme. Enhancing awareness and genuine participation in the planning, design, implementation, and evaluation phases are important prerequisites for establishing successful primary refuse collection schemes.

Research Objectives

Self-help and use of community participation may, in many cases, be the only solution for solving the waste collection problems in low-income areas. In the course of SANDEC's solid waste research, a pilot project was initiated on alternative waste collection in a typically low-income urban area in the city of Karachi, Pakistan. This pilot project, which was conducted by a local NGO "Association for Protection of the Environment (APE)", focused on the following social issues:

- Acquire experience in people's concern in general and in their attitude towards waste collection in particular.
- Field testing an approach to enhance community awareness and initiate genuine involvement of the community in all stages of the waste collection project.

A further objective of the pilot project was to find a suitable technical, institutional and financial framework for an alternative waste collection scheme and to implement it.

The Shah Rasool Colony was selected for the pilot project on the basis of meetings with key officials responsible for slum upgrading as well as with community representatives, and of preliminary information collected from various areas, including the required characteristics listed in Table 1.

Tab. 1 Selection criteria for the pilot project on alternative refuse collection in a typically low-income urban area of Karachi, Pakistan

Selection Criteria for the Pilot Project	Objective
Low-income urban housing area	Research focus on low-income urban areas
Population of less than 10,000 inhabitants	Manageable population size
Well-defined boundaries	Clearly defined operating area
Within the municipal boundary	Clearly defined institutional authority
Available basic infrastructure	Main community priorities, e.g. sanitation and water supply, partly fulfilled
Area where lease titles are being granted	Area regarded as "legal" by the public authorities
Willingness of community representatives and opinion leaders to cooperate	Available link to community members
Area with an inadequate solid waste collection system	Area with a potential for improvement of the collection system
Inexistent NGO or community-based organisation (CBO) working in waste collection in the same area	No overlapping efforts

Fig. 1
Overflowing municipal bin and scattered waste

Shah Rasool Colony

Shah Rasool Colony is a low-income area of Karachi consisting of different ethnic groups.

The Shah Rasool Colony (SRC) covers an area of 3.7 ha (9.2 acres) with a population of approx. 3000 inhabitants or about 400 households. The area is inhabited by the following ethnic groups: the majority are Pathans from the North-West Frontier Province (NWFP) and Punjabis. Local people, Christians and Hindus form a minority.

Since background data on the Shah Rasool Colony was scarce, APE conducted various surveys on physical reconnaissance, available infrastructure, socio-economic condition and on the communities' attitude towards solid waste and waste handling habits. The socio-economic and attitude survey was conducted in 10 % of the households.

Household storage is common. Waste is disposed of on a daily basis by the women or children in informal heaps in the neighbourhood.

This survey revealed that 85 % of the households use some sort of waste container. For reasons of limited container capacity and average of six persons per household, the household waste container is emptied on a daily basis. The main responsibility for cleanliness of the households lies with the women. Most household waste is disposed of by women or children in informal heaps in the neighbourhood. These are, however, subsequently scattered due to scavenging. Private sweepers are hired only in a few cases to dispose of the household waste. They are paid about US $ 0.5-1 per month for this service.

Two municipal bins are available in the area, but their capacity is insufficient and the municipal collection service is very unreliable or inexistent (Fig. 1). Only 12 % of the respondents use these municipal bins. APE also defined waste quantity and quality at household level. The data revealed a generated average waste quantity of 0.4 kg/cap/day with an average bulk density of 130 kg/m^3.

Methods of Enhancing Community Awareness

As aforementioned, one of the main objectives of the project was to field test an approach on providing information to the population on environmental issues. Motivation was then expected to follow automatically. The planned information and education activities included mass media training, group campaigns, video forums, pamphlets, and home visits. While preparing the material, focus was placed on the following points:

- Conveying short and clear messages.
- Highlighting personal responsibilities and obligations of the individuals in maintaining clean and healthy conditions.
- Defining the role of the municipality as regards its potentials and limitations.
- Informing on the duties and responsibilities of the individuals and community in cooperating with the municipality.
- Informing on the advantages of cleanliness in the promotion of health.

The roles played by the different key community members were first identified before involving all community members.

In the Shah Rasool Colony, informal community leaders were identified as influential people on the basis of their personal or religious status. All are men who have proved instrumental in community development activities, and who maintain contacts with the government departments and municipality. Depending on their ethnic background, their meeting place was either the mosque (Pathans) or their homes (Punjabis). They were found to be very active and cooperative with the APE staff.

Women are key community members as they are responsible for maintaining a healthy and clean household.

With regard to SWM projects, women are key community members as they are responsible for maintaining a healthy and clean household and are directly affected by inadequate waste management at the household and community level. Informal meetings with women revealed that they showed a keen interest in improving their sanitary condition. However, the different ethnic backgrounds must also be taken into consideration. Pathan women are generally restricted to their homes and prefer to communicate at home, while Punjabi women are more liberal, and also attend informal meetings more frequently. The best time to contact the women was found to be from 2-4 p.m. when lunch is over, the young children asleep and men at work, thus, giving enough time for women to discuss general and individual problems.

Two women shopkeepers in the area proved to be important key members, as they enjoy a good reputation, have good contacts with the community and are enthusiastic supporters of the project.

Key people are also religious leaders at the mosques. As supporters of the project, they can influence and motivate the followers through their activities.

The Karachi Metropolitan Corporation (KMC) is responsible for SWM at municipal level, whereas the Sindh Katchi Abadi Authority (SKAA) is in charge of management and development of the "katchis abadis", the squatter settlements. The Karachi Water and Sewerage Board (KWSB) and the Karachi Electric Supply Corporation (KESC) are two other institutions responsible for providing water supply, sewerage and electricity.

Informal meetings were conducted for different ethnic and gender groups.

Informal meetings conducted separately for different ethnic and gender target groups were generally held throughout the community involvement project. These meetings discussed general matters pertaining to community welfare and area cleaning, as well as the most appropriate communication methods to enhance awareness in solid waste management among the community. Community members stressed the need for training of volunteers by APE on health aspects of inappropriate solid waste handling and potential improvements of the existing system. Its objective was to reach a wide dissemination of the knowledge acquired by visiting each house so as to inform and educate also those people who do not attend the community meetings. APE therefore trained "female" volunteers on issues associated with health, hygiene, waste management, and cleanliness.

Other methods of dissemination used in the information and education campaigns included targeting religious schools; i.e., the "maktab", and the mosque in general. Christians were additionally contacted through the churches. To reach the children of the community, APE initiated an essay competition with prizes in primary and secondary schools entitled "How can I keep my area clean". Published articles in local newspapers and handbills were also used as further educational measures.

Other Activities

To gain confidence, it is necessary to address other issues of health and welfare not directly related to SWM.

The community often does not accord high priority to solid waste. To gain the confidence of the community members, it is essential to also address community-sensitive issues of welfare and health not directly related with solid waste management. APE supported different activities, such as the "Celebration of the Cleanliness Week" and a vaccination campaign against the spread of Hepatitis B. During the rainy season, the community was assisted in flood control by contacting different authorities, such as the sewerage author-

Fig. 2
Wheelbarrows as primary collection vehicles

ity and the Karachi Electric Supply Corporation. In addition, the community was also motivated and supported in its effort to obtain lease titles.

Primary Waste Collection Scheme

Technical design and organisational structure of a waste collection system were discussed and finalised in informal meetings.

Collectors equipped with wheelbarrows and brooms collect waste from door to door on a daily basis.

Use of garbage containers was promoted among the residents who were urged to use any type of waste container with a lid at first, but to refrain from using plastic bags. Sweepers, known to the area and equipped with wheelbarrows and thick brooms for street sweeping (Fig. 2), were hired to collect the waste from the households on a daily basis.

The sweepers wear visible overalls and protective gloves, and are supplied with a soap and disinfecting agent for cleaning the wheelbarrows. The waste is transferred to the municipal bins or to specially designated dump sites until more municipal bins are available. APE assisted the community in their request for two additional communal bins, and contacts were also made with the municipal corporation to ensure waste collection from the communal bins. Alternatively, a private contractor was commissioned to collect the waste in case the area is not serviced by the municipality.

A community organisation manages the collection system. Women volunteers supervise the collection and levy user fees.

Volunteers from the community formed a financial and institutional committee to monitor and supervise waste collection. These volunteers are mostly women, especially unmarried women, who can devote more time to such voluntary activities and who reside in the lanes/streets they supervise. Two volunteers in each lane/street supervise the sweepers, ensure that the waste is collected regularly and appropriately, and levy the user fees. These women have formed a CBO. This CBO is entrusted with the task of collecting the funds and paying the sweepers. Weekly and monthly meetings should ensure appropriate planning and evaluation of the system. The monthly waste collection charges were established by the committee at US $ 0.4-0.6 per household, however, widows without an income are exempted from these charges.

If competent individuals working on a voluntary basis withdraw, they must make sure that their knowledge and skills are passed on to their successors.

Conclusions

Self-help and use of community participation may, in many cases, be the only way of solving the waste collection problems in low-income areas. However, community awareness and willingness to participate are key aspects in any planning and implementation project on alternative waste collection systems. In many community participation projects, the donors or the municipal and/or government agencies try to motivate the communities and beneficiaries, however, they neglect to gain their confidence first. The Inform-Educate-Motivate strategy [2] developed by the professionals of APE was successfully applied and implemented in a pilot project. The "informing" strategy familiarised the community with the pollution hazards and the resulting public health and environmental impacts. During the "educating" phase, the different segments of the community were targeted with specific material on SWM (video, handbills, etc.). Motivation followed automatically and the community was supported in its improvement effort. The main communication methods comprised informal meetings with community members of different gender and ethnic/religious backgrounds, house visits and information campaigns at schools, mosques and churches. The community was also involved in the assessment of its prevailing condition and in the design and implementation of an alternative waste collection scheme. A local CBO was activated to collect user fees from the households, as well as to organise and supervise sweepers during their waste collection activities. A survey conducted after implementation of the scheme, yielded significant improvements in solid waste handling. It also revealed a positive attitude towards other communal and participatory activities and provided additional knowledge on health, cleanliness, sanitation, and SWM issues.

Area		3.7 ha
Households		400 hh
Inhabitants		3000 inh
Average income		80 US$ / month
Roads		secondary, mostly unpaved roads
Equipment		3 wheelbarrows, 5 brooms, 3 baskets, waistcoats, gloves, disinfecting soap and agent
Personnel		1 full-time and 2 part-time (more when street sweeping is required)
Type of service		door-to-door
Frequency		daily
Coverage		65%
Working hours		3-5 hours daily
Capital costs		aprox. 150 US$ for equipment
Operating costs	Personnel	full-time collector 32 US$/month
		total personnel costs 60-70 US$/month
Fee collection	by	lane volunteers (total of 16)
	frequency	monthly
	amount	0.4-0.6 US$
Managed by		CBO

Problems, Limitations and Constraints

Community-based collection schemes often collapse when a motivated member of the management, or a few competent individuals working on a voluntary basis withdraw from the scheme (Pfammatter & Schertenleib, 1996). The current waste collection scheme in the Shah Rasool Colony is also susceptible to such a breakdown as the current volunteers who manage the scheme are mostly young and unmarried women. Therefore, it is essential for them to pass on their knowledge and skills to their successors before withdrawing from the scheme.

Similar to all the other schemes, this primary collection scheme is also heavily dependent on the provision of a regular municipal collection service. The current situation is far from ideal as additional communal bins are necessary and a private contractor had to be commissioned due to the unreliability of the municipal collection service.

Political affiliations also restricted the project development as the majority of the residents joined the opposition party, thereby creating resentment by the ruling class towards any area upgrading effort.

A population control campaign, which was negatively received by the community members, also interfered with the solid waste project as some community members incorrectly assumed that the solid waste project staff was backing the campaign.

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Detailed information on the pilot project in Shah Rasool Colony can be obtained from Christian Zurbrugg or APE at Suite 807, 8th Floor, Fortune Center, 45-A, Block 6 P.E.C.H.S. Main Shahrae-faisal Karachi 75400, Pakistan, e-mail: ape@cyber.net.pk

Resource Recovery in a Primary Collection Scheme in Indonesia

by Christian Zurbrugg and Christina Aristanti

Introduction

As centres of population and human activities, cities consume natural resources and generate waste which has to be disposed of inside and outside city boundaries. Urban areas, thereby, present environmental problems over a range of spatial scales; i.e., the household, the place of work, the neighbourhood, the city, the wider region, and the world. Urban Solid Waste Management (SWM) is currently regarded as one of the most immediate and serious problems faced by urban governments. Inadequate or unavailable solid waste collection and disposal services result in indiscriminate dumping of waste on streets and public areas, clogging of urban drainage systems, contamination of water resources and proliferation of insect and rodent vectors. Such conditions increase health risks by direct human contact with solid waste, and constitute major factors in the spread of gastrointestinal and parasitic diseases. Even if the efficiencies of existing collection systems are improved significantly, a large section of the population will realistically not be served by municipal services, especially in low-income areas where insufficient pressure is exerted on municipalities to provide the necessary services. In other words, residents of low-income areas have to manage their own waste and develop alternative waste collection systems adapted to their economic needs.

Apart from the difficulties associated with the collection services, the municipalities also have to deal with the final disposal of solid waste. Numerous existing dumps or landfills have almost reached their maximum capacity and new sites are increasingly difficult to find or are located far from the collection areas, thus, leading to high transport costs. A decrease in the amount of solid waste to be disposed of by material recovery and recycling is, therefore, of prime importance. Since a large fraction of municipal solid waste in developing countries is composed of organic and putrescible material, composting could offer a potential recovery option.

Background

Experience revealed that large centralised and highly mechanised composting plants have often failed to reach their target and were soon abandoned due to high operational, transport and maintenance costs. Financial and technical viability can only be reached if the composting plants are decentralised, located close to the generated waste, and if they make use of low cost technologies based mainly on manual labour. Small scale decentralised communal composting plants are considered a suitable option to maintain transport costs low and minimise problems and difficulties encountered with backyard composting.

SANDEC and Yayasan Dian Desa (NGO) in Yogyakarta have initiated a joint pilot project to gain experience in integrating resource recovery options into a community-based primary collection scheme. Main focus was placed on a small scale decentralised composting unit operated by waste collectors. This pilot project particularly aimed at encouraging low-income urban communities not only to manage their own waste collection, but also to integrate resource recovery and recycling, and to allow other communities to profit from this knowledge and enable replication in other urban areas.

Pilot Project Area

Perumahan Minomartani, with a total of 7,800 inhabitants in 1,570 households, forms part of Yogyakarta's urban area. Administratively, it is divided into six "community units" (RW), each consisting of about five "neighbour units" (RT). The RWs are responsible for the management of household collection. Four of the six community units set up a common community-based primary collection scheme called "Unit Pengelolaan Sampah Minomartani (UPSM)". It has now developed into a well-established informal organisation run on a voluntary basis. This organisation is in charge of household waste collection and transport to an intermediate dumping site. The municipal cleansing department is, however, responsible for secondary waste collection and transport from the intermediate dumping site to the final disposal area.

The Composting Unit

After holding a formal meeting with the local leaders of the community units and the UPSM staff, the concept of a composting unit linked to the primary collection scheme was finalised and first steps were undertaken to find an appropriate site. Finding space for such activities was not easy as the area is densely populated. Following numerous discussions and negotiations, an ideal site was found adjacent to the intermediate dumping site and near the river, thereby, allowing water access. The 300-m^2 plot was rented for two years, and a 200 m^2 working area was paved and covered by a simple zinc roof. Six of the eleven waste collectors have agreed to work at the composting unit.

The composting process chosen is based on heap composting with passive aeration. The collected municipal solid waste is first separated manually into organic and inorganic fractions as well as into recyclables which can be directly resold (Fig. 1). The inorganic, non-recyclable fraction is transported to the nearby intermediate dumping site. The organic waste is subsequently piled around a bamboo triangle tunnel (Fig. 2) which serves

The composting process is based on heap composting with passive aeration. After two months, the compost can be bagged and is ready for sale.

to aerate the compost pile (Fig. 3). During the first month, the heap is turned weekly, the moisture content determined and the heap watered if necessary. Remaining non-degradable materials are removed manually while turning the heap. The compost, which is completely decomposed in a month, is left to settle for an additional month. Finally, the finished compost product is sieved and bagged for sale.

Fig. 1 Municipal solid waste separated manually into organics, inorganics and recyclables

After working on the unit for a month, the waste collectors were trained on the principles of composting, on the composting steps, on processing the final product, and on quality control to perfect their skills and knowledge. In the first few months, the monthly compost production amounted to about 300 kg. To improve labour efficiency, Yayasan Dian Desa conducted a time and motion study of the activities on the site. Improvements were introduced and production was raised to 1,300 kg/month.

Sorting of the municipal waste and sieving of the finished product are the main factors restricting higher production rates.

Sorting of the incoming waste and sieving of the finished product were the main factors restricting higher production rates. To ease sieving, a simple crusher was developed and used prior to sieving the compost. This significantly increased production to 3,000 kg/month.

Marketing

Yayasan Dian Desa assumed responsibility for marketing as the others have little spare time.

The pilot project first planned for the compost product to be marketed jointly by the community-based organisation managing the collection scheme (UPSM) and the collectors. However, this was not feasible as the UPSM staff are all volunteers with a permanent job and limited spare time. Their marketing efforts are conducted on a person to person basis in their work environment. The collectors cannot devote much time to marketing as their waste collection and composting work leaves them very little spare time. Yayasan Dian Desa, therefore, assumed responsibility for marketing and developed fliers, participated in exhibitions and designed an attractive packaging for the compost product so

Fig. 2 Bamboo triangle tunnels placed in the centre of the organic waste allow for an aeration of the compost pile

as to attract consumers. In order to promote and launch the product, the compost was first sold through retail in bags of 2 and 4 kg at a subsidised price of Rp. 400/kg. A cost covering price of Rp. 750/kg was subsequently introduced. However, marketing of compost at this price proved far more difficult and became almost impossible due to the economic crisis in Indonesia, forcing people to focus more on satisfying their basic needs.

Marketing of compost at a cost covering price proved to be very difficult and became almost impossible due to the economic crisis in Indonesia.

Future Outlook

The pilot project attracted the attention of numerous representatives from universities, NGOs and government institutions who visited the composting unit. Since the local government has shown a keen interest in replicating the system in other communities, Yayasan Dian Desa and the team leader of the composting unit were asked to act as technical advisors. However, the prospects of marketing the compost product have encountered major difficulties, as the demand for compost is still lacking and retail marketing is unable to cope with the increasing supply of compost produced. Since the organic waste recovery concept is currently planned to be replicated by other primary collection schemes, the problem is likely to intensify in the near future. It is also vital for the government to become aware of the cost saving factor of these schemes: i.e., the waste to be disposed of in landfills or dumps is significantly reduced. Composting projects should involve and be supported by the responsible government agencies at an early stage, and government support for awareness programmes, product subsidies and marketing efforts should be pursued further. Apart from reducing waste to be disposed of, compost is a product that can be used not only as organic fertiliser, but which also plays a role in improving soil properties. It is a resource that can reduce soil depletion and erosion, help bind nutrients, improve water retention capacity, and allow for a proper circulation of air and water.

The sale of compost encountered major difficulties. Demand for compost is still lacking and retail marketing is unable to cope with the increasing supply of compost produced.

A comprehensive general marketing study is an important prerequisite for the successful marketing of compost. The study should analyse available and potential consumers as well as their habits before developing appropriate strategies and activities to enhance awareness of the benefits of compost, and also to promote increased demand. The focus should not only be placed on consumers at household level, but also on bulk consumers such as small and medium sized urban farming enterprises (e.g. market gardening, horticulture). Urban agriculture, which is gaining increased importance in the supply of food for the rapidly expanding cities of the developing world, is a potentially significant market for the use of compost (Schnitzler et al. 1998).

A compost marketing study is essential for its successful commercialisation. The study should focus not only on consumers at household level, but also on bulk consumers such as small and medium sized urban farming enterprises.

Important potential markets for compost are those located near the composting unit. By keeping the distance between producer and consumer small, the transport costs can be minimised and the product made more attractive from a financial viewpoint.

Fig. 3 Fresh composting heap with passive aeration system

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For additional information about the pilot project in Indonesia, contact either Yayasan Dian Desa, Jl. Kaliurang km 7, P.O. Box 19, Bulaksumur, Yogyakarta, Indonesia or Christian Zurbrugg.

The Challenge of Solid Waste Disposal in Developing Countries

by Christian Zurbrugg

Overview

Most of the municipal solid waste (MSW) in developing countries is dumped on land in a more or less uncontrolled manner. Such inadequate waste disposal practices create serious environmental problems that may impair human and animal health and result in economic and other welfare losses. Environmental degradation caused by inadequate waste disposal leads to surface and groundwater contamination by leachates, soil contamination by direct waste contact or leachates, to air pollution by waste burning, and to the spread of diseases by different vectors like birds, insects and rodents.

Health Issues

Uncontrolled dumping contaminates the environment and poses a public health risk. It also causes contamination of water and soil by leachate, spread of diseases by vectors, air pollution by fires and physical dangers like landslides and explosions.

In the past few decades, urban growth has resulted in uncontrolled dumping sites frequently surrounded by settlements and housing estates that are often centrally located. Such uncontrolled dumps without site management directly endanger the health of nearby or on-site residents. It is, however, absurd to believe that other citizens are not affected, as the chemical and biological contaminants from inadequate disposal will inevitably find their way to them. The public may be affected by contamination of its drinking water, by soil contamination passed onto the aquatic and terrestrial food chain and through the spread of diseases by different vectors. Inhabitants near or on the site, most often the urban poor, are subject to direct contamination from hand to mouth and through inhalation of dangerous volatile compounds and aerosols. There is also a direct physical danger emanating from possible waste landslides, collapsing dumps, explosions, fires, and waste-related transport accidents.

Financial and Social Issues

Municipalities have great difficulties in trying to define their current solid waste management costs. Financial resources often barely cover collection and transport costs, leaving no resources for safe disposal.

Financial and institutional constraints are one of the main reasons for inadequate waste disposal, especially where local governments are weak or underfinanced, and in areas of rapid population growth. Due to the frequent lack of detailed cost accounting, numerous governments have great difficulties even in trying to define their current solid waste management costs. Whenever solid waste management systems based on user fees are introduced, the fees often barely cover collection and transport costs, leaving practically no financial resources for the safe disposal of waste. Financing this part of the solid waste management cycle is made even more difficult as most people are willing to pay for the removal of the refuse from their immediate environment, but are generally not concerned with its ultimate disposal and act according to the motto “out of sight, out of mind”!

Landfills as such are subject to public opposition since most inhabitants associate them with uncontrolled dumps. They are unaware that a sanitary landfill differs from an uncontrolled dump.

As a result of rapid urbanisation, many existing disposal sites were gradually surrounded by settlements and housing estates. Since the environmental degradation associated with these dumps directly affect the population, disposal sites are subject to growing public opposition. People are unaware that a sanitary landfill differs from an uncontrolled dump. Together with land scarcity, public opposition is one of the reasons why siting of new landfills is becoming increasingly difficult. Siting a new landfill far from the central collection point and, therefore, far from the urban area, may have the advantage of less public opposition. However, it also implies higher transfer costs and additional investments in the infrastructure of roads, thereby, aggravating the financial problems of the responsible authorities.

Technical Issues

Many governments now acknowledge the environmental and public health risks associated with uncontrolled waste dumping. However, officials frequently believe that uncontrolled waste dumping is the only possible disposal solution. Inadequate training of officials and engineers, and lack of guidelines for siting, design and operation of new landfills, including upgrading options for existing open dumps, are also responsible for the currently deficient disposal practices. Often the only guidelines and training material available come from high-income countries. These are based on technological standards and practices adapted to the conditions and regulations of industrialised countries, and not on the different technical, economical, social, and institutional aspects of developing countries. To alleviate their disposal problems, the authorities turn to waste treatment methods like composting or incineration which, however, do not eliminate the need for a disposal site and are not necessarily adequate and certainly more expensive than safe landfill disposal.

Inadequate training of officials and engineers, and lack of appropriate guidelines are also responsible for the currently deficient disposal practices.

Upgrading Existing Waste Disposal Sites

For the responsible authorities, siting, planning and designing a new landfill is a lengthy and costly affair, often only possible with external financial aid. However, upgrading of uncontrolled waste disposal sites does not necessarily have to be a difficult or expensive task. It should not be regarded as an alternative to a new site, but as a means to significantly prolong the operating life of existing sites, and to reduce the negative environmental impacts that would anyhow have to be dealt with upon closing the sites. Upgrading does not imply that a dump will be converted automatically into a sanitary landfill. Designing a controlled, engineered landfill with a minimum level of environmental pollution and public health risk (here denoted as “sanitary” landfill), can be a step-by-step process dependent on the financial means of the authorities. Such a stepwise approach should be assisted by support measures, such as landfill disposal standards and legislation. The upgrading process can prolong the operating life of existing sites, allowing the responsible authorities to engage in serious siting procedure for a new landfill.

The key to upgrading waste disposal sites is to first acknowledge deficiencies in present landfill operation and/or design methods, and to determine their environmental and health impacts. The next step is to identify the problems and find ways to improve the situation.

Upgrading of uncontrolled waste disposal sites does not necessarily have to be a difficult or expensive task. It can be a step-by-step process dependent on the financial means of the authorities. Such a stepwise approach should be assisted by support measures, such as landfill disposal standards and legislation.

Guidelines

It is important for the authorities to be assisted in the upgrading process either by site specific consulting or by guidelines and manuals on technical improvement possibilities. Literature is very scarce, especially on the different technical, economical, social, and institutional aspects of developing countries. In their booklet “Guidelines for an Appropriate Management of Domestic Sanitary Landfills”, Oeltzschner & Mutz (1994) focused mainly on the issues pertaining to the siting of new landfills. However, they also attempted to close the existing knowledge gap by providing some valuable information on low-cost gas collection systems. Matsufuji (1990) established the “Technical Guidelines for Landfill De

In 1988, the government of Malaysia formulated an action plan to improve the existing disposal sites. Considering the limited financial and technical know-how available, open dumps were “gradually” converted to sanitary landfills (Huri bin Zulkifli, 1993). The improvements steps were targeted as follows:

- target 1: controlled tipping,
- target 2: landfill with embankments and daily cover,
- target 3: landfill with leachate recirculation,
- target 4: landfill with leachate treatment.

Main reasons for the current waste disposal problems:

- *Lack of funds. The recovery of costs is often only associated with waste collection and transport. Disposal costs are frequently unknown and tipping fees are seldom levied.*
- *Lack of technical expertise. There is little expertise on suitable landfill design and operation technologies or available options for upgrading existing dumps.*
- *Lack of regulations, standards and guidelines. These are necessary to ensure control, induce improvements and provide guidance in the development of appropriate and pertinent technologies.*

Uncontrolled dumping along the access road to Dandora dump site, Nairobi, Kenya

Main challenges presented by dumps:

- Uncontrolled tipping with no specific working area, inadequate waste spreading, compacting and covering.
- Landfill fires.
- Hindrance of landfill operation by scavengers.
- Lack of leachate and gas management.

Although literature on waste disposal in developing countries is still scarce, some valuable information has recently been published. However, further information is still necessary on viable technologies adapted to the economic and technical conditions of developing countries.

sign and Operation" for the aforementioned improvement strategy of the government of Malaysia. Part two of these guidelines covers detailed technical aspects, such as construction of embankments, drainage systems and liners for the engineer, as well as operating procedures for the manager. This excellent reference guide is widely used in Malaysia. The publication entitled "Guidance for Landfilling Waste in Economically Developing Countries" by Savage et al. (1998) constitutes a very good reference tool covering all aspects of landfills such as siting, design and operation. It also describes measures for remediation, corrective action and resource recovery. However, due to its wide spectrum of topics, it contains few details on specific technologies. Finally, a new guide for decision-makers (Rushbrook & Pugh, 1998) helps the waste managers of low and middle-income countries to identify the main issues and problems of inadequate disposal and to take key decisions. It recommends a minimum standard to be achieved and also expresses desirable improvements for reaching these standards.

However, to attain such minimum standards, further information is still necessary on viable technologies adapted to the economic and technical conditions of developing countries.

Scavengers must be recognised as an integral part of solid waste management. Alternatives to conventional landfill scavenging must, however, be sought to stop disruption of landfill operation and management.

Resource Recovery

Since landfill scavengers tend to disrupt operation and management of landfills, they are not widely accepted by most authorities responsible for waste disposal. However, the importance of scavenging activities in reducing waste volume and resource recovery, and its economic benefits must be acknowledged by the solid waste managers and regarded as a component part of the solid waste management scheme.

Incorporating of scavenging activity in an early stage of the waste cycle; i.e., on the household or collection level, and recognising it as an integral part of solid waste management, can provide an alternative to landfill scavenging. Creation of scavenger cooperatives can improve their business opportunities and control the occupational health hazards. However, as landfill scavenging is often inevitable, solutions must also be sought to minimise disruption of landfill operation by assimilating the scavengers into the on-site work process.

Landfill mining is an interesting aspect connected to upgrading efforts and waste resource recovery. Since the waste in most developing countries has a high organic content, and since many of the existing sites have been used for years, reuse of the decomposed material has a potential worth investigating further. Landfill mining is already practised at some sites by the informal sector. In Deonar, the waste disposal site of Mumbai (Bombay), India (Coad, 1997), labourers manually extract decomposed materials from part of the site. The waste is dried, screened and the fine material is mixed with cow dung and other components before it is bagged and sold as fertiliser. Recovered fine soil material can be sold as compost or used as cover material on the site. Coarse inert materials can be used for maintenance of access roads. Landfill mining not only offers a resource recovery potential, but also allows for the excavated area to be upgraded and subsequently reused as disposal space. However, additional information is necessary on occupational health aspects, degree of waste decomposition and quality.

Mining of decomposed material on the landfill has a potential worth pursuing further. It not only offers a resource recovery potential, but could also allow for the excavated area to be upgraded and subsequently reused as disposal space.

New Landfills

Upgrading of dumps may prolong their operating life, however, rapid urbanisation will inevitably force municipalities to locate new landfill sites. Selection of an ideal location is of key importance when planning a new landfill site. Identification of an appropriate site requires a systematic selection process, whereby the selection criteria can be prioritised according to local climatic, political and cultural circumstances (Rushbrook & Pugh, 1998). A poorly chosen site may involve high waste transport costs (e.g. if the site is far from the collection area) or high site construction costs (e.g. liner, leachate treatment). An assessment of the capital and recurrent landfill costs is given in Table 1. Depending on the landfill size and engineered environmental protection measures chosen (e.g. liner, drainage, leachate treatment), the costs can vary between US $ 5.6 and 11.3 per ton capacity for a 10-year landfill life. The table below illustrates the importance of finding a site requiring few protection measures.

A systematic selection of an ideal location is of key importance when planning a new landfill site.

Total Capital and Recurrent Costs in US $ (per ton capacity for a 10-year landfill life)	Large Landfill 1000 t/day	Medium Landfill 500 t/day	Small Landfill 250 t/day
Landfill without engineered liner or leachate system	5.6	6.5	9.6
Landfill with off-site clay liner and leachate system, excluding geomembrane	7.0	8.0	11.3

Tab. 1 Assessed landfill costs for different landfill sizes (Cointreau-Levine, 1997)

Appropriate landfill design comprises control of water, traffic, soil, and waste movement, thereby, minimising the environmental impacts and operational problems.

To compensate for the lack of financial resources, developing countries are given international financial aid in achieving disposal improvements. However, even if funding is secured, affordable and appropriate design and operation technologies are still essential to ensure sustainability of unit operation. Many engineered sanitary landfills turn into uncontrolled dumps as soon as maintenance and operating costs cannot be secured by the responsible authorities.

Conclusions

Since final waste disposal has, so far, received little attention from municipalities and from the public at large (out of sight, out of mind), uncontrolled dumping is still the most common practice of waste disposal in cities of developing countries. However, contamination of water resources and air pollution from such disposal sites, and increased public health risks for nearby residents are of growing concern. To improve the current waste disposal activities, the following important objectives should be attained in future:

- *Stop uncontrolled waste dumping by first planning upgrading measures of existing disposal sites.*
- *Develop appropriate landfill standards to allow for a step-by-step approach in the establishment of long-term standards.*
- *Develop appropriate low-cost guidelines for upgrading, designing and operating a landfill.*
- *Plan for siting new landfills by using a systematic and transparent process.*
- *Ensure cost assessment and cost recovery by appropriate financing systems.*
- *Develop sustainable markets for recovered or manufactured products from municipal solid waste so as to encourage small-scale organic waste recycling and promote existing informal recycling activities.*

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Persons and institutions interested in a collaboration on the development of suitable options for upgrading waste disposal sites are invited to contact Roland Schertenleib or Christian Zurbrugg

“A Clean Body Cannot Reside in an Unclean City”

Ghandi

Awareness Programmes for a Cleaner Mumbai
A Project of Clean Mumbai Foundation

by Mrs Kunti Oza

The quality of life in Mumbai City (Bombay) is progressively deteriorating. Clean Mumbai Foundation firmly believes that it is not only the municipality’s duty to keep the city clean, but the obligation of every inhabitant in the city to improve the quality of life or at least try to avoid its further deterioration. Education and awareness programmmes are regarded as a major step towards such an improvement, together with the introduction of effective enforcement of a legal framework. The main railway station - Churchgate - was chosen as pilot project area. The objective of the education and information campaigns is to influence not only the residents, but also the over one million people of different socio-economic backgrounds using the railway station daily, so as to disseminate the message into other parts of Mumbai City. The action plan of the Churchgate project involves the following activities:

Awareness

- Involving all social classes of society, resident associations, government authorities, business establishments, schools, and colleges in the project.
- Gaining more information on the existing practices of solid waste handling by involving students to conduct surveys of the households.
- Conducting awareness campaigns on cable TV and signboards. The boards with visual messages, which were set up in the area, focussed on littering, spitting and noise.

Infrastructure and Service

- Providing waste collection bins for street litter as well as household waste storage bins for residents.
- Implementing a curb-side waste collection system and a pilot programme on waste treatment by vermiculture.
- Implementing and supervising a household separation concept. While dry waste is collected, wet waste is composted by the residents in their gardens.
- Introducing a second collection and sweeping tour in public areas as one cleaning per day proved insufficient.
- Coordinating the three government agencies (Electricity, Telephone and Road Repair) in their effort to organise a general overhaul of the area.
- Installing public toilet blocks.
- Upgrading the area by more greenery sponsored by businesses.

Legislation and Enforcement

- Enforcing fines for indiscriminate dumping, littering and spitting in public places.

The project, which was funded by “Bombay First” in the first year, will subsequently be subsidised by the citizens, offices, restaurants, hotels and further funds which are now being raised through a fund raising campaign. The project is run by volunteers of Marine Drive Citizens’ Association, The Oval and Cooperage Residents’ Association, Nariman Point and Churchgate Citizens’ Association and Maharsh Karve Road Association.

Further information can be obtained from *Clean Mumbai Foundation, 91 Bennett Villa, Wodehouse Road, Mumbai - 400 039, INDIA; phone: +91-22-204 4838, fax: +91-22-262 2489.*

Solar Water Disinfection: An Update of a Success Story

by Martin Wegelin and Swen Vermeul

An average of 66 % of the users prefer bottles as these are easy to handle, sturdy and durable

General Acceptance of SODIS

The objective of the SODIS demonstration projects, conducted by local institutions in seven different countries, was to study the socio-cultural acceptance and affordability of this treatment option. The recently carried out survey revealed that an average of 84 % of the users will certainly continue to use SODIS after conclusion of the project, and about 13 % consider (maybe) using it in the future. Only 3 % refuse to use SODIS as their health is allegedly not affected by the present water quality. The figures obtained from two countries differ from the overall survey results inasmuch as the percentage of "maybes" was comparatively high in Burkina Faso (30 %) and China (45 %). Involvement of the users in the projects was hardly observed in these two countries.

Preference Given to SODIS Bottles

An average of 66 % of the users favour SODIS plastic bottles as these are easy to handle, sturdy and durable. Furthermore, the number of SODIS bottles can be increased by locally available ones, or broken bottles can be replaced. The relatively high percentage of users favouring plastic bags in Colombia (52 %) and Burkina Faso (66 %) is remarkable when compared with that of other surveyed countries. In Colombia, the SODIS plastic bags were complemented by locally available bags. In Burkina Faso, however, plastic bottles were rarely used.

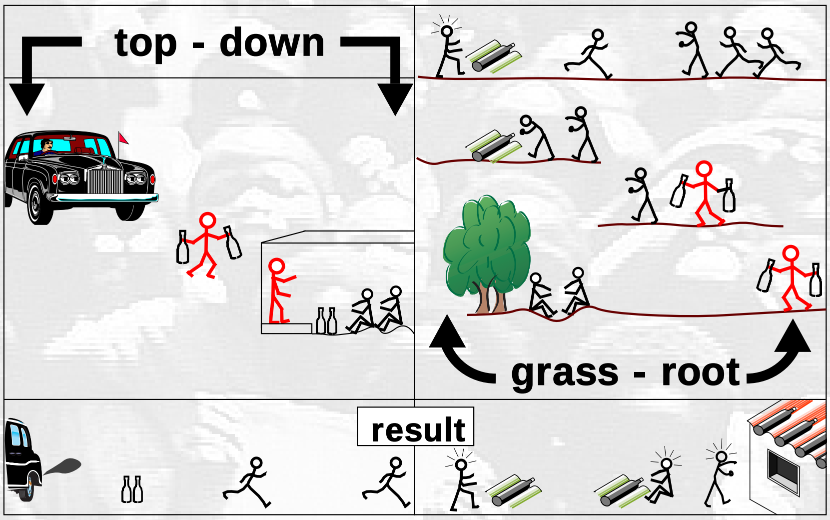
The demonstration projects clearly indicate an overall user preference for SODIS plastic bottles. These will be definitively used even after official conclusion of the SODIS demonstration project. This acceptance was observed during an unexpected project visit in Colombia: CINARA's project staff last visited the demonstration villages in November '97. Six months later in June '98, when these villages were revisited, 80 - 90 % of the visited households were exposing their bottles to the sun.

Tab. 1 Acceptance and preference (bottle vs. bag) of SODIS in various countries. The acceptance is generally high, especially in those countries where the new technology has been introduced in a grass-root approach

	I will prefer			I will continue to use SODIS				Participating Households	
Country	Plastic bottle	SODIS bag	Other container	Certainly	Maybe	Probably not	Definitely not	Start of project	End of project
Colombia	46	52	2	90	8	0	2	34	58
Bolivia	73	27	0	93	0	0	7	6	33
Burkina Faso	19	66	15	70	30	0	0	80	94
Togo	73	27	0	93	0	0	7	93	215
Indonesia	95	5	0	90	5	3	2	29	330
Thailand	75	23	2	97	0	0	3	255	430
China	81	19	0	55	45	0	0	50	100
average	**66**	**31**	**3**	**84**	**12.6**	**0.4**	**3**	**Total: 547**	**1260**

Dissemination: Grass-Root and Top-Down Approach

Some of SANDEC's partners applied the grass-root approach by intensively involving the users in the dissemination of the technology. Other institutions used the top-down approach by planning the introduction of SODIS through a rather structured programme. The number of participating households developed differently. At the beginning of the SODIS demonstration projects, roughly 550 households participated in the projects. A year later (autumn 1997), this number increased to 1260 households. The selected approach is somehow reflected in the figures obtained, e.g. Yayasan Dian Desa, an NGO in Indonesia, introduced SODIS in the initial phase to 29 families only. However, at the end of the official project phase, this number increased tenfold to 330 participating households. This development is in contrast to the experience made in China, where the Ningxia Sanitation and Antiepidemic Station (NSAS), a governmental institution, targeted for the first and second phase of the SODIS project 50 and 100 households, respectively.



Top-down approach and grass-root approach for SODIS dissemination. A grass-root approach appears to be the more efficient way to introduce the SODIS technology than a top-down approach

National SODIS Workshops and Recommendations

National SODIS workshops, held after conclusion of the demonstration projects, presented and discussed the results of the SODIS demonstration projects, and generally also included a visit to one of the demonstration sites. The workshop participants evaluated SODIS as an alternative water treatment option, discussed possible dissemination strategies in different working groups and formulated the following recommendations:

- SODIS is accepted as an alternative treatment option for water disinfection.
- SODIS should be integrated in on-going projects (water supply and primary health care programmes).
- The exchange of information at national level should be fostered through a SODIS network and assisted by SANDEC's partner organisations.
- SANDEC is asked to support the exchange and dissemination of information at international level, and to provide technical assistance to local institutions.

For further information please contact Martin Wegelin or visit our new home page: http://www.sodis.ch

Lessons Learned in the Demonstration Projects

- *The project staff has to gain its own experience in the application of SODIS.*
- *SODIS users have to be trained in the application of the new water treatment process.*
- *SODIS bags have to be replaced by locally available plastic bottles. The Swiss plastic bags are new and attractive, however, they are also expensive, weak and fragile.*
- *Dissemination of SODIS is not a technological problem, but rather a question of marketing and dissemination of information. Adequate information and controlled implementation are necessary for large scale SODIS use.*

Outlook

EAWAG/SANDEC plans more detailed studies on the process to consolidate and complement the available information, and to promote the SODIS technology at international level. These studies will include:

- *Further investigations on the inactivation of parasites by SODIS.*
- *Public health improvements through use of SODIS will be examined in case-control studies.*
- *SODIS, as alternative water treatment process, will be discussed and reviewed during an e-mail conference, and the outcome presented in a synthesis paper.*
- *Since SODIS is based on the use of empty plastic bottles - a waste product of the soft drinks industry - negotiations are being conducted with the respective industry on a joint venture with the SODIS project.*

When the Pits are Full – Selected Issues in Faecal Sludge (FS) Management

by Martin Strauss, Udo Heinss and Agnès Montangero

Quantitative Aspects

To date, FS produced in most cities of developing countries remains largely unaccounted for.

Much of the faecal sludge produced, collected and disposed of in urban centres remains as yet unaccounted for. Most inhabitants of cities like Jakarta, Manila, Bangkok, Accra and many others use on-site excreta disposal facilities. Yet, officially reported collection volumes remain far below the anticipated values.

In Manila and Bangkok, e.g. 60 - 65 % of the population are served by septic tanks. City authorities will have to deal with the haulage and treatment of 3 – 5,000 m^3 of septage per day[1] (= 500 - 800 vacuum tanker loads) once their FS collection and haulage services are upgraded to collect all the sludges produced (Veroy, Arellano and Sahagun 1994; Stoll 1995).

In large cities of Latin America, generally more than 50 % of the houses are connected to sewerage systems. In medium sized and smaller towns, however, most houses are served by on-site sanitation systems, notably septic tanks from which faecal sludges need to be collected and properly handled.

Centralised vs. Semi-centralised Treatment

Long distance haulage of FS is not sustainable. FS should be pre-treated in semi-centralised treatment plants.

The haulage of relatively small faecal sludge volumes (5 - 10 m^3 per truck) through congested roads over long distances in large urban agglomerations is neither an economically nor ecologically sustainable solution. New excreta collection, transport and treatment concepts will, therefore, have to be developed in conjunction with sanitation systems selected or adapted to suit the varying socio-economic conditions of the urban population.

Sludge dewatering from 98 % to 75 % water content will result in a 12 times volume reduction.

It is, thereby, of key importance to minimise overall FS haulage volumes and mileage, while guaranteeing safe sludge treatment and disposal. Planning and installing small to medium sized semi-centralised FS treatment plants could contribute to attaining this goal. A semi-centralised treatment system may consist in faecal sludge dewatering and subsequent treatment and discharge (or reuse) of the separated liquid. Assuming that the dewatering process (e.g. by sludge drying beds) yields a reduction from 98 % to 75 % of the water content (equivalent to an increase in solids content from 2 % to 25 %), the transported dewatered sludge volume would be 12 times smaller than the raw FS volume[2]. In contrast to wastewater treatment, FS treatment is not dependent on the available topography.

Use of neighbourhood or condominial septic tanks could be an appropriate sanitation concept for many densely populated urban districts. Accessibility of septic tanks or latrines for emptying vehicles could be improved by locating the tanks at easily accessible sites. Conveyance of the septic tank effluents to wastewater treatment plants via solids-free and, hence, relatively low-cost sewers, would reduce the widely practiced and uncontrolled discharge of septic tank effluents into open drains and ditches. It would also reduce the risk of shallow groundwater pollution, which could result from the infiltration of

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[1] Based on an average septage collection rate of 1 litre/cap • day.
[2] The reduction in sludge volume is inversely proportional to the increase in solids content.

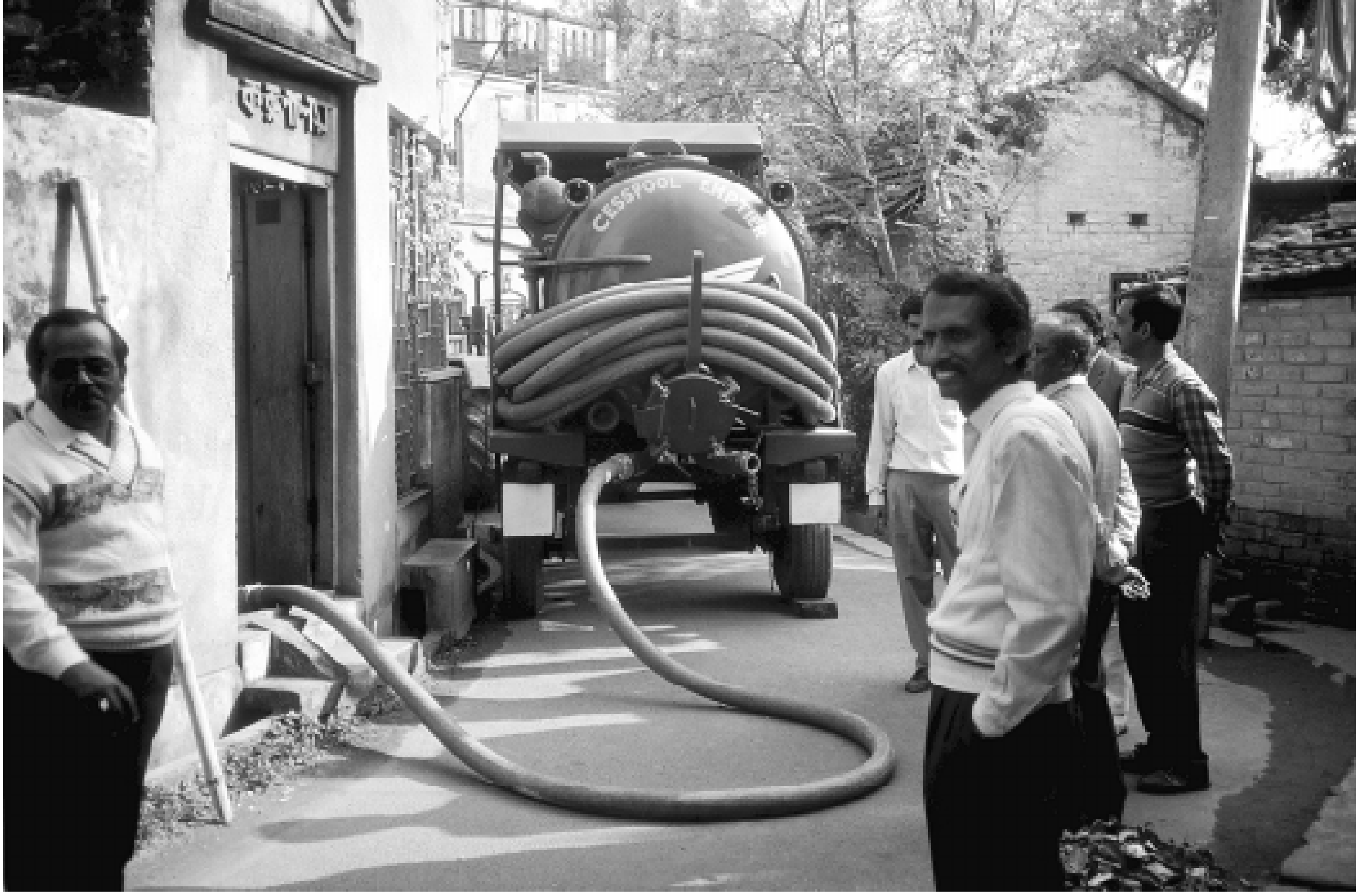

Fig. 1 Septage collection with a 2-m³ cesspool emptier in a side lane in Bharakpur, West Bengal, India. Hauling small volumes of FS over long distances in metropolitan areas is uneconomical. Sustainable strategies involving semi-centralised treatment must, therefore, be developed

septic tank effluents. A reduction of the transported FS volumes could be attained by installing septage dewatering/drying beds (planted beds, foremost) near condominial septic tanks or at semi-centralised treatment sites as described above. The drained liquid may be discharged into the solids-free sewer.

Effluent Quality Standards

The majority of economically less developed countries have issued effluent discharge standards for wastewater treatment (WWT). Apparently, the enacting of separate standards for FS treatment has not been considered in most of these countries to date. WWT standards are usually applied instead. Given the unfavourable economic conditions prevailing in most of these countries, the established standards are often too high to be met. Effluent standards are frequently not controlled or enforced.

The effluent standards are too stringent and not enforced in many developing countries.

Examples of faecal sludge treatment standards are known from China and Ghana. In the Province of Santa Fé, Argentina, current WWT plant effluent standards also apply to FS treatment. A helminth egg standard has been established for sludges used in agriculture (Ingallinella 1998).

In industrialised countries, the tightening of environmental protection legislation has occurred gradually. It ran parallel with the economic and institutional growth in these countries. This allowed a stepwise upgrade of the wastewater and sludge treatment technologies to control an increasing number of contaminants and to reduce the overall pollution loads (Johnstone and Horan 1996). A suitable strategy for less industrialised countries may also comprise the selection of a phased approach pertaining to stringency of standards and choice of components (pollution indicators), including certain types of waste to be targeted for. Regarding faecal sludges, emphasis should be placed in a first phase on the removal of organic contaminants to reduce surface and groundwater pollution.

Effluent standards for FS treatment plants should focus in a first phase on organic contaminants and helminth eggs.

Fig. 2 Supernatant from a FS settling tank overflowing into an anaerobic pond at the Achimota FSTP in Accra, Ghana. What standards should be established and how many ponds in series are required to meet these standards?

Furthermore, removal and inactivation of excreted pathogens is important as it will lower public health risks in densely populated urban areas, and enable the safe use of treated effluents and biosolids in agriculture.

The following aspects should be taken into consideration when stipulating FS treatment plant (FSTP) effluent and plant sludge quality guidelines:

- Discharge vs. reuse. When stipulating quality levels for plant effluent and biosolids, a distinction should be made between their discharge into the aquatic or terrestrial environment, and their reuse in agriculture or aquaculture, respectively. Variables like COD or BOD and NH_4 are of prime importance for FS discharge. Hygienic characteristics (helminth eggs and faecal coliforms) and nitrogen are the relevant criteria in reuse practice.

- Total vs. filtered BOD (COD) effluent standards. Where ponds are used to treat faecal sludges or co-treat FS and wastewater, effluent standards for BOD or COD should be stipulated for filtered rather than for unfiltered samples. This is necessary since algal cells produce about 70 % of the BOD in the effluent of well-functioning ponds. Algal BOD has a different potential impact on the receiving waters than BOD of untreated wastewater or FS. Algae produce oxygen during daylight hours and are likely to be consumed by the zooplankton before they exert their BOD in the receiving water (Mara 1997).

Table 1 contains a set of effluent and plant sludge quality guidelines. The suggested values are based on the considerations outlined above.

Tab. 1 Suggested Effluent and Plant Sludge Quality Guidelines for the Treatment of Faecal Sludges (Heinss, Larmie, Strauss 1998)

	COD [mg/l]	BOD [mg/l]	Helm. eggs [No./l]	Faecal colif. [No./100 ml]
A: Liquid effluent				
Treatment for discharge into receiving waters:				
• Seasonal stream or estuary				
- unfiltered	300-600	100-200	2-5	10^4
- filtered	100-150	30-50		
Treatment for reuse [a]:				
• Unrestricted irrigation [b]	n.c.	n.c.	1	10^3
• Restricted irrigation [c]	n.c.	n.c.	1	10^5
B: Treated plant sludge				
• Use in agriculture	n.c.	n.c.	3-8/g TS [d]	Safe level if egg standard is met

n.c. - not critical
[a] Irrigation rates and effluent quality standards must be established so as not to exceed the crops' nitrogen requirements (100 ... 200 kg N/ha · year depending on the crop).
[b] Irrigation of crops likely to be eaten uncooked, sports fields, public parks (WHO 1989)
[c] Irrigation of cereal crops, industrial crops, fodder crops, pasture, and trees (WHO 1989)
[d] Based on the nematode egg load per surface unit area derived from the WHO guideline for wastewater irrigation (WHO 1989), and on a manuring rate of 2-3 tons of dry matter/ha · year (Xanthoulis and Strauss 1991)

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Excreta News - Field Research Progress in Faecal Sludge (FS) Treatment

by Martin Strauss, Udo Heinss and Agnès Montangero
With contributions from Thammarat Koottatep, Asian Institute of Technology (AIT), Bangkok, and Seth A. Larmie, Water Research Institute (WRI), Accra

Partners have been identified to jointly investigate some promising FS treatment options.

Overview of Field Research Activities

Since publication of its last Newsletter in October 1997, SANDEC conducted the following collaborative field research in FS treatment:

Treatment option/process	Partner*	Activity
Solids-liquid separation:		
Settling-thickening	WRI	Conclusions and recommendations
Unplanted sludge drying beds	WRI	Conclusions and recommendations
Planted sludge drying beds	AIT	Parameter testing, monitoring
Pond treatment:		
Anaerobic ponds	WRI	Conclusions and recommendations
Attached-growth facultative ponds	AIT	Monitoring; comparing w. conventional fac. ponds
Co-treatment w. wastewater:		
Pre-settling/anaerobic ponds for FS	UNR	Initiating coll. research and commissioning of plant
Pond treatment of FS supernatant and wastewater	UNR	Initiating coll. research and commissioning of plant
* Water Research Institute, Accra, Ghana	WRI	
Asian Institute of Technology, Bangkok,Thailand	AIT	
Universidad Nacional de Rosario, Rosario, Argentina	UNR	

WRI/SANDEC Collaboration

The Sogakope (Ghana) seminar on FS treatment marked the conclusion of four years of joint field research in Ghana.

WRI/SANDEC concluded their field research collaboration on solids separation and pond treatment by holding a two-day international workshop on FS treatment in Sogakope, Ghana, in December 1997. The workshop brought together consulting engineers, officials from state and municipal authorities, external support agency personnel, and field researchers from Ghana, Benin, Mali, Tanzania, and Switzerland. The workshop discussed the results and conclusions of four years field research conducted by WRI, the state-of-the-art, problems and planned implementation of FS treatment in Ghana, and defined the gaps-in-knowledge in FS treatment. The proceedings are summarised in Strauss and Heinss (eds. 1998).

The joint SANDEC/WRI publication presents results on solids separation and FS pond treatment, including pond design recommendations.

The second, revised edition of the report entitled *“Solids Separation and Pond Systems for the Treatment of Faecal Sludges in the Tropics – Lessons Learnt and Recommendations for Preliminary Design”* by Heinss, Larmie, Strauss (1998) was recently published[1]. The design example on settling/thickening and liquid pond treatment contained in the annex of the publication has been expanded. Per capita area requirements for various treatment alternatives have also been included.

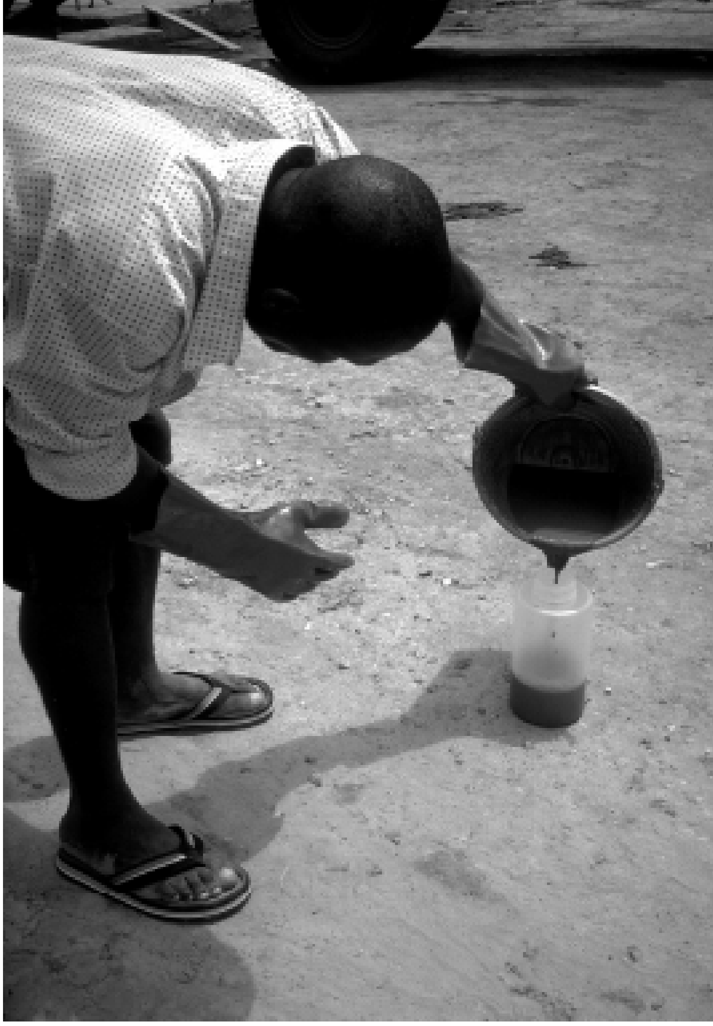
[1] The document may be ordered from SANDEC

AIT/SANDEC Collaboration

AIT and SANDEC launched a joint field research programme in 1996 to investigate alternative low-cost FS treatment options. The processes under investigation comprise **cattail-planted sludge drying beds** (**"constructed wetlands" (CW)**) and **attached-growth waste stabilisation ponds** (**AG-WSP**). The joint field research shall be pursued to establish the long-term performance of the constructed wetlands, to find the optimum process combination for CW and AG-WSP, to determine the suitability of attachment media, and to develop guidelines for anaerobic/facultative pond treatment.

AIT/SANDEC's published article entitled "Use of Reed Beds for Faecal Sludge Dewatering" presents results of a literature review on the use of reed beds for dewatering sewage treatment plant sludges[2]. The article also includes preliminary results of the AIT/SANDEC fieldwork conducted so far at AIT. A more extensive document on lessons learnt and preliminary design guidance for use of planted sludge drying beds will be published in 1999.

The recently acquired knowledge from the AIT/SANDEC project was shared with planners and engineers from the private sector, government, municipalities, and research organisations in a half-day seminar conducted at AIT in August 1998. A two-day international workshop shall be held at AIT in March 1999 to again present lessons learnt, preliminary design guidelines and cost information. It shall also serve as platform for practitioners to discuss day-to-day problems in FS management, and to learn about alternative low-cost options in FS treatment practised in SE-Asia.



FS sampling at Achimota faecal sludge treatment plant (FSTP) in Accra, Ghana. Four years of monitoring raw FS, effluents and plant biosolids allowed to fill a good number of gaps-in-knowledge. Yet, further field research is necessary to establish sound guidelines, particularly for high-strength FS treatment

UNR-CIS[3] /SANDEC Collaboration

UNR-CIS/SANDEC's field research collaboration, which started in October 1998, investigates the combined treatment of septage and municipal wastewater in a pond system. Septage is pre-treated in batch-operated settling/anaerobic ponds. Its liquid fraction (supernatant) is then co-treated with wastewater in a facultative and maturation pond. The objective of the field research is to determine at what extent pre-treatment of septage will improve the overall plant performance. The project also aims at defining the best way to operate the settling ponds for solids separation and subsequent drying. Design and operational guidelines along with operating costs shall be developed to facilitate planning and implementation of FS/wastewater co-treatment in ponds. Field research will be conducted at the full-scale septage-cum-wastewater pond scheme in Alcorta, Province of Santa Fé. Of the 4,000 inhabitants, 1,400 are served by sewerage and 2,600 use septic

Pilot constructed wetlands for septage dewatering at AIT, Bangkok, showing healthy cattail. Parameter tests allowed to establish sustainable dewatering operations while maintaining optimum plant growth

[2] The document may be ordered from SANDEC.

[3] CIS - Centro de Ingeniería Sanitaria, Prof. Ana María Ingallinella, Head. E-mail: cis@unrctu.edu.ar.

The collaboration between UNR-CIS and SANDEC will focus on co-treatment of septage and wastewater. Septage will be pre-treated in batch-operated settling/drying ponds.

tanks. The organic loads discharged into the treatment system via wastewater and septage amount to 60 and 20 kg BOD/day, respectively.

A one-day seminar on low-cost septage treatment was held at the University of Rosario on 17 June 1998. It was attended by some 30 participants from private consulting firms, municipal and provincial authorities and research institutions. The seminar agenda comprised FS treatment practices and problems encountered in Argentina and worldwide, a presentation of the planned UNR-CIS/SANDEC field research and a presentation of the results of collaborative R&D as conducted by SANDEC in Ghana, Thailand and the Philippines.

Results of Field Research in a Nutshell

WRI's Investigations in Accra

The following is a summary of the results and recommendations of four years of collaborative field research by WRI/SANDEC. The research encompassed investigations on raw FS characteristics, FS settling/thickening, pond treatment of the FS liquid, and dewatering of FS on sludge drying beds:

Raw FS Characteristics

Accra's septage exhibits a good settling behaviour, while sludges from unsewered public toilets are resistant to solids separation.

In Accra, two types of FS are generated; i.e., some with relatively high solids, ammonia and COD contents, and some in which these constituents occur in relatively low concentrations. Constituent levels are at least 5-10 times higher in FS than in municipal wastewater. Faecal sludges collected from unsewered public toilets and bucket latrines at intervals of days or weeks are of the high-strength type. They are biochemically unstable; i.e., barely digested. This renders the sludge resistant to dewatering.

Septage is usually of relatively low strength and biochemically more stable as it is generally stored for one or more years in septic tanks prior to collection. Accra's septage exhibits good solids-liquid separability (separation under quiescent conditions is completed within 60 min.).

Separability of FS mixtures is dependent on the mixing ratio. Mixtures containing up to 25 % by volume of fresh, undigested sludge generally settle within 60 minutes. FS mixtures may cease to separate if the amount of fresh sludge exceeds 25 - 30 % by volume. As in most cities around the world, FS characteristics in Accra vary greatly between different municipal areas.

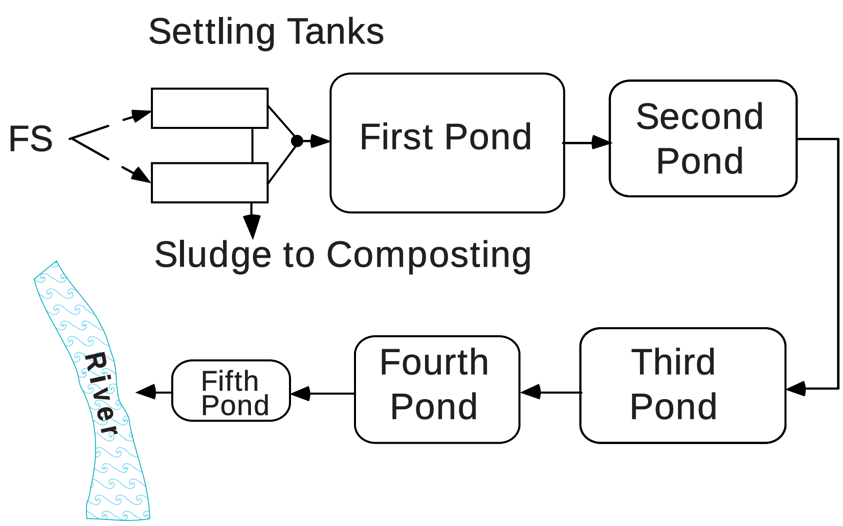


Fig. 2 Functional sketch of the Achimota FS treatment plant monitored by WRI in Accra (Ghana)

Settling/Thickening

The decisive criteria for sizing non-mechanized, batch-operated settling/thickening tanks as currently used in Ghana for solids separation in faecal sludges, is the volume required to store the settled and floating solids. In addition, tank geometry, inlet/outlet arrangements and loading pattern are crucial in guaranteeing good treatment performance. The accumulation rate of separated solids in settling-thickening tanks were found to range between 0.15 and 0.2 m^3/m^3 of FS exhibiting 1:10 - 1:5 ratios by volume of high and low-strength sludges.

Pond Treatment

Pond systems offer a suitable option to treat low to medium-strength FS. While the design of facultative and maturation ponds treating FS should follow the principles developed for wastewater ponds, loading limits for anaerobic ponds treating FS have not yet been firmly established. The organic loading rates are presumed to be higher than for wastewater. If FS is pre-treated to reduce the solids load, the combined treatment of FS and wastewater may be recommended as a suitable option. Pond design must be based on organic and nitrogen loads of both FS and wastewater.

Anaerobic ponds offer a suitable option to treat FS. Maximum loading rates may be higher than in wastewater treatment plants.

High-strength, “fresh” FS needs to be subjected to anaerobic digestion prior to solids separation and further treatment of the liquid fraction. Such primary treatment may consist in (deep) anaerobic ponds or vessel-type anaerobic digesters. High-strength, “fresh” FS exhibits excessive ammonia concentrations. This may lead to a suppression of the methane-forming bacteria and, thus, disturb the anaerobic process. Furthermore, when trying to treat the liquid fraction of such FS in a pond system, it may cause toxicity to algae and result in a suppression of facultative pond conditions. Dilution with municipal wastewater in co-treatment may offer a feasible option. Other possible measures include surface aeration to induce nitrification, ammonia stripping over cascades, effluent recirculation, and lime dosing.

Fresh, barely digested sludge must be treated anaerobically prior to further handling.

Unplanted Sludge Drying Beds

Unplanted sludge drying beds can be used to treat high-strength septage and primary pond sludge (TS = 1.6-7 %); i.e., sludges with a fairly high solids content and a rather high degree of biochemical stability. The sludge depth should not exceed 30 cm to guarantee effective dewatering/drying. Results of field research performed at WRI, illustrating the contaminant removal in the percolating water and the drying efficiency of the drying beds, are summarised in SANDEC News No. 3 (October 1997)[4] .

Unplanted sludge drying beds lend themselves to dewatering and drying of FS with high solids content and a rather high degree of biochemical stability.

Further Investigations

The following subjects have been identified for further field and action research to be conducted by local institutions in Ghana:

- Ammonia toxicity to algae in pond systems.
- Treatment of barely digested high-strength public toilet and bucket latrine sludges in deep anaerobic ponds and anaerobic digesters.

SANDEC may act as discussion partner in these projects.

[4] The document may be ordered from SANDEC.

AIT's Investigations in Bangkok

The interim results and conclusions obtained so far by AIT/SANDEC's field research are summarised hereafter.

Constructed Wetlands

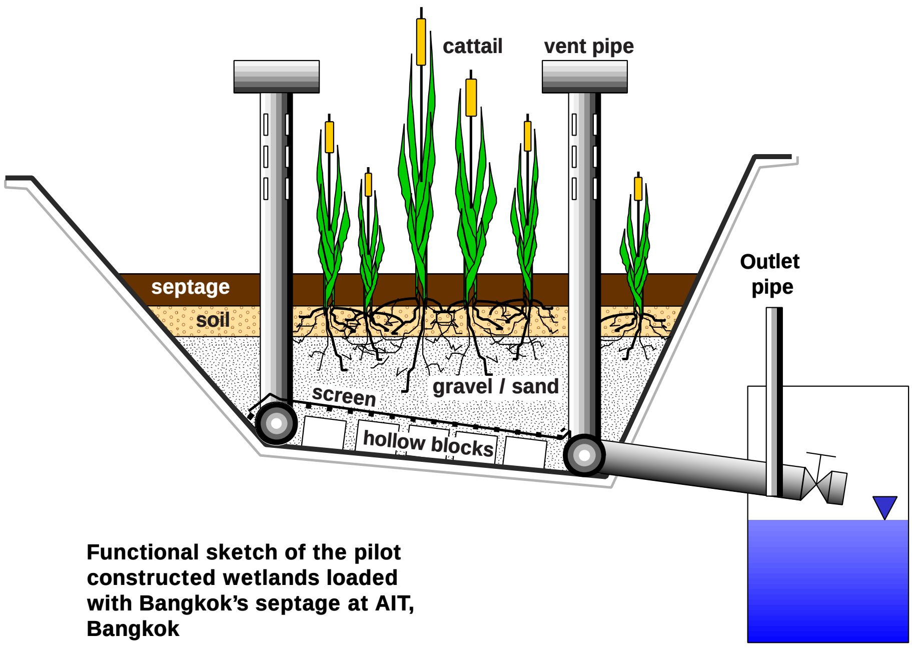
Three pilot constructed wetlands (CW) were build at AIT to test their suitability in septage treatment.

Three CW of 25 m^2 each were constructed and operated since February 1997. They are loaded with Bangkok's septage once to twice a week at rates equivalent to 80 - 250 TS/m^2 • year.

Encouraging results were obtained so far on removal efficiencies in the percolating liquid and sludge dewatering in the CW. At the same time, periodic reed wilting has, however, also occurred. Measures, such as an increased septage loading rate (associated with a lowering of the TS content in the dewatered sludge) and percolate ponding in the reed bed underdrain, have led to improved plant growth. Results obtained so far (after about 18 months of CW operation) have led to the following tentative design and operation guideline for treating Bangkok's type of septage (TS 18,000; SS 13,000; VSS 9,500; COD 11,400; BOD 2,700; TKN 840 mg/l):

Solids surface loading rate is the decisive design factor when sizing planted and unplanted sludge drying beds.

Solids loading rate:	250 kg TS/m^2 • year
Loading frequency:	once a week
Percolate ponding:	six days



Functional sketch of the pilot constructed wetlands loaded with Bangkok's septage at AIT, Bangkok

Avoiding plant wilting is an important operation criterion when treating septage in planted sludge drying beds.

A 30-cm dewatered sludge layer with roughly 30 % TS was obtained after 18 months of septage loading. Although a TS content of up to 40 % can be reached, this would most likely lead to cattail wilting. Good vegetation is of key importance since the root system ("rhizome") of the cattail or reed assures continuous permeability of the entire filter media, consisting of the gravel/sand layer and the accumulating, dewatered FS. Moreover, a TS increase in the dewatered sludge from 30 % to 40 % is insignificant in terms of sludge volume reduction. A significant volume reduction can already be reached by lowering the sludge water content from 98 % to 80 %.

Considerable contaminant removal is attained in the septage wetlands. The need for post-treatment of the drained liquid is dependent on effluent standards and type of end use.

The average percolate quality achieved so far is given in the table below.

		Raw septage	Percolate	% removal	no. of samples
SS	mg/l	10 - 20000	700	> 90	25
CODtot	mg/l	18 000	940	95	25
TKN	mg/l	1 200	150	90	15

Plastic modules in the attached-growth waste stabilisation ponds at AIT, Bangkok. The ponds are used to polish the percolate from the planted septage drying beds (Photo: Thammarat Koottatep)

Six days percolate ponding yielded higher overall N removal than two days ponding. This is attributed to the occurrence of anoxic conditions, which promote denitrification. The need for post-treatment of the CW percolate is dependent on the effluent standards stipulated for either discharge into surface waters or for reuse in agriculture.

Attached-growth Waste Stabilisation Ponds

Three of the four facultative waste stabilisation ponds, put in operation in early 1998, are equipped with media to allow attachment of algae and bacteria. One is operated as control.

The ponds are used to polish the CW effluent. Plastic modules and Manila rope, a natural fibre, are tested as attachment materials. Biomass attachment is expected to lead to improved pond performance and, hence, to land and construction cost savings. Only an insignificant number of monitoring campaigns has been conducted so far. There is indication, however, that the tested growth media do not differ in their performance. Compared to conventional facultative pond treatment, the use of attachment media tends to yield improved effluent quality for SS, TKN and NH_3-N, but not for COD.

Staff News

Udo Heinss, Environmental Engineer and graduate from Dresden Technical University, joined SANDEC in 1994 and has since devoted most of his time to the FS treatment project. He will gradually shift the emphasis of his work to non-centralised wastewater treatment, an area in which SANDEC intends to engage intensively in the near future.

Agnès Montangero, who joined SANDEC on 1 October 1998, will fill Udo’s post in the FS project. She is an Environmental Engineer and graduate from the Swiss Federal Institute of Technology (ETH).

SANDEC would like to thank Udo Heinss for his great commitment and excellent contribution to filling the gaps-in-knowledge in FS treatment. We warmly welcome Agnès Montangero as a new team member and wish her fulfilment in the smelly but challenging and rewarding field of faecal sludge treatment.

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On the Bookshelf

SANDEC NEWS

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Apart from the publications cited in the context of the articles, we recommend to our readers the following publications:

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