EAWAG
SANDEC
Water & Sanitation in Developing Countries

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Applied Research on the Management of Sludges from On-Site Sanitation Systems in Developing Countries

Rationale, Issues and Project Overview

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Rationale

- The Department of Water & Sanitation in Developing Countries (**SANDEC**) of EAWAG[1] is carrying out applied research in low-cost sanitation technologies for developing countries. In this context, it is engaged in a project whose objective is to develop and test appropriate options for the management of faecal sludges (FS). These are the sludges collected from unsewered private and public toilets, septic tanks and aqua privies. The prime reason why SANDEC is engaging in this field is the fact that, in urban areas of developing countries, only a minority of inhabitants is served by water-borne sewerage. The majority of those who do avail of installations for safe excreta disposal, are served by private or public latrines and septic tanks. Yet, contrary to e.g. wastewater treatment, the appropriate management of FS has received relatively little attention by urban planners to date, and only limited R+D work has been done in this field so far.

Situation, Issues and Problems

- Much of the faecal sludge produced, collected and disposed of in urban centres remains as yet unaccounted for. In cities like Jakarta, Manila, Bangkok and Accra, as well as in most towns of Latin America, Africa and Asia, the majority of the inhabitants use on-site excreta disposal facilities. Daily faecal sludge production ranges from 0.20 l/cap in pit latrines, to 1 l/cap in septic tanks, to 2 l/cap□day in unsewered public toilets, approximately. Officially reported collection volumes, however, remain much below expected values. FS volumes to be treated (and thus accounted for) will probably increase sharply as cities will be upgrading their FS collection and management system to reduce pollution and health risks.

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- The table below lists FS disposal/treatment situations in a few selected countries and urban areas.

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	-----

- In Manila and Bangkok, e.g., 60-65 % of the population are served by septic tanks. There, city authorities may have to cope with the haulage and treatment of 3 – 5,000 m^3 (!) of septage per day (= 500-800 tanker loads), once their FS collection and haulage services will have been upgraded to collect all the sludges.
- Treatment plants for the separate treatment of faecal sludges (FS) or for co-treating FS and wastewater exist but in a few countries so far. SANDEC is aware that such plants are being operated in Argentina, Ghana, Benin,

Indonesia, Thailand, and China. In the majority of countries, there do not exist quality standards for the effluent and biosolids from faecal sludge treatment plants (FSTP).

- In some countries (e.g. in Botswana, Tanzania, South Africa), FS are added to the urban wastewater stream for co-treatment in wastewater treatment plants, generally waste stabilisation ponds (WSP). These are in many cases overloaded and suffer from malfunction for lack of adequate operational measures, monitoring and maintenance.
- In China, the traditional excreta disposal practice consists in collecting the excreta from individual houses and public toilets by buckets and vacuum tankers for use in agriculture and aquaculture. Most of the approximately 30 million tons of sludges that are reportedly collected in China's cities every year are used untreated. Concern regarding the potential health impact has led Chinese authorities and research institutions to increasingly engage in research and development (R+D) for FS.
- In the U.S.A., 25 % of the inhabitants are served by septic tanks. Most of the septage is co-treated in wastewater treatment plants. In some states, notably in the northeast, pond systems are used to separately treat septage. They typically consist of an (anaerobic) sedimentation pond followed by an infiltration pond.
- FS collection and haulage in larger cities is faced with immense difficulties: Suitable sites for FS or FS/wastewater co-treatment plants may be found at the outskirts of cities only. Hence, haulage distances tend to be large. 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 not sustainable in the long run, neither from an economic nor from an ecological viewpoint. The current widespread practice is for vacuum tankers to discharge their load at shortest possible distance from the points of collection to render collection services and earnable income more effective.
- New concepts of excreta collection, transport and treatment will, therefore, have to be developed in conjunction with sanitation systems adapted to the varying socio-economic urban population segments. Faecal sludge haulage volumes and mileage are to be minimised. Planning and installing small to medium-sized decentralised FS treatment plants could contribute to easing the haulage problem. Such a decentralised treatment system may consist in faecal sludge dewatering and subsequent treatment and discharge (or reuse) of the separated liquid.

Objectives and Approach

- The main objective of SANDEC's project on FS treatment is to put in the hands of planners and field engineers design and operational guidelines for sustainable options of faecal sludge treatment in developing countries. Such guidelines shall be based on the field evaluation of promising treatment options in pilot and full-scale treatment works. Towards this end, collaborative field research has been sought with a number of partners in Africa, Asia and Latin America. A second objective is to assist our research partners in enhancing their monitoring and evaluation capacity in the field of human waste management, especially faecal sludges.
- The Project is being carried out in three phases, viz.
  - Phase I: Identification
  - Phase II: Collaborative Field Research
  - Phase III: Synopsis

  Knowledge and experience acquired through the collaborative field research are disseminated through technical reports, presentations to conferences and

publications. National and regional project seminars, jointly organised by the research partners and SANDEC, form another important tool for dissemination. The seminars constitute, at the same time, a platform for strategic and technical discussions among planners and engineers from local authorities and from the private sector.

- The Project is in the field research phase. However, new identifications for field research partnerships and projects are periodically undertaken. Also, interim results are processed and published to provide preliminary guidance to practitioners.

Treatment Options and Field Research Partners

- SANDEC has identified a number of treatment processes and options of which it believes that they are suitable under many situations prevailing in developing countries. They are:
  - Settling-thickening tanks and sedimentation ponds for solids-liquid separation
  - Anaerobic and conventional facultative ponds
  - Attached-growth facultative ponds
  - Unplanted and planted sludge dewatering/drying beds
  - Use of FS for soil reclamation
- The following collaborative field research programme has been developed with selected partners so far:

Treatment process or option; management issues	**Executing or project partner** [1,2]
Pond systems	
• Primary treatment (solids separation):	
- Settling-thickening	WRI (Ghana)
- Sedimentation ponds	UNR (Argentina); KMA/UESP (Ghana)
• Anaerobic ponds	WRI; UNR; KMA/UESP
• Facultative ponds	UNR; WRI; KMA/UESP
• Attached-growth facultative ponds	AIT
Sludge drying beds	WRI and IWMI (unplanted beds); AIT (planted beds, "constructed wetlands")
Soil reclamation	
• Restoration of soils damaged by volcanic eruptions	UP/NEC (Philippines)
Co-composting	
• Joint composting of faecal sludge and municipal/organic solid waste	IWMI – UST – KMA (Kumasi, Ghana)
FS management + planning issues	
• Miscellaneous aspects	CREPA

[1] AIT Asian Institute of Technology; CREPA Regional Centre for Water Supply & Sanitation (Burkina Faso); IWMI Intern. Water Management Institute, Ghana branch; KMA Kumasi Metropolitan Assembly; UESP Urban Env. Sanitation Project, Ghana; UNR Universidad Nacional de Rosario; UP/NEC Univ. of The Philippines/ National Engg. Center; UST Univ. Science & Technology, Kumasi (Ghana); WRI Water Research Institute

[2] SANDEC would gladly provide the readers with the particulars of its field research partners for direct contacting and exchange; alternatively, you may find their addresses in the SANDEC homepage indicated on p. 1.

- The published and unpublished documents referenced below, contain the results of field research conducted to date, of lessons learnt and recommendation for preliminary design.

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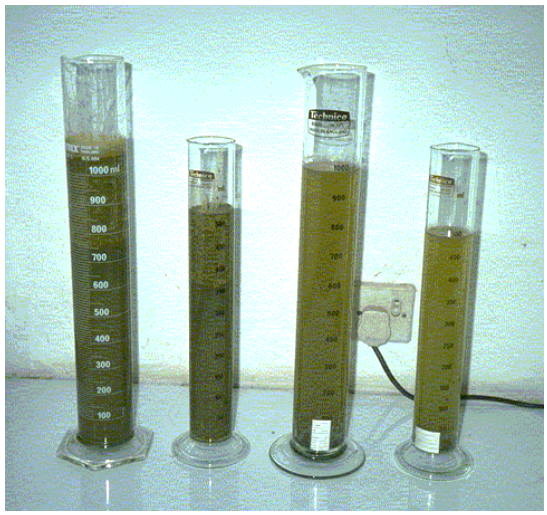
Illustrations on FS Treatment and SANDEC's Collaborative Field Research

A large number of FS samples has been characterised in the course of SANDEC's collaborative field research projects; results document the great variability of FS characteristics among different types of on-site sanitation installations, within cities and between different cities and countries

A vacuum truck discharging faecal sludge from unsewered public toilets into the headwork of an FS treatment plant (Accra, Ghana)

A faecal sludge settling/thickening tank being loaded with fresh sludge hauled by vacuum tankers. The movable bridge allowed profile sampling across the entire tank during treatment plant monitoring (Accra, Ghana)



Settling and solids separation tests in cylinders at laboratory scale; such simple experiments can serve to estimate the solids-liquid separation behaviour of FS and the approximate rates of accumulation of separated solids in full-scale settling units; at left, highly concentrated FS from an unsewered public toilet; at right; a thinner FS collected from septic tanks; the solids-liquid interfaces are only faintly visible in this photograph (Water Research Institute, Accra, Ghana)

Top:

Pilot-scale, cattail-planted sludge drying beds (“constructed wetlands”). The beds are equipped with vent pipes to allow bottom ventilation through natural draught. This helps to avoid prolonged anaerobic conditions, which may lead to root damage. Young shoots have just been planted. The freeboard of 1.50 m allows continuous FS loading for several years without having to remove dewatered sludge (AIT, Bangkok, Thailand)

Bottom:

Cattail on the septage-fed wetlands in full growth (AIT, Bangkok)

Solids-liquid separation and anaerobic degradation of septage in primary pond; the effluent is co-treated with municipal wastewater in a facultative (secondary) pond; settled solids are sun-dried and subsequently used in agriculture (Alcorta, Prov. of Rosario, Argentina)