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

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With contributions from Thammarat Koottatep, Asian Institute of Technology (AIT), Bangkok, and Seth A. Larmie, Water Research Institute (WRI), Accra

Overview of Field Research Activities

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

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.

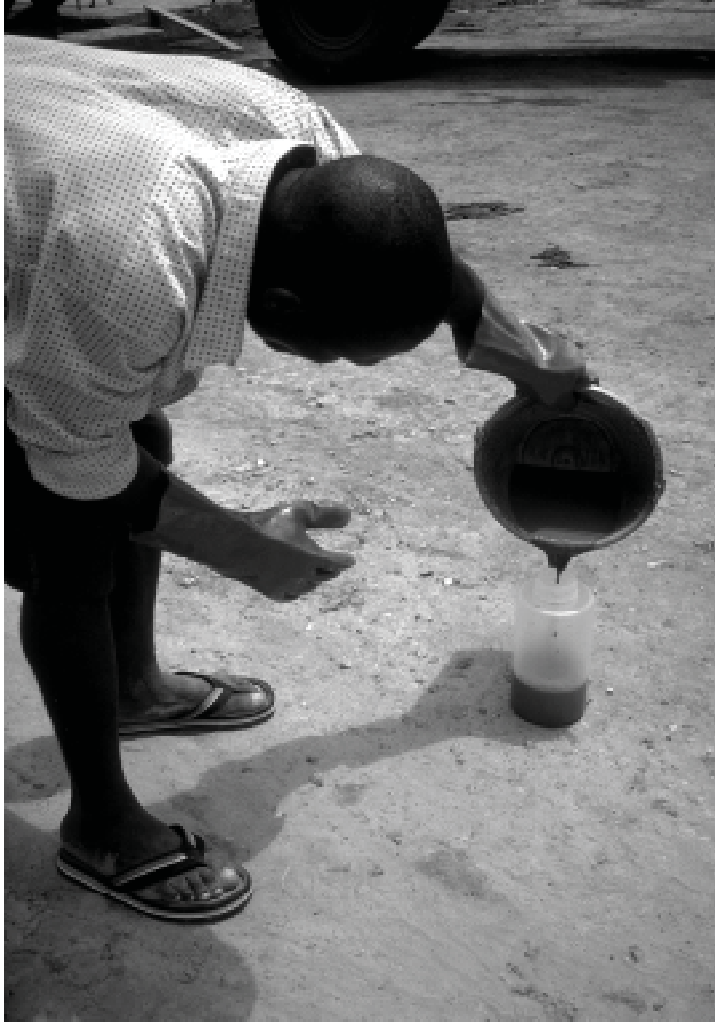
[1] The document may be ordered from SANDEC

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:

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

Raw FS Characteristics

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.

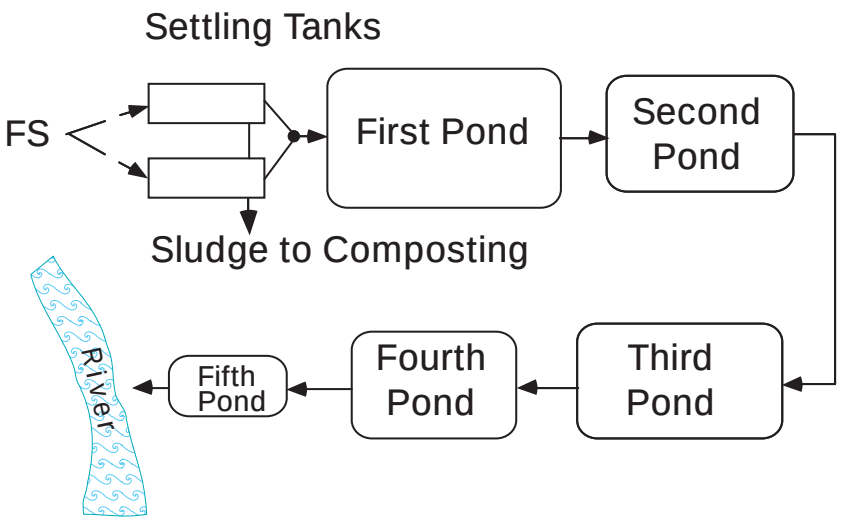


Fig. 2 Functional sketch of the Achimota FS treatment plant monitored by WRI in Accra (Ghana)

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

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

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.

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

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.

Unplanted Sludge Drying Beds

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

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] .

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

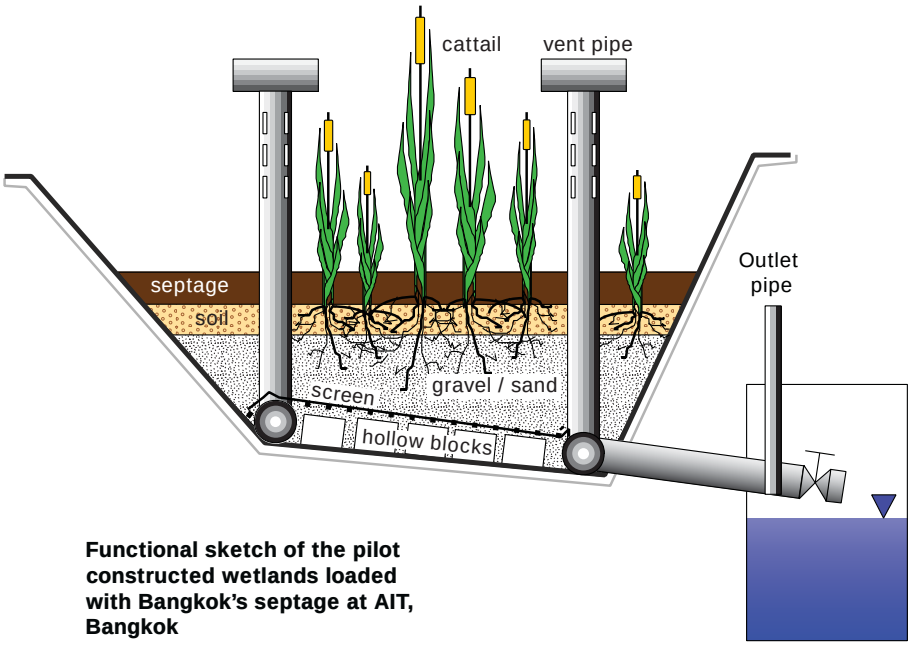
Three pilot constructed wetlands (CW) were build at AIT to test their suitability in septage treatment.

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.

Project Documents

Heinss, U., Larmie, S.A., Strauss, M. (1998). Solids Separation and Pond Systems for the Treatment of Faecal Sludges in the Tropics - Lessons Learnt and Recommendations for Preliminary Design, EAWAG/SANDEC, Report No. 05/98.

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