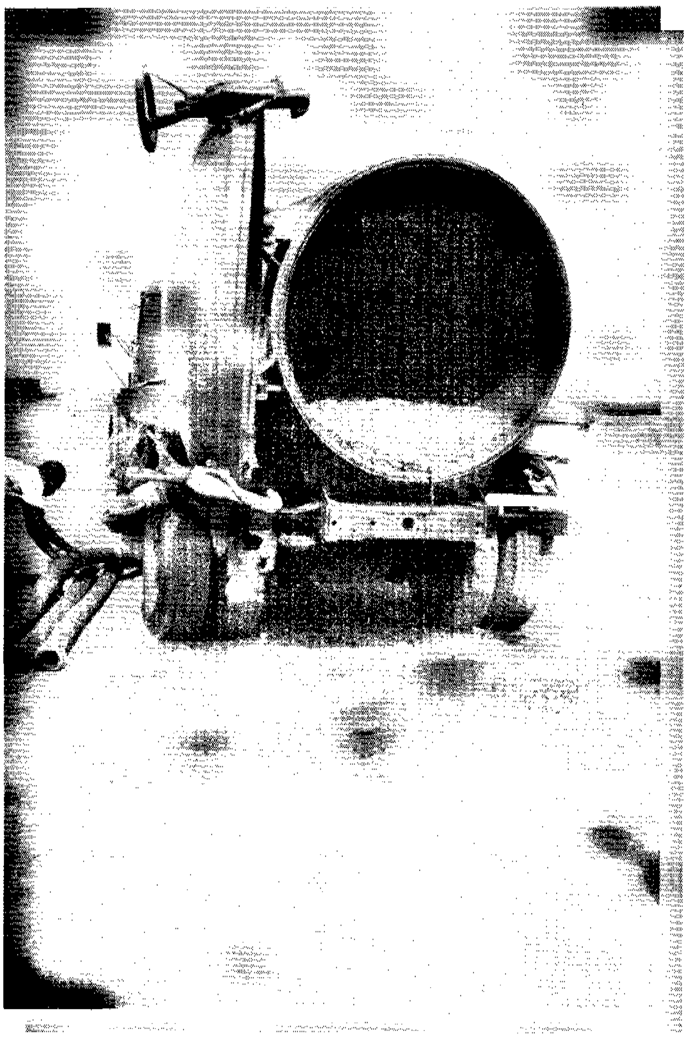
Proceedings

Workshop on Faecal Sludge Treatment

Sogakope, Ghana, 3 - 5 December 1997



Water Research Institute (CSIR, Ghana)
EAWAG/SANDEC
Carl Bro (Ghana)

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Workshop on Faecal Sludge Treatment

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Acronyms, Abbreviations and Glossary

Acronyms

AMA	Accra Metropolitan Assembly
CSIR	Council for Scientific & Industrial Research, Ghana
EAWAG	Swiss Federal Institute for Environmental Science & Technology, Duebendorf, Switzerland
EMPA	Environmental Protection Agency (Ghana)
IDA	International Development Association (part of the World Bank Group)
MLGRD	Ministry of Local Government and Rural Development
PWCBT	Project-Wide Capacity Building and Training (a component of the World Bank/IDA funded UESP program executed by Carl Bro/Ghana)
RWSG-WA	UNDP/World Bank Regional Water & Sanitation Group - West Africa (Abidjan, Ivory Coast)
SANDEC	Dept. of Water & Sanitation in Developing Countries at EAWAG
UESP	World Bank/IDA Urban Environmental Sanitation Project, Ghana
WRI	Water Research Institute (Council for Scientific and Industrial Research, CSIR), Accra, Ghana (formerly Water Resources Research Institute, WRRI)

Abbreviations

BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
FC	Faecal coliforms
FS	Faecal sludge
FSTP	Faecal sludge treatment plant
HE	Helminth eggs
HRT	Hydraulic retention time
NH_4-N	Ammonium nitrogen
NH_3-N	Ammonia nitrogen
PTS	Public toilet sludge
R + D	Research and development
SS	Suspended solids
STP	Sewage treatment plant
TS	Total solids
WSP	Waste stabilisation pond(s)

Glossary

Faecal sludge	Sludge of variable consistency collected from so-called on-site sanitation systems; viz. latrines, non-sewered public toilets, septic tanks, and aqua privies
Septage	Content of septic tanks (usually comprising settled and floating solids as well as the liquid portion; digested to various degrees)
Public toilet sludge	Sludge collected from unsewered public toilets (usually of higher consistency than septage and little digested)
Pan latrine sludge	Sludge collected from bucket latrines (similar to PTS but even less digested)
Percolate	The liquid seeping through a sludge drying bed and collected in the underdrain

Preface

Background and Rationale

The management of sludges from on-site sanitation systems (bucket and pit latrines, unsewered public toilets, aqua privies and septic tanks) constitutes a major problem in most cities of Asia and Africa. Faecal sludges often are disposed of on land or into water courses, or used in agriculture untreated or only marginally treated. In a number of urban centers, FS is co-treated in wastewater treatment plants which however, are rarely designed to accommodate the added waste load and hence fail to produce good effluents. Ghana is one of the first countries where the government and municipal authorities have been endeavouring for nearly a decade now to treat faecal sludges in treatment plants which are designed and built for this very purpose. Four FSTP are in operation in Ghana today, thereof two in Accra, one in Koforidua and one in Obuasi, exhibiting a combined design capacity of some 700 m^3 FS/day. New FSTP are being planned for and shall soon be implemented as part of the Urban Environmental Sanitation Project (UESP) which comprises the cities of Tamale, Kumasi, Takoradi, Accra and Tema and which is jointly financed by the Government of Ghana and World Bank/IDA.

EAWAG/SANDEC initiated field research on faeacal sludge treatment in 1992. In its search for suitable partners in places where FS treatment schemes were already in operation, SANDEC became introduced to the FS management efforts in Ghana. Key liaison persons at the time were Ato Brown, former country repreentative of RWSG-WA in Ghana, and Collins Annoh, formerly involved in the design and implementation of Accra's first FS treatment plants, successor of A. Brown in the same post and now independent consultant. The search soon fell on the Water Research Institute (WRI) of CSIR in Accra which presented itself as an experienced and dedicated partner to engage in joint field research. The proposal was to conduct in-depth investigations of the two main FS treatment plants in Accra at Achimota and Teshie. The Waste Management Department of the Accra Metropolitan Assembly which is the agency in charge of FS treatment plant construction and operation showed equal interest in a study of the existing plants.

From this, four years of fruitful collaboration between WRI, WMD and SANDEC, coordinated by Collins Annoh, evolved. An in-depth view of the treatment processes applied in the two plants and of pilot-scale sludge drying beds established on the WRI premises could be gained and conclusions and recommendations were formulated.

The prime rationale for the workshop was to disseminate the results of the field research collaboration. Furthermore, WRI and SANDEC, being applied research institutions, wanted to obtain feedback from engineers, planners and administrators, regarding the feasibility of their recommendations and possible needs for further, practice oriented field research.

Summary

The Workshop on Faecal Sludge Treatment marked the end of four years of field research collaboration between WRI and EAWAG/SANDEC. One objective of the Workshop was to present the results of the field studies and recommendations emanating from them to the professional community of planners and engineers who are dealing with FS management in Ghana and in the Region. At the same time, the Workshop was to serve as a platform for the discussion among the participants on current issues and problems in FS management in their respective countries. It was recognised from the onset that inspite of four years of intensive field research, more questions remain to be answered. The event therefore also aimed at formulating a prioritised list of research and development in FS management in Ghana for the next few years.

The Workshop attracted some 30 participants comprising government officials, consultants, entrepreneurs and representatives of support agencies, including invited specialists from Tanzania, Benin and Mali. The publication produced by WRI and EAWAG/SANDEC as a result of the joint field research served to create a common level of information and as a basis of discussion[1].

The first day of the Workshop was devoted to plenary inputs (Chpt.1) which comprised presentations on the outcome of the WRI/SANDEC field research; a global view on FS management problems and solutions in other countries of Africa and Asia; a description of the historical development and current situation of FS management in Ghana; case-study descriptions of schemes in operation or in the planning stage in Tanzania, Benin and Mali. The second day was devoted to semi-guided group discussions on operational/management aspects and on treatment options and design (Chpt. 2).

The Workshop lead to the following set of issues/researchable questions warranting further applied field and action research:

- Ammonia toxicity
- Anaerobic treatment
- Improved settling tanks
- Economic aspects of FS use
- Hygienic quality of treated FS

The group gathering and debating at Sogakope brought together the entire

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1 The publication by Heinss, U, Larmie, S.A. and Strauss, M. is entitled *Solids Separation and Pond Systems for the Treatment of Faecal Sludges in the Tropics - Lessons Learnt and Recommendations for Preliminary Design* (SANDEC Report no. 05/98). It is available free-of-charge from either EAWAG/SANDEC (Duebendorf, Switzerland) or from WRI (Accra, Ghana).

range of stakeholders from the field of faecal sludge management: entrepreneurs engaged in the collection and treatment of FS; consulting engineers contracted to do planning, design and implementation of FSTP; engineers and administrators from national, regional and municipal authorities being in charge of FS disposal at various levels of public management; donor agency specialists; and applied researchers. The participant body thus represented a great variety of experiences all related to the same common issue, and enabled an integrated discussion of a variety of aspects of FS management.

The two days were characterised by dedicated professional discussions which happened in a lively and cheerful atmosphere.

Acknowledgments

The Workshop was jointly organised by WRI (Seth A. Larmie, Isaac Hodgson, Esther Dumakor), Carl Bro (Accra)/PWCBT (Peter Hawkins, Margret Fitz-William, Kofi Frimpong) and Colan Consults (Collins Annoh, Kofi Agyenim-Boateng).

Credit for financial support is due to the Swiss Agency for Development and Cooperation (SDC). WASTE consultants (Gouda, the Netherlands) and the UNDP/World Bank Regional Water & Sanitation Group for West Africa (RWSG-WA) financed the participation of four specialists from Mali, Benin and Tanzania.

Proceedings

1 Plenary Presentations

1.1 Keynote Address

Martin Odei

Mr Chairman, distinguished researchers, engineers and scientists, ladies and gentlemen:

It is a privilege for me to be with you this morning and to welcome you to this important workshop on the treatment of septage and faecal sludges.

This Workshop, I am informed, provides a forum for knowledgeable persons both in the design and operation of faecal sludge reatment plants, to seriously deliberate on matters pertaining to present problems and also to look at future research and development options.

The Council for Scientific and Industrial Research (CSIR), as the national body with the mandate to coordinate all such research activities in this country is naturally happy to be a partner to such a workshop.

Indeed the functions of the Council include to advise government on scientific and technological advances likely to be of importance to national development and in particular to advise government and its agencies on scientific and technological matters affecting the utilization and conservation of the natural resources of Ghana and on how best scientific research may be coordinated and employed in the interest of such utilization and conservation.

The Council also encourages scientific and industrial research of importance to the development of industry, technology, agriculture and medicine in the national interest.

Mr Chairman, one of the major environmental problems facing this country today is sanitation. It is ironical that at the close of the 20st Century when others are seeking ways to manage complex modern-day organic pollutants in our environment, we in this part of the world should still be grappling with fundamental issues relating to microbiological pollution arising from our insanitary habits. It appears that provision of sanitary facilities cannot keep pace with the fast rate of urban population growth. This means that we must strategise effectively to ensure optimum use of limited resources.

Recent progress in environmental work in this country including the enactment of the EPA Act 490 of 1996 require developments to respond to strict environmental permitting requirements. The challenge to this august body is therefore to come out with recommendations which will provide cleaner technologies and products on a sustainable basis. The final effluent from the treatment plants should for example, satisfy Environmental Protection Agency (EPA) standards. The compost manure from the sludge treatment should be hygienically safe for public use. The treatment plant itself should not be offensive to the general public.

Mr Chairman, the Government is restructuring the CSIR to make it more responsive to private sector needs and to promote demand-driven research. A bill which re-established the CSIR to regulate research as well as the application of science and technology to development was approved by Cabinet and gazetted in July 5, 1995. This has since been enacted by Parliament. One salient feature of the bill included the addition of contract research and commercialization of research results to the functions of the Council.

It is gratifying to note that the Water Research Institute (WRI) has since 1993 been actively engaged in this collaborative research work with the Swiss Federal Institute for Environmental Science & Technology (EAWAG). This has led to recommendations for the design of anaerobic and facultative pond systems for the treatment of septage and public toilet sludge in tropical climates. The work is very relevant since most parts of this country are not sewered and on site santitation facilities are mostly used. The Council is particularly happy with this effort and will continue to assist all its Institutes and staff to vigorously pursue such collaborative undertakings.

I am also informed that, during the study period three (3) Swiss students had the opportunity to conduct practical field training in Ghana and to acquire skills in cross-cultural collaboration in scientific work. I am sure my staff also benefited immensely from the presence of these students.

These are all commendable achievements. The presence of such important international and local personalities and scientists to scrutinize this 4-year research effort and brainstorm for two full days to provide recommendations for future work further testifies to the seriousness of this collaborative work and the benefits we as a nation can obtain from this effort.

To all gathered here from abroad, I say AKWAABA.

I wish all of you here a very useful time and also wish the Workshop very fruitful deliberations.

1.2 Why to Treat FS and What is the Specific Challenge ?

Martin Strauss

Why FS Treatment?

The majority of urban dwellers in developing countries who have got access to safe sanitation systems, are served by on-site sanitation facilities such as family latrines, unsewered public toilets and septic tanks (see Graph **A** below). In contrast to the treatment of wastewater collected in sewerage systems, treatment of faecal sludges collected from on-site installations has received little attention by planners and engineers until recently.

Much of the faecal sludge produced, collected and disposed of in urban centres remains unaccounted for. This is illustrated in Graph **B** for the cities of Jakarta, Manila and Accra. There, the majority of the inhabitants use on-site excreta disposal facilities, yet, officially reported collection volumes remain much below expected values[1]. FS volumes to be treated (and thus accounted for) will probably increase sharply as cities will be upgrading their FS collection and management system. In Wuhan (China), reported and thus accounted for FS collection volumes correspond well with what is expectedly produced in the city.

What is Special About FS Treatment ?

Faecal sludges exhibit a much higher strength than wastewater (see the Table below). To achieve satisfactory FSTP effluent and solids quality is a particular challenge for developing countries where treatment options which are low in capital and operating cost, only, tend to be sustainable. They usually require relatively large land areas. While substantial knowledge exists on both low and high-cost wastewater technologies, sustainable FS treatment technologies still require large inputs of field research, development and testing before they may be propagated as "state-of-the-art" options.

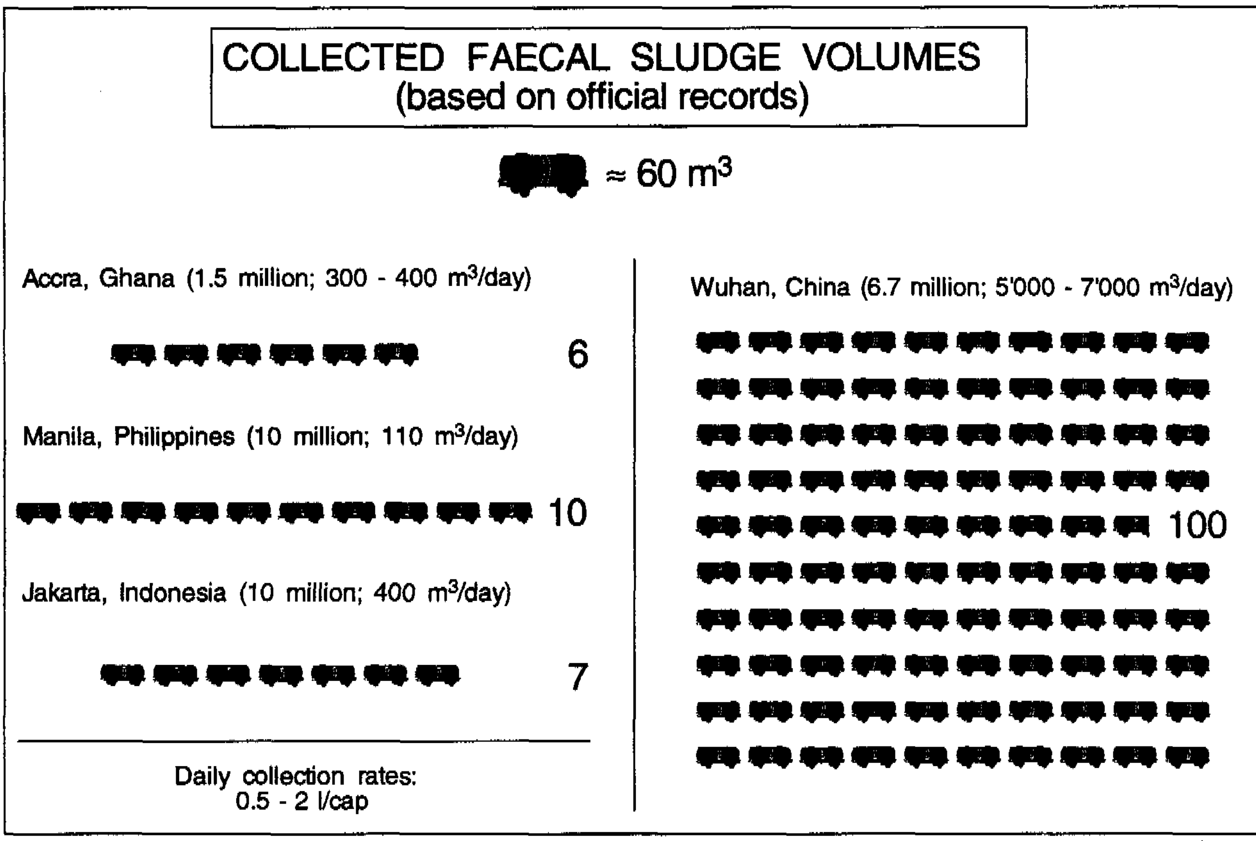
[1] See also the Table on sub-page II, p.12, for daily per-capita FS volumes

Table

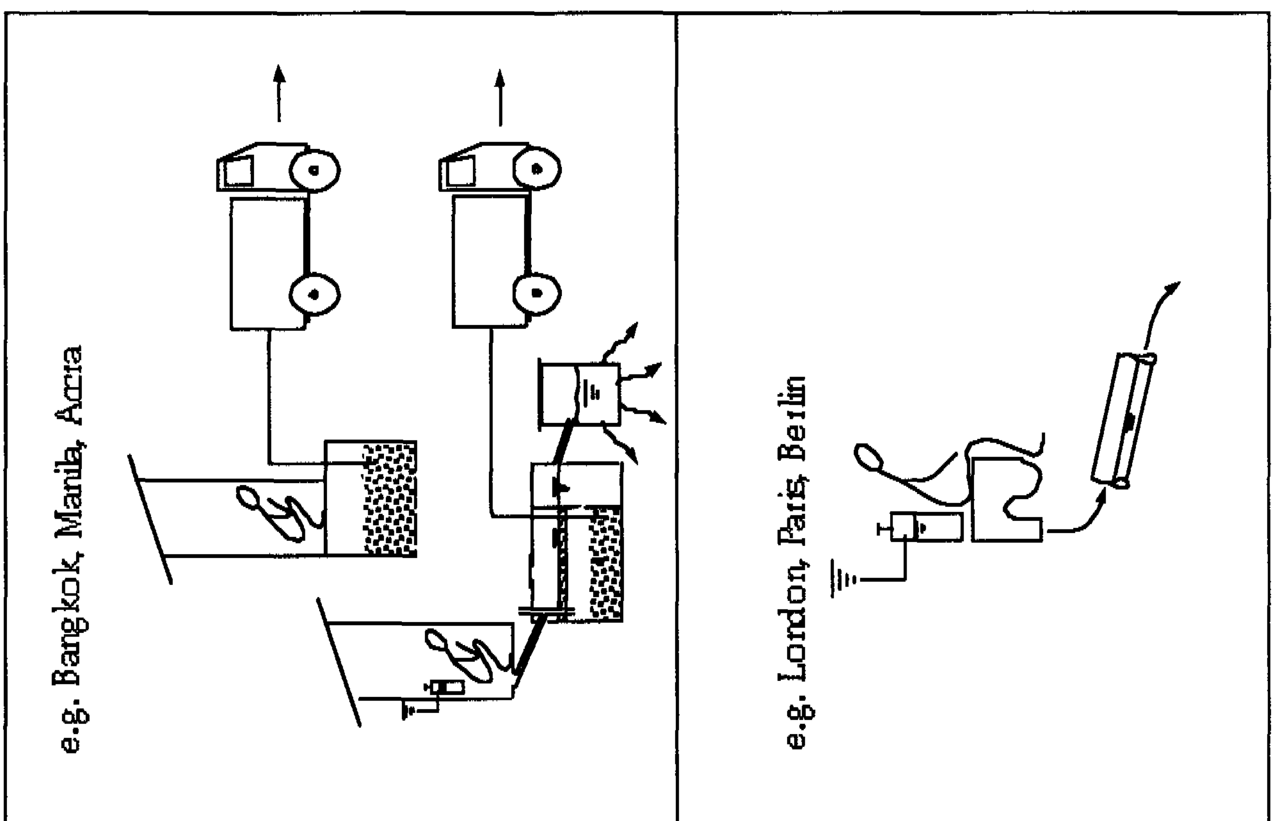
FS Treatment in Developing Countries vs Wastewater and Sludge Treatment in Industrialised Countries

	FS treatment in DC	**Wastewater + sludge treatment in IC**
Sludge characteristics		
• Solids content	1 - 8 %	0.1 - 1 %
• BOD	600-30,000 mg/l	150 - 250 mg/l
• Helminth eggs	4,000 - 60,000 / l	0 - 20 / l
• Org. stability	Low	High (digested sludge)
• Dewaterability	Medium to low	High (digested sludge)
• Contaminants	Low	Often high
Socio-economically	Sustainability through low and medium-cost options (usually land-intensive)	Medium to high-cost options sustainable (so far !)
Effluent standards	Non-existant	Existing
Know-how	Lacking	Existing

Graph B



Graph A

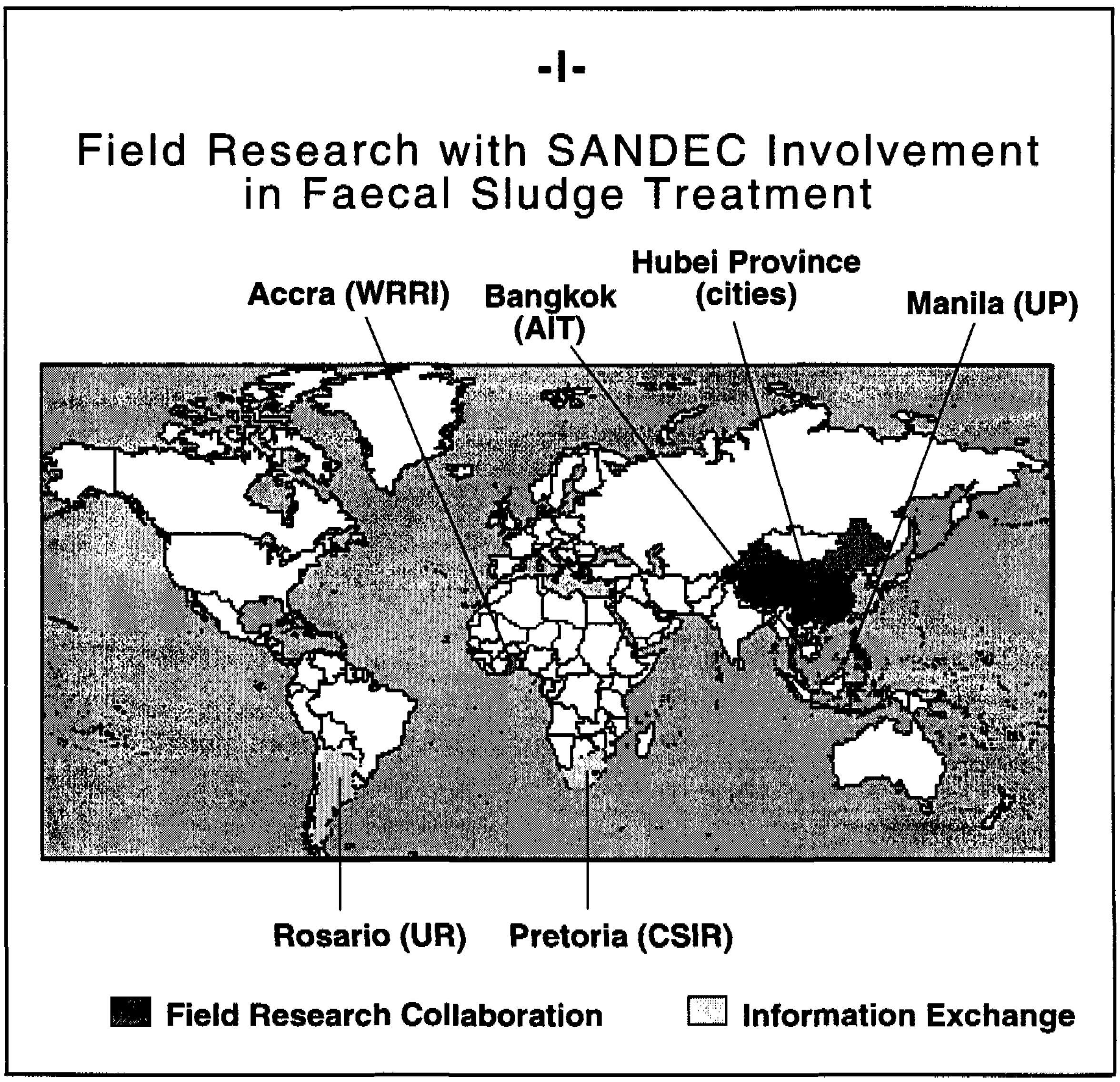


1.3 Global Overview of Faecal Sludge Treatment

Udo Heinss

In this overview, various low to medium-cost options for the treatment of faecal sludges are presented. SANDEC is conducting collaborative field research on FS treatment with institutions in several countries. With others, who are active in the field SANDEC is exchanging information.

The author may be contacted for further information about the treatment options described below, some of which have been in use for several years already.



-II-

Overview Faecal Sludge Treatment Options Introduced in this Presentation

① Extended Aeration + Pond Treatment

② Land Disposal / Agricultural Use

③ Constructed Wetlands

④ Co-Treatment with Sewage

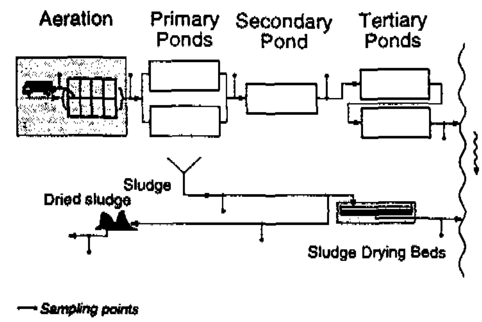
⑤ Co-Composting with Solid Waste

⑥ Anaerobic Digestion

-III-

①

PULO GEBANG (Jakarta) SEPTAGE TREATMENT PLANT MONITORING



Pulo Gebang is one of two Faecal Sludge Treatment Plants in Jakarta (Indonesia) which use aeration as a preliminary step prior to pond treatment. The plant was commissioned in 1984.

The sludge is aerated for 6 days. Through this a partial stabilisation (BOD decrease and improvement of sludge settleability) can be attained.

-IV-

②

UP - NEC
(University of the Phillipines - National Engineering Centre)
and EAWAG/SANDEC

LAND RECLAMATION USING SEPTAGE

Project Phasing

Phase I: **Septage characterization and lab-scale soil improvement studies**

- Physico-chemical, hygienic and agronomic characterization of Metro Manila septage;
- Laboratory experiments to determine the change in soil-mechanical properties and cultivation potential of alluvial soil, lahar and lahar-soil mixtures when septage is added.

Phase II: **Treatability studies, scale-up and economic evaluation of treatment technique.**

Phase III: **Field demonstration and Information Dissemination**

-V-

②

UP - NEC
(University of the Phillipines - National Engineering Centre)
and EAWAG/SANDEC

Results of the Preliminary Study (Phase I) to Determine the Value of Septage for Land Reclamation in Volcano Ash Devastated Areas in the Philippines

1. **Manila septage:**
   High in nutrients
   Low in heavy metals

2. **Enhancement:**
   Growth of grass and vegetables

3. **Increase:**
   Water holding capacity and organic matter of soil

③

Applicability of Sludge Dewatering and Mineralisation in Reed Bed Systems

Overview of results from different sewage sludge reed beds

- Typical rates of the reed beds vary from 50 - 100 kg TS/m^{2}year
- Reeds improve the dewatering of the sludge. *TS increase from 2-3% to 30 - 40 %.*
- Mineralisation supported by reeds
- Reduction of the sludge volume is effected by dewatering and mineralisation. *Sludge volume reductions of ≥ 90 % were achieved*
- Feeding over long periods without removing the sludge is possible. *Several reed beds have operated for 8-10 years without sludge removing*
- No clogging
- Strong anaerobic environment hinders the growth of reeds. A venting system enabling passive ventilation is therefore required when treating anaerobic sludges.

③

AIT/SANDEC Collaborative Field Research on Faecal Sludge Treatment

Constructed Wetlands for Septage Treatment

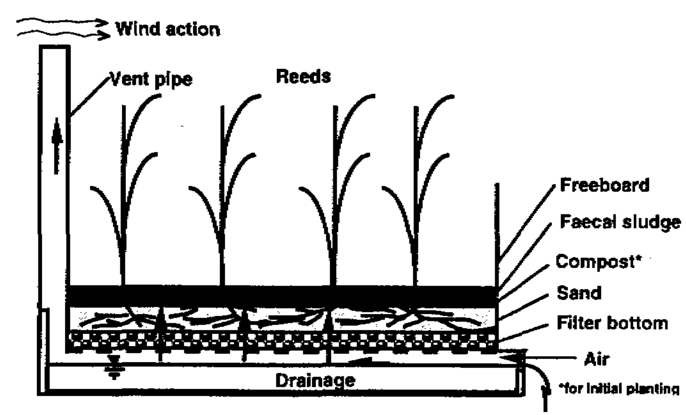
Results of Start-Up Phase (April/May 1997)

- TS_{raw} 14 g/l (Vol. solids 75 %)
- Loading 80 - 125 - 250 kg TS/m^2·yr (once - twice / week)
- Depth of filter bed 0.55 m

- Removal efficiencies in the percolate after 2 months of operation:

  COD 95 - 99 % NH4-N 80 - 99 % P 75 %

- TS in the dried sludge: 40 - 60 % (Vol. solids 50-65 %)



④

EAWAG/SANDEC

SOS - Treament of Sludges from On-Site Sanitation Systems

Recommendations for Co-Treating FS + Wastewater

In pond systems

- FS should be pre-treated for solids separation
- Critical variables for the calculation of the sludge load:
  - BOD: To avoid organic overloading and the development of anaerobic conditions in the facultative pond
  - NH_4 / NH_3 - N: To avoid ammonia toxicity to algae

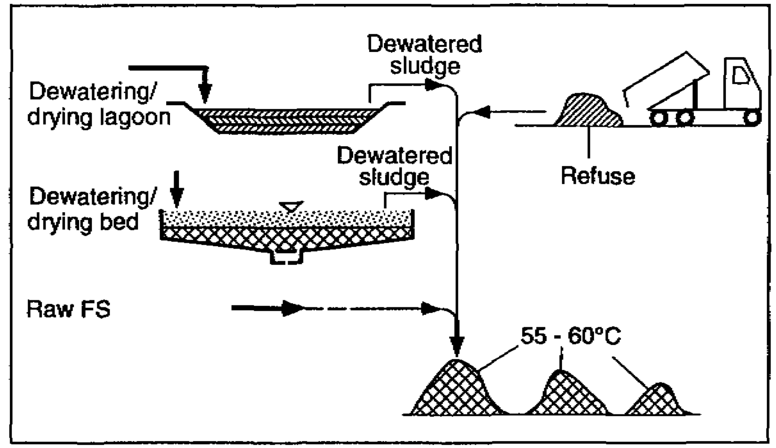
In activated sludge

- FS should be pre-treated (solids and grease separation and BOD elimination)
- Critical variables: BOD and NH_4 => additional oxygen demand for BOD elimination and nitrification; NH_3 - N toxicity in anaerobic digester possible

Example for co-treatment of wastewater and septage:
Alcorta (Argentina): Septage is pre-treated in shallow ponds. The supernatant is added to the wastewater which is treated in a pond system. The algae development is not inhibited as the septage is not high in ammonia.

⑤

Scheme of a Co-Composting Plant



Example for co-composting solid waste and faecal sludge from bucket latrines :
Rini/Grahamstown (South Africa) - Pilot project (closed down in 1997 as the bucket latrines were replaced by a sewerage system):
The raw liquid sludge was spread with a hose over static windrows made up from unscreened refuse and which were periodically aerated. The semi-matured compost was screened after three weeks.

-X-

⑥

Anaerobic Digestion with Gas Utilization

Example for the decentralised use of anaerobic technology

SULABH (Indian NGO) operates:

3,000 pour-flush public toilets (2-3 l / flush)

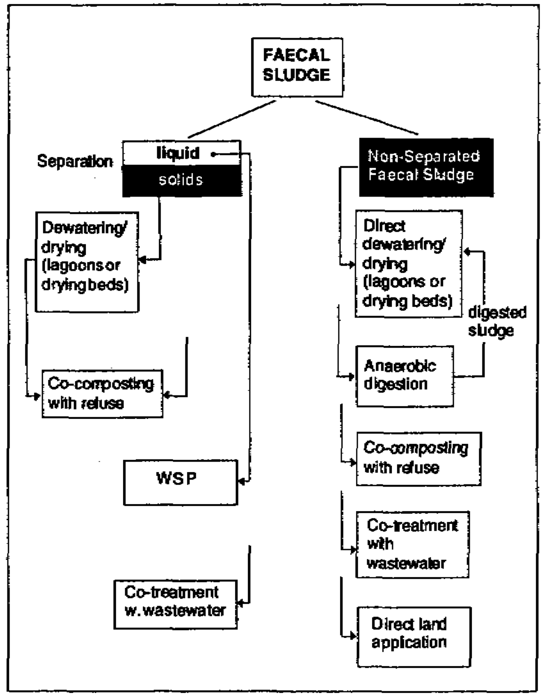
60 with anaerobic digester and gas utilization

=> the gas is used for cooking and lighting

-XI-

Summary

Options for Treating Faecal Sludge



1.4. Research Findings of the WRI-SANDEC Collaborative Field Research

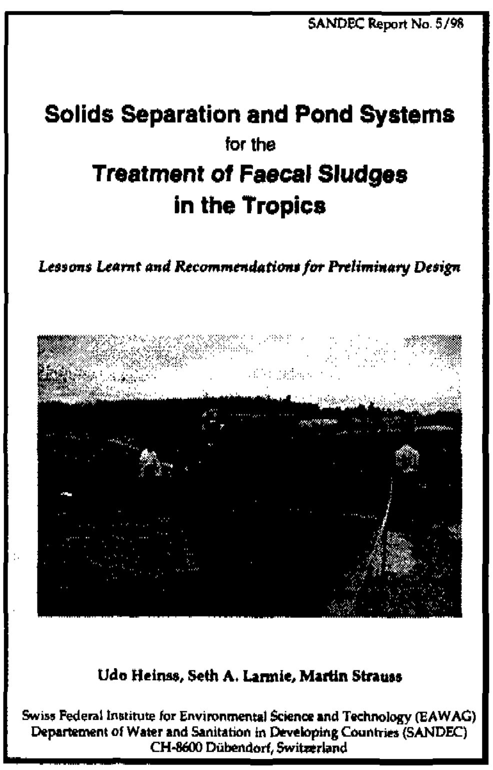
Seth Larmie

Below, the main results of the Collaborative Field Research which has been conducted by WRI and SANDEC since November 1993, are presented.

The field research comprised the following:

- Determination of the characteristics of faecal sludges (FS) collected in Accra (see p.12 below)
- Monitoring of a full-scale faecal sludge treatment plant and determining the suitability of FS treatment by solids separation in sedimentation/thickening tanks and by pond treatment of the supernatant (see pp. 14-16 below)
- Determination of settling properties of different faecal sludges (p.15/VIII)
- Testing pilot sludge drying beds for FS treatment (see p.17 below)

The results are evaluated in the recently published document "Solids Separation and Pond Systems for the Treatment of Faecal Sludges in the Tropics".



SANDEC Report No. 5/98

Solids Separation and Pond Systems
for the
Treatment of Faecal Sludges in the Tropics

Lessons Learnt and Recommendations for Preliminary Design

Udo Heinss, Seth A. Larmie, Martin Strauss

Swiss Federal Institute for Environmental Science and Technology (EAWAG)
Departement of Water and Sanitation in Developing Countries (SANDEC)
CH-8600 Dübendorf, Switzerland

-I-

Faecal Sludges from On-Site Sanitation Systems in Tropical Countries: Characteristics, Classification and Comparison with Tropical Sewage (after Strauss et al. 1997 and Mara 1978)

Item	Type "A" (high-strength)	Type "B" (low-strength)	Sewage - for comparison's sake
Example	Public toilet or bucket latrine sludge	Septage	Tropical sewage
Characterisation	Highly concentrated, mostly fresh FS; stored for days or weeks only	FS of low concentration; usually stored for several years; more stabilised than Type "A")	
COD mg/l	20, - 50,000	< 10,000	500 - 2,500
COD/BOD	2 : 1 .... 5 : 1	5 : 1 .... 10 : 1	2 : 1
NH_4-N mg/l	2, - 5,000	< 1,000	30 - 70
TS mg/l	≥ 3.5 %	< 3 %	< 1 %
SS mg/l	≥ 30,000	≈ 7,000	200 - 700
Helm. eggs, no./l	20, - 60,000	≈ 4,000	300 - 2,000

-II-

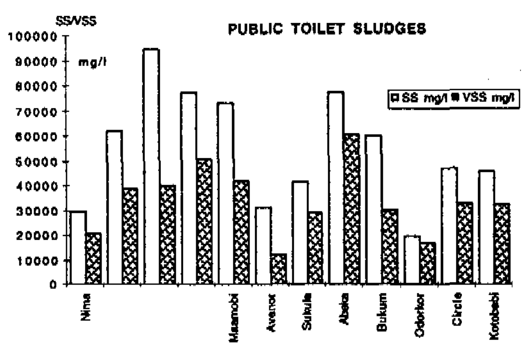
Daily Per Capita BOD, TS, TKN Quantities of Different Types of Faecal Sludges

Variable	Septage 1)	Public toilet and "pan"/bucket l. sludge 1)	Pit latrine sludge 2)	Fresh excreta
• BOD g/cap·day	1	16	8	45
• TS g/cap·day	14	100	90	110
• TKN g/cap·day	0.8	8	5	10
• l/cap·day	1	2 (includes water for toilet cleansing)	0.15 - 0.20	1.5 (faeces and urine)

1) Estimates are based on a faecal sludge collection survey conducted in Accra, Ghana.

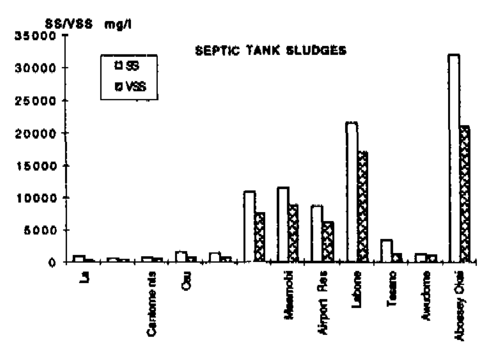
2) Figures have been estimated on an assumed decomposition process occurring in pit latrines. According to the frequently observed practice, only the top portions of pit latrines (~ 0.7 ... 1 m) are presumed to be removed by the suction tankers since the lower portions have often solidified to an extent which does not allow vacuum emptying. Hence, both per capita volumes and characteristics will range higher than in the material which has undergone more extensive decomposition.

-III-



The variation of the SS/VSS concentrations in public toilet sludges from different parts of Accra/Ghana reflects the influence of the public toilet operation modus (frequency of emptying, groundwater or surface water intrusion)

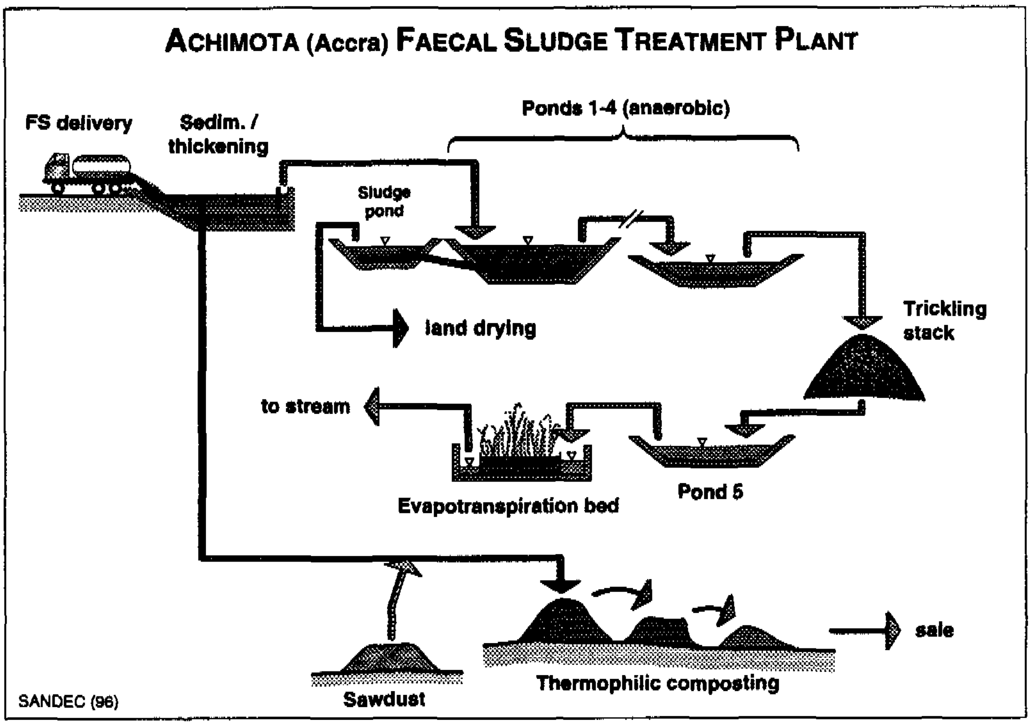
-IV-



The reasons for the remarkable variations in the SS/VSS concentration of septage from different places in Accra are:

- Variations in septic tank use and emptying frequency
- Difficulties in sampling and analysing of representative samples due to inhomogeneity of septic tank contents (more so than the public toilet sludge)
- The emptying practice

-V-



The Achimota FSTP treatment plant is in operation since 1990. Usually, a mixture of public toilet sludge and septage is treated at this site.

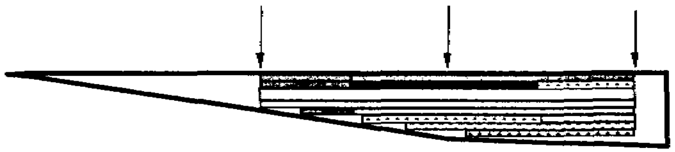
The treatment system developed by Annoh and Neff in 1988 includes a solids-liquid separation step in settling/thickening tanks, followed by a series of four anaerobic ponds, a trickling stack, a “maturation” pond and a series of evaporation beds. The solids separated off in the settling tanks are co-composted with sawdust, an abundant and appropriate by-product of the local timber industry. The Achimota FSTP was used to conduct field studies to assess operation and performance of the **sedimentation/thickening tanks,** including the series of four **ponds** treating the supernatant from the solids-liquid separation step (ponds nos. 1-4 in the figure).

The results of the monitoring of the batch-operated settling/thickening tanks and of ponds nos. 1-4 are presented on pp.14-16 below.

-VI-

SS Concentrations in a Sedimentation Tank

(after 3 weeks of operation)



Legend : SS- Concentrations

- ■ >130 g/l
- ■ 100-130 g/l
- ⊡ 40-90 g/l
- □ 10-40 g/l
- □ 0- 4 g/l Clear water layer

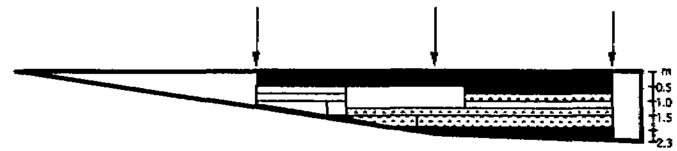
↓ Sample points

It can be noted that the clear water layer is very thin (less than 0.3 m). The scum has a very high SS concentration because of evaporative drying and flotation processes.

-VII-

SS Concentrations in a Sedimentation Tank

(after 4 weeks of operation)



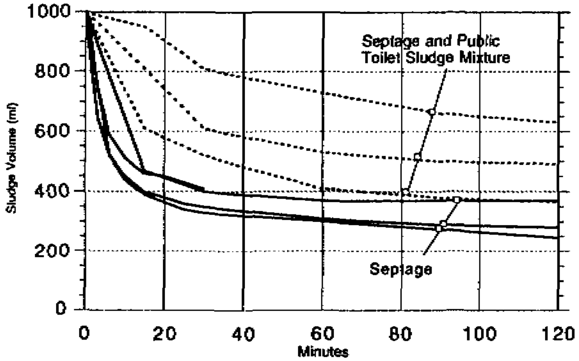
Legend :SS- Concentrations

↓ Sampling points

- ■ >130 g/l
- ■ 100-130 g/l
- ⊡ 50-90 g/l
- □ 10-30 g/l
- □ 0- 4 g/l Clear water layer

Comparing this profile with the profile of one week before it can be seen that the settled sludge is further thickened (to SS concentrations over 130 g/l). The tank is filled with solids except a clear water layer in the centre of the tank. Therefore, the quality of the effluent will deteriorate (higher SS concentration) and the removal of the solids from the tank becomes necessary.

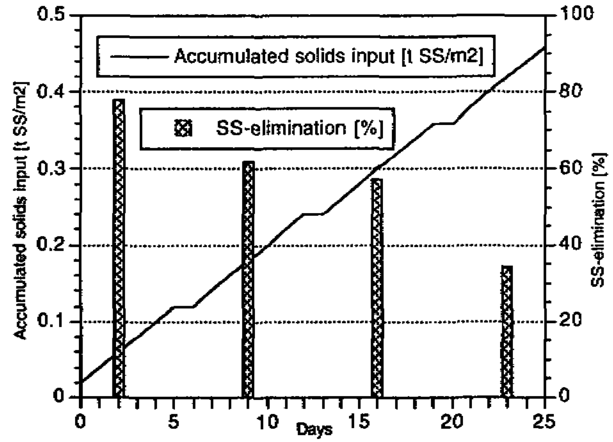
-VIII-



The mixture of septage and public toilet sludge shows poor settleability. The extent of this depends on the share of public toilet sludge and its degree of stabilization or digestion.

Sepatage which has been stored over long periods of time exhibit usually better settleability.

-IX-

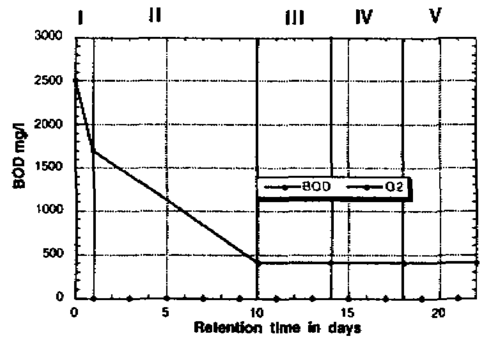


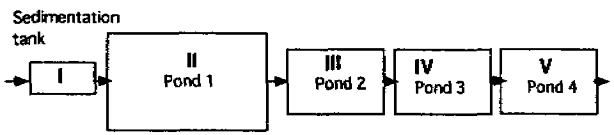
This Figure shows cumulative solids loading and suspended solids (SS) removal plotted as a function of tank operating time as observed at the Achimota FSTP.

During the first five days of tank operation, significant BOD and SS removal amounting to 55 % and 80 %, respectively, was attained in the supernatant. Solids removal (SS) remained above 40 % for a period of three weeks. However, BOD removal rapidly dropped to below 20 % after about ten days. Prolongued high removal could be achieved by optimising the tank geometry and limiting the loading periods to ≤ 15-20 days.

-X-

Achimota Faecal Sludge Treatment Plant in Accra/Ghana
Example for Pond System Treating Faecal Sludge Without Development of Facultative Conditions





Area (m2)	1500	1000	1000	1000
Volume(m3)	1500	650	650	650
Loading BOD loading (kg/ha*d)	1600	500	500	500

-XI-

The Achimota FSTP in Accra, Ghana, which was comissioned in 1989, was monitored over a 10-week period in early 1994. The overall BOD elimination (sedimentation/ thickening followed by four ponds) amounted to about 80 %. The Figure reveals that anaerobic conditions prevail throughout the pond system.

Mainly settleable BOD was removed in the sedimentation/ thickening tank. Anaerobic digestion in the liquid layer is not possible as retention time is too short. In the first pond (8-9 days of retention), anaerobic digestion proceeded until a low BOD concentration of 300-350 mg/l BOD was reached. Average elimination amounted to 75 %. For the particular mixture of faecal sludges, 300-400 mg BOD/l may constitute the lower limit of substrate concentration at which anaerobic digestion proceeds. SS elimination in the primary pond amounted to 17 % only as the sedimentation tank was well-functioning and not overloaded, during the time of observation!.

-XII-

WRI/SANDEC Collaborative Field Research
on Faecal Sludge Treatment

Drying Beds for Faecal Sludge Treatment

Results of 14 Test Runs
(1995 - 1997)

- TS_{raw} 1.6 - 7 %
- L 200 - 600 kg TS/m²·yr
- Depth of filter bed = 0.40 m

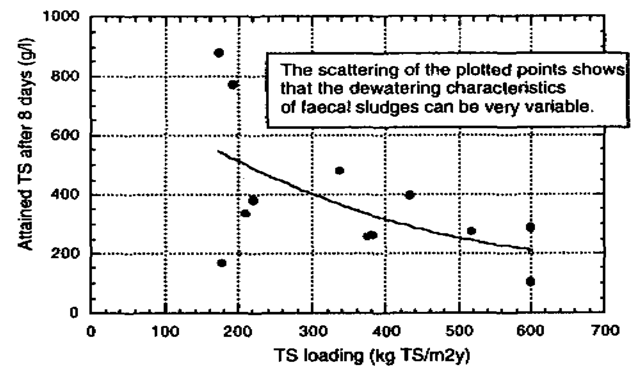
Removal efficiencies in the percolate:

70 - 90 %	COD
40 - 60 %	NH_4-N
≥ 95 %	SS

Dewatered sludge consistency:

TS	35 - 70 %	(L = ≤ 200 kg TS/m²·yr)
TS	20 - 30 %	(L = ≥ 200 kg TS/m²·yr)

-XIII-



The figure shows the TS concentrations attained after a period of eight days as a function of TS loading rate. The experiments this figure is based on were conducted during the dry season with sludge application depths of ≤ 20 cm. Average temperature and period of sunshine, including pan evaporation, amounted to 27 °C, 7.8 hours/day and 5.4 mm/day, respectively.

The various types of sludges revealed the following drying behaviour over a period of eight days:

- Mixtures of public toilet sludge (Type A) and septage (Type B) at a 1:4 ratio: Good dewaterability, drying to over 70 % TS in eight days
- Primary pond sludge: Rather good dewaterability, drying to 40 % TS
- Public toilet sludge (Type A): Highly variable drying behaviour; this variability can very likely be attributed to differences in age of the collected sludge which, in turn, is dependent on emptying frequency of the public toilets. Digested sludge dewaters more easily than undigested sludge. Fresh, nearly undigested sludge therefore hardly lends itself to dewatering on drying beds.

1.5 Recommendations for Effluent Guidelines and for the Selection of Treatment Options

Martin Strauss

Effluent Guidelines

It is useful to have at hand FSTP effluent and solids quality guidelines when evaluating FS treatment options and when mandated to design and operate faecal sludge treatment plants. Effluent standards normally stipulated for wastewater treatment plants (WWTP) in industrialised countries are too strict to be met or to be enforceable in the majority of developing countries. Moreover, to achieve WWTP effluent standards in faecal sludge treatment plants by treatment options affordable to most developing countries might prove unfeasible in the majority of cases. This is to a large extent due the high-strength nature of FS as compared to municipal wastewater and to the relatively large land area required when treating wastes with options which are low in capital and operating cost. Below, a set of FSTP effluent and solids quality guidelines is given based on economic, technical and institutional/ enforcement considerations.

In the Table, differentiation is made between guidelines values for FSTP effluent discharge into water courses and use in agriculture. Further to this, a hygienic quality guideline value for process solids (in-plant-sludge) is presented, using nematode egg counts as an indicator for residual human parasite contamination.

Recommended Quality Guidelines

	COD [mg/l] unfiltered	COD [mg/l] filtered	BOD [mg/l] unfiltered	BOD [mg/l] filtered	NH_4-N [mg/l]	Helm. eggs	F. coliforms [no./100 ml]
A: Liquid effluent							
Treatment for discharge into receiving waters:							
• Seasonal stream or estuary	≤ 300-600	150 - 200	≤ 100-200	50-70	10-30	≤ 2-5/ liter	≤ 10^4
• Perennial river or the sea	≤ 600 - 1,200	300 - 600	≤ 200-500	150-200	20-50	≤ 10/ liter	≤ 10^5
Treatment for reuse:							
• Restricted irrigation	n.c.		n.c.		1)	≤ 1/ liter	≤ 10^5
• Vegetable irrigation	n.c.		n.c.		1)	≤ 1/ liter	≤ 10^3
B: Treated plant sludge							
• Use in agriculture	n.c.		n.c.		n.c.	≤ 3-8/ g TS	Will be at safe level if egg standard is met

n.c. - not critical

1) Irrigation rates and hence effluent quality to be chosen such that the crop nitrogen requirements (100 .... 200 kg/ha·year) are not surpassed

Strategy and Options to Treat Low and High-Strength Faecal Sludges

(emphasising the use of pond systems)

The guidance provided below may be followed to select suitable options for treating low and high-strength faecal sludges. It has been shown that ammonia (NH_3-N) toxicity to algae and hence inhibition of facultative pond conditions are likely to occur if high-strength sludges such as PTS amount to > 8-10 % (in terms of population equivalents) of the sludge delivery to the plant. Measures would have to be introduced to counteract this and to enable the development of facultative pond conditions. The upper limit of high-strength sludge proportions is set by the solids-liquid separability of the sludge mixture. Current knowledge suggests that it might be safe to opt for separate treatment of high and low-strength sludges if the share of high-strength sludge is >> 30 %. At these mixing ratios, solids-liquid separation is likely to be impaired strongly. The recommendations for treatment strategies and process options are formulated for three distinct cases of high and low-strength FS mixtures.

Low-strength FS (septage falls into this category in most cases) and the liquid fraction of higher strength FS may be co-treated with wastewater either in WSP systems or in activated sludge plants. In pond systems, the FS should be pretreated to reduce the solids load. Pond design should be based on the combined loads from both FS and wastewater with respect to BOD and ammonia. FS co-treated in activated sludge plants should be pretreated, too, mainly to reduce the solids, BOD and grease loads. The combined BOD or COD loads must be taken into account for design. If nitrification is to be achieved, the combined NH_4 loads also become a decisive design variable.

Treatment *cases, strategies* and *options*

(A)

Share of high-strength FS < 8 -10 %

↓

Treatment of low-strength or of mixtures of high + low-strength FS

"Primary" treatment:

- Settling/thickening tanks; or Primary anaerobic pond

"Secondary" treatment:

- (Anaerobic +) facult. pond (+ maturation pond if required)

(B)

Share of high-strength FS = 10 - 30 %

↓

Combined or separate treatment of high and low-strength FS

See Case A for recommended treatment options

Ammonia toxicity to algae is likely to occur, particularly so in combined treatment. One of the following measures or a mixture thereof must therefore be introduced:

- Intermittent aeration in the facultative pond
- Cascade stripping of ammonia
- Lime addition
- Recirculation

(C)

Share of high-strength FS >> 30 %

↓

Separate treatment of high-strength FS

"Primary":

Anaerobic pond or anaerobic digester + drying beds

(possibility of ammonia toxicity in the anaerobic processes)

"Secondary":

Ponds for sludge liquor + percolate
(separate treatment or joint treatment w. low-strength FS or wastewater)

1.6 History of Faecal Sludge Treatment in Ghana

Collins Annoh

a Developing Country Context

The problem of inadequate waste management in developing countries is recognised as one of the major areas requiring development assistance in recent years. Various projects have been implemented in an effort to address the problem by improving collection, treatment and disposal services.

The effort with regard to human excreta management has been limited to a few areas, including development and provision of improved technologies for domestic and public on-site sanitation facilities, pilot sewerage schemes for collection and treatment of tropical sewage, provision of collection vehicles and equipment, etc.

In most developing countries, about 60 – 80 % of the urban population is provided with various on-site sanitation facilities. Thus, the importance of improving on human excrement management, through provision of collection vehicles (cesspit emptiers) and adequate facilities for treatment and safe disposal of collected waste, cannot be overemphasised.

The various technologies for on-site sanitation result in the generation of faecal sludges of varying characteristics different from those for tropical sewage. The major problem confronting sector professionals is to develop appropriate technologies for treatment and safe disposal of such faecal sludges. In view of this, various research activities including literature reviews have been commenced in a number of developing countries in Asia, Africa and Latin America.

In Ghana, work done so far has provided a lot of insight regarding characterisation of faecal sludges (septage as well as sludges from unsewered public toilets and bucket latrines), and has enabled preparation of preliminary guidelines for the design of facilities for the treatment and disposal of such material.

b Local Context

The effort to seek appropriate options for treatment of septage commenced in earnest in 1986, under the then Accra City Council Waste Management Improvement Project with technical and financial assistance from GTZ/KFW. Various research activities were undertaken in Accra with the following objectives:

- To obtain adequate data on the characterisation of septage
- To test different treatment options
- To provide an opportunity to develop design criteria for septage treatment

Initially, from 1986 to 1989, these research activities included the following, among others:

- Construction, operation and performance monitoring of 3 No. pilot septage treatment plants at Teshie and Korle Gonno in Accra;
- Review of the design of some system components in order to optimise operational performance;
- Field sampling and laboratory analyses of faecal material collected from the various sources of origin, notably, public toilets (aqua privies), pan latrines and wc/septic tanks;
- Review of the limited literature available on septage treatment; and
- Consultations with expatriate professionals having similar research interests.

While these research activities were ongoing, the first prototype plant was constructed in 1989/90 at Achimota (Plant A) for a number of reasons, notably:

- The need to provide a disposal facility to the north of the city as part of a strategic sanitation planning in order to reduce the incidence of unauthorised dumping, and to reduce the cost of haulage, particularly to the Waste Management Department of the A. M. A.
- The need to test run to obtain adequate operational data for system components of a prototype plant.

As a result of limited funding, the plant was constructed using an in-house construction gang and equipment (highly depreciated) of the Waste Management Department with limited supervision thereby affecting the quality of construction.

A follow-up intervention supported by the government of Ghana through the Ministry of Local Government and Rural Development was initiated in Koforidua in 1990 as a result of incessant requests by the New Juaben Municipal Assembly. Though construction was started in 1992, it was not until mid 1995 that the plant could be commissioned. Funding was provided by the New Juaben Assembly with assistance from the MLG&RD. Construction supervision was mainly provided by the P.W.D regional office.

The third prototype was constructed at Teshie in 1994/95 to test new conceptual designs in an attempt to improve on operational performance.

Since 1993, a collaborative research between SANDEC, the Department of Water & Sanitation in Developing Countries at EAWAG, Switzerland; WRI-CSIR and the Waste Management Department of the AMA, has been undertaken to provide additional and adequate data through performance monitoring of two full-scale, prototype septage treatment plants in Accra. The generated data allowed to formulate design and operational management guidelines for septage treatment.

Since 1995, the Government of Ghana on recognising the need to improve environmental sanitation in the five major cities in Ghana, and in partnership with the World Bank and other donors, is implementing the Urban Environmental Sanitation Project (UESP). The sanitation component of the project seeks to improve on excreta management by providing adequate facilities for on-site sanitation and septage treatment.

As a result, consultants have been engaged to plan and design septage treatment facilities to be provided in all the five project cities. Given the previous local initiatives with regard to research and design, conceptual designs were prepared to guide detailed design of all septage treatment facilities to be provided under the UESP.

The initiative under the UESP provides an excellent opportunity for the project cities to develop improved and adequately constructed treatment facilities for collected septage. The facilities shall be designed and located at sites to meet the social, environmental and economic aspirations of all stakeholders, including the project cities, MLGRD, EPA, nearby local communities, and the public at large. A participatory approach through consultations with all stakeholders cannot be overemphasised. Additionally, through these initiatives, the problem of inadequate construction of facilities as a result of limited funding shall be overcome.

c Chronology of Faecal Sludge Treatment Initiatives

Before 1980s	Drying, burial and marine disposal
1986	Pilot research activities using prefabricated metallic containers fitted with valves, etc.
1986	First Pilot Treatment Facility Constructed at Teshie (20 cu. m/d capacity)
1987	Pilot activities using treated septage for irrigating sugar cane plantation
1988	Initiation of collaborative research with the Agric. Dept., Univ. of Ghana, Legon
1989	Second Pilot Treatment Facility constructed at Teshie (40 cu. m capacity)
1990	Third Pilot Treatment Facility constructed at Korle Gonno, Accra
1990	First Prototype Plant constructed at Achimota, Accra
1991	Planning and design of facility in Koforidua
1992	Commencement of construction in Koforidua
1993	Commencement of collaborative field research with SANDEC (formerly designated IRCWD), RWSG, W.M.D. and WRRI
1994	Commissioning of facility in Koforidua
1994	Commencement of Phase II of collaborative field research with Sandec, WRRI, W.M.D. and Colan Consult
1995	Second Prototype Plant constructed at Teshie, Accra
1995	Commencement of Phase III of collaborative field research with Sandec, WRRI, W.M.D. and Colan Consult

1.7 Current Situation in FS Management in Ghana

Peter Hawkins

a. *Scale of the Problem*

- 1997: 6 million urban residents
- 2015: 12 million urban residents

Served (very approximately) by:

- Sewerage	5%	
- Septic tanks	25%	**
- Pit latrines	5%	
- Pan latrines	15%	**
- Public toilets	40%	**
- "Free range"	10%	

- ** i.e., 80% septage or high-strength FS, equivalent to 4.8 million people

  - ☛ 6,000 m3/d (~1,200 tanker loads)
  - ☛ @ 4,000 mg/l BOD: 24 T/d BOD
  - ☛ @ 30,000 mg/l SS: 180 T/d SS

b. *Current Situation*

- Insufficient tankers and dumping capacity:

  - Tankers: actual fleet ~50, requirement ~150
  - Treatment, actual capacities:

Achimota	150 m^3/d
Teshie	80 m^3/d
Koforidua	100 m^3/d
Obuasi	400 m^3/d
TOTAL:	**730 m^3/d**
Requirement:	**~6,000 m^3/d !**

- Many official dump sites provide no treatment
- "Informal" dumping when sites are not conveniently situated
- Poor quality treatment due to both operation and design problems

c. *Current Facilities*

The Table below lists the faecal sludge treatment and disposal measures for the major cities and towns in Ghana.

City, town	Treatment and/or disposal
Accra:	
- Korle-Gonno (beach)	Sedimentation, composting pilot aeration plant (non-functional)
- Achimota	Sedimentation, ponds, composting of separated solids
- Teshie	Sedimentation, ponds, composting of separated solids
Kumasi	Discharge into Subin river (ponds non-functional)
Sekondi-Takoradi	Beach discharge (ST broken)
Tema	Mixed/sewage, retention, outfall
Tamale	Informal dumping; purchase for agricultural use
Koforidua	Sedimentation, ponds, composting of separated solids
Obuasi	Sedimentation, ponds, composting of separated solids
Cape Coast, Elmina, Swedru	Trenching systems

d. Main Issues and Problems

- Lack of facilities
  (but 5-6 new ones will soon be built, thereby more than doubling the current capacity)
- Staff training and motivation
- Funding
- Monitoring of influent material
- Shock loading
- Ammonia toxicity
- Desludging procedures

1.8 Faecal Sludge Collection and Treatment in Cotonou, Benin

Fidéle Tonon

200-300 m^3 of faecal sludge per day are collected with suction tankers, typically having a capacity of 6 m^3. Sludge collection is completely privatised.

Owners of septic tanks pay a fee for the sludge removal which is controlled by the government. They are free to choose among several sludge collection companies. Competition has led to improvements in the pit/tank emptying technology and service. In order to empty the pit/tank completely, including thick sludge, the trucks flush water into the tank, thereby increasing the fluiditiy of the sludge accumulated at the bottom of the tank.

The Ministry of Health is the controlling authority. It claimed, a few years ago, that faecal sludge disposal practices were unacceptable. As a result, Sibeau, one of the sludge collection companies, constructed and now operates a septage treatment facility.

The currently used treatment plant consists of a pond system. Problems occur because of the high solids load of sludges. The removal of solids from the ponds proves to be difficult. Some sludges (fresh brewery sludge/undigested sludges) form a thick scum layer. The disposal of the separated solids is also unresolved. There is controversy about its use in agriculture due to potential transmission of pathogenic organisms. The BOD concentration in the effluent of the pond treatment system reportedly amounts to an average of 300 mg/l.

1.9 Decentralised Faecal Sludge Management in Bamako, Mali

Mamadou Diarra

Appropriate management of solid waste and faecal sludge is one of the most pressing current problems in Mali's urban centres, particularly in the City of Bamako. Proliferation of unauthorised municipal dumping sites, discharge of untreated faecal sludge in gutters, on roads and in the environment, pose an imminent public and environmental health risk. To contribute to adequate solutions to the City's environmental sanitation problems, the Municipal District No. IV has been selected for a demonstration project on decentralised and entrepreneur-based solid waste and faecal sludge management. The District, together with WASTE[1], CPAC[2] and ALPHALOG[3], has initiated a project on the implementation of a solid waste and faecal sludge treatment complex in the said municipality. Preliminary studies have been completed and implementation of the project is about to start. The project comprises two components, viz. solid waste and faecal sludge.

Solid Waste

The "Groupements d'Intérêt Economiques" (GIE, Economic Interest Groups) ensure by cart the primary collection to the transfer points. Eight transfer points will be set up throughout the municipality. The transfer points will consist of plots enclosed by walls fitted with a wire frame. Their location will depend on the availability of space and distance which can be covered by the donkeys. The waste is transported by dump trucks from the transfer points to the treatment site. The biodegradable material will be separated and composted. Windrow composting, as used by Mrs Véronique Gnanih in Tohoué, Porto Novo (Benin), will be the composting method applied.

[1] A Dutch consulting firm
[2] Coordination des Partenaires d'Assainissement en Commune IV, Bamako ("Coordination of Sanitation Service Partners in District IV, Bamako")
[3] Name of a non-profit organisation in sanitation

The windrow is built in successive layers alternating with layers of municipal waste mixed with faecal sludge and layers of hyacinths used for their macrophyte properties. Hyacinths abound in the Bamako region. The compost and humus will be marketed or used in the banana field also foreseen in the project. The banana field must cover a surface area of one hectare.

Recyclable material (cans, plastic containers, glass, cereal bags, metals, drinking bottles, etc....) will be separatrd off and sold.

Faecal Sludge

As with the solid waste, GIE manages the emptying of latrine pits and soakaways using donkey-drawn trailers equipped with a metal storage tank and a manually operated suction pump. Under the improved FS management strategy, the sludge will be transported to transfer reservoirs. Eight transfer reservoirs will be set up next to the transfer points The sludge will be trailer transported from the transfer reservoirs to the treatment station. The liquid waste will be subjected to coarse screening before it is treated in a three-pond system consisting of anaerobic, facultative and maturation ponds. Detention periods in the ponds will amount to 3, 15 and 6 days, respectively. Hyacinths will be cultivated in the facultative and maturation ponds and in the storage basin of the treated effluent. The hyacinths float on the pond surface. Their roots located in the pond water absorb nutrient salts. Bacteria attaching to the roots as a biofilm decompose organic matter. Treated effluent is stored in a reservoir and subsequently used to irrigate banana trees and compost windrows. The sludge occasionally drawn from the anaerobic ponds will be added to the windrows.

Financial Aspects of the Project

The internal rate of return of the project is estimated at about 15 %. The project will create new jobs and significantly improve the municipal public health situation.

1.10 Faecal Sludge Treatment in Dar es Salaam, Tanzania

Shaaban Mgana

Sources of Faecal Sludge

Rural Areas: About 95% of the population use pit latrines as excreta disposal facility.

Urban Areas : About 85% of the populations use pit latrines and septic tank systems as excreta disposing facilities. The remaining 15% of the population are connected to sewerage systems or have nothing.

Treatment of Faecal Sludge

Rural Areas: There is no treatment offered to pit latrines sludge. Once a pit latrine is full, it is abandoned and a new one is dug.

Urban Areas: Some limited faecal sludge from pit latrines and septic tanks does receive some treatment particularly in the city of Dar es Salaam (the business capital of Tanzania). In other urban areas, faecal sludge is not treated at all.

In the congested areas, where there is not enough space to construct new pit latrines, once the old latrines are full, a traditional way of handling faecal sludge is used: A person gets into the pit latrine and physically empties the faecal sludge, disposing it into a shallow pit dug adjacent to the old latrine. Later the borrow pit is covered with earth. The latrine pit can now continue to be used. This is a very unhygienic way of handling faecal sludge since the person who empties the pit does it manually with hand tools like bucket, hoe, rope and spade. Sometimes even if there is ample space for locating pit latrines, the traditional method is preferred if there exists an expensive superstructure over the pit latrine. Digging a new pit latrine means incurring another cost of putting up an expensive superstructure - which either can not be afforded or is a waste of resources.

Another approach is MAPET (i.e. Manual Pit Emptying Technology). This is an improvement over the traditional approach. The MAPET equipment has two main components: a handpump and a 200 litre vacuum tank, both mounted on pushcarts. The sludge is pumped manually from the pit latrine into a MAPET tank. The sludge is then discharged into a hole dug within the neighbourhood of the existing pit latrine. This approach is more hygienic than the traditional way though the faecal sludge does not receive better treatment other than burying it.

The fourth approach involves transfer of faecal sludge to central sewage/sludge treatment facilities operated by the city council. This service is particularly practised in planned areas where septic tanks and pit latrines are easily accessible.

At the moment, there are three locations of waste stabilisation ponds where faecal sludge treatment takes place. These are: Vingunguti, Msasani, and Mgulani waste stabilisation ponds. In all these ponds, there are dump stations receiving faecal sludge brought by vacuum tankers. The sludge is treated separately using anaerobic ponds. The effluent from the anaerobic ponds then meets effluent from the wastewater facultative pond. The combined flows are then further treated in maturation ponds.

The following design has been chosen for the anaerobic ponds treating faecal sludges at the Vingunguti and Msasani pond schemes (Howard Humphrey (T) Ltd., Dar es Salaam, Tanzania):

- 2 parallel anaerobic ponds each exhibiting:
- Hydraulic retention time: 5 days
- Depth: 5 m
- Expected BOD removal: 70 %

Resulting in the following individual pond volumes:

- at Vingunguti: 5,000 m^3 (including 4,400 m^3 for solids accumulation);
  design FS delivery rate = 120 m^3/d
- at Msasani: 3,400 m^3 (including 2,650 m^3 for solids accumulation);
  design FS delivery rate = 144 m^3/d

Evaluation of Anaerobic Ponds Treating FS

The Environmental Engineering Department of the University College of Lands and Architectural Studies (UCLAS) conducted an evaluation of the performance of the Vingunguti and Msasani anaerobic faecal sludge treatment ponds in 1990 and 1994, respectively.

Results showed that the Vingunguti ponds appear to perform better than the Msasani ones, despite the fact that the design for both ponds were based on the same criteria (see above). The difference in performance might be attributable to differences in operational care, maintenance and repair practices followed in the two plants.

The average BOD removal efficiency in the anaerobic ponds amounted to 73 % at Vingunguti and to 43 % at Msasani. The average removal efficiency for suspended solids (SS) were 65.5 and 37 %, respectively. Ammonia nitrogen removal was 40 % at the Vingunguti scheme.

In principle, the treatment approach adopted which incorporates the separate anaerobic treatment of FS prior to the combined treatment of the FS liquid fraction with municipal wastewater is sensible and appears to be working well. It is recommended, though, that an anaerobic pond be introduced as a primary treatment unit for wastewater ahead of the facultative pond. The effluents from both the FS and the wastewater anaerobic ponds could then be co-treated in the facultative pond as against in the maturation pond. Finally, depending on the required effluent standards, polishing treatment of the combined flows could be effected in one or more maturation ponds.

The solids which are separated and accumulated in the anaerobic ponds are removed manually using hand tools and then left on the ground surface to dry. These operations need to be improved particularly with respect to the sludge handling and to observing appropriate drying periods to achieve a hygienically safe product useable in agriculture and gardening.

Final Remark

Though there is, in Tanzania, some effort for treating faecal sludge as shown above, most of the FS remains untreated. There is need for the planning and implementation of large additional plant capacity to treat pit latrine sludge and septage.

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2 Group Recommendations

The participants were grouped into four working/discussion groups such that each group had a balanced composition with respect to the professional background and institutional affiliation of its members. Group nos. 1 and 3 primarily discussed operation and management aspects, whereas group nos. 2 and 4 dealt with treatment option and design issues, mainly. All groups were asked to formulate recommendations for further field and action research.

2.1 Treatment Options and Design (Group nos. 2 + 4)

Group 2

a FS disposal in small towns and/or of small volumes

- Controlled trenching to dispose of PTS in small towns or for small volumes in selected sub-districts may constitute a suitable option if groundwater is not at risk and suitable sites can be identified.

b Selecting options based on the FS mixture

- As the mixture of low and high strength sludges varies from place to place, three typical situations of FS collection and delivery may be taken as a basis for selecting appropriate treatment options. These are:

  1 - Almost exclusively PTS

  2 - A mixture of PTS and septage: with < 15-20 % PTS

  3 - Almost exclusively septage

- For Case 3, standard pond systems comprising one or more anaerobic ponds operated in series and a facultative pond are recommended. Either sedimentation tanks or primary ponds may be devised for solids separation.

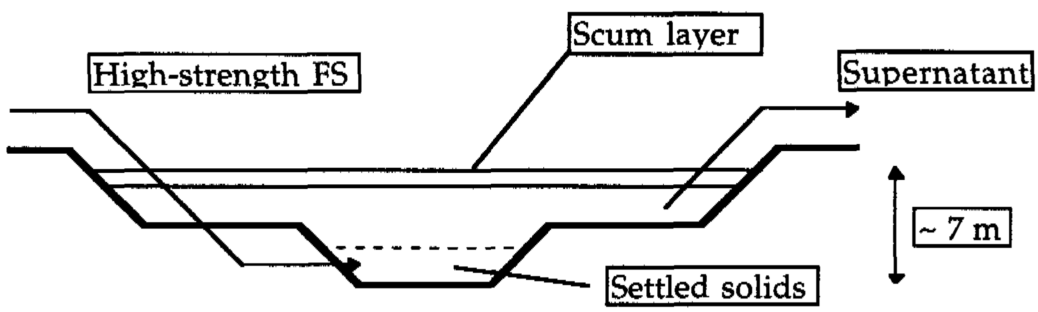
- For Case 1 and 2, treating the FS may pose particular challenges as PTS are high in solids, organics and ammonia. Ammonia may be toxic to both anaerobic bacteria and algae. Further to this, PTS tends to be fresh and undigested and, hence, is difficult to dewater. Such high-strength sludges should be subjected to separate primary treatment prior to co-treating its liquid fraction with either septage or wastewater.

c ***Separate primary treatment of high-strength FS (PTS or bucket latrine sludge):***

- It is recommended to provide facilities which are specifically designed to treat public toilet or bucket latrine sludge prior to treating their liquid fractions (together with septage in Case 2).

- Anaerobic processes are recommended for the primary treatment of PTS. The following options were discussed:

  - **Deep anaerobic ponds:**



Deep anaerobic ponds are likely to constitute the simplest option; the removal of the separated solids may, however, prove to be difficult due to the depth of the pond. The presumably high density of the settled solids may preclude gravity draw-off under hydrostatic pressure.

Deep anaerobic ponds allowing for complete or nearly complete digestion are likely to bring about satisfactory solids separation as well.

  - **Sludge digester** tanks with optional gas utilization and stirring system or mixing through gas production; fairly high level of sophistication

  - **UASB** reactor: not considered suitable for FS treatment in developing countries as its safe operation requires close process control which may not be available and difficult to achieve with FS which has a high variability in the composition of each tanker load and whose discharge into the treatment plant leads to surges in the plant flow.

- Ammonia toxicity to anaerobic bacteria could be solved through the addition of a base to increase the pH and subsequently strip off ammonia gas.

  Urine separation at source and its separate collection and use in agriculture may constitute a viable though still theoretical solution. While constituting a sound resource recovery option (using nitrogen and phosphorus contained in the urine in relatively high proportions), ammonia toxicity problems in treatment plants could be avoided.

d ***Primary treatment of low-strength FS (septage or mixtures of septage and high-strength FS):***

- The use of **Imhoff tanks** as an alternative to primary anaerobic ponds or batch-operated settling/thickening tanks may constitute a suitable option for both solids separation and anaerobic digestion of the separated solids.

e ***Changes in public toilet design to improve the treatability of PTS:***

Design:

- New or reconstructed public toilet facilities may be designed to operate as pour-flush toilets. The ammonia toxicity of the PTS will be reduced as a result of dilution. The disadvantage is the increase in water requirement and of the sludge volume to be transported from the public toilet to the treatment plant.

Operation:

- The improper practice of removing sludge from the public toilet is seen as a major reason for the very fresh undigested character of the PTS. Suction truck operators usually remove only the top layers of the stored excreta due to limitations in transport capacities and the fact that the settled solids have often solidified to an extent which makes them unliftable by a vacuum tanker pump. Older sludge therefore remains in the tank and builds up as a partly digested and thickened sludge layer with a high TS concentration. The effective tank volume above this layer gradually decreases as more thickened sludge accumulates. Many public toilets therefore have to be serviced as often as once a week. It is reported that tanks which have a content of 5 truck loads (around 25 m3) are serviced with one truck once a week which removes but the top layer of sludge which is essentially undigested. Removing the entire tank contents once in five weeks would improve the treatability of FS in plants like Achimota.

f *Suggestions for further field/action research*

The following issues warrant further field or action research:

- The use of deep ponds and digester tanks for the primary treatment of PTS.
- Methods for removing the settled and stored solids from deep anaerobic ponds inclusive of the specific case if sawdust for co-mixing is not available.
- The use of Imhoff tanks for the primary treatment (solids separation and anaerobic digestion) of modest-strength FS.

Group 4

a *Strategy for Treating Faecal Sludges:*

- The Group recommended to opt for the **combined treatment** of **septage** and **PTS** rather than treating them separately. The operation may be simpler than when attempting to devise separate treatment. In case anaerobic digesters would be opted for as preliminary treatment, septage may assist in dilution and hence prevention of ammonia toxicity to anaerobic bacteria.

b *Pond systems as the preferred option:*

- It is recommended to use stabilisation pond systems to treat the sludge mixture. Except for the first pond, this system corresponds to the usual wastewater treatment system consisting of anaerobic, facultative and maturation ponds. To adapt this system to treat PTS, the primary pond should be designed such as to allow for long retention periods to ensure digestion, solids separation and solids storage. Therefore, such ponds should be designed as deep anaerobic ponds (up to 7 m). Hydraulic retention time (HRT) and the storage volume for settled solids will be the relevant design variables.

- A pond system comprising the following pond stages and HRT may serve to treat septage/PTS mixtures:

- Primary, deep anaerobic pond for digestion and solids-liquid separation	15-20 days
- Secondary + tertiary anaerobic pond in series for supernatant treatment	10 + (5-10) days
- Facultative pond	20-30 days
- 2 maturation ponds in series for (if hygienisation for reuse is required)	7 days each

c ***Miscellaneous items:***

- Reuse of pond effluents should be opted for whenever possible. The pond system must be designed accordingly (addition of maturation ponds to achieve the required hygienic quality)

- The overflow structures between the ponds should be designed in such a way that solids carry-over can be minimised.

d ***Suggestions for further field/action research:***

- Ammonia stripping with cascades
- Recirculating facultative pond effluent to keep ammonia levels in the pond influent low
- Determining solids accumulation rates in the primary anaerobic ponds
- Anaerobic digesters for PTS: design and operation

2.2 **Operation and Management** (Group nos. 1 + 3)

Group 1

a ***Planning Aspects***

- A careful selection of the number and sites of FSTP must be made as part of urban planning in order to minimise overall haulage, eliminate uncontrolled dumping due to excessive haulage distances, and to match actual plant loading with the plant design capacity.

- The selection of FS treatment options must be made in a holistic manner, i.e. by taking into consideration technical, socio-economic, and institutional factors, as well as traditional practices of FS management and utilisation (e.g. direct agricultural use).

- Environmental impact assessments (EIA) should be made in an early planning stage.

- FSTPs should be designed for the "worst case", i.e. for a peak proportion of high-strength (public toilet) sludges which may reasonably be expected at the particular plants.

- FSTP effluent standards:

  - They should allow for site-specific requirements (discharge into inland water vs. discharge into the sea vs. use in agriculture)

  - The Group had conflicting views whether FSTP effluent standards should be the same as for wastewater treatment plants or whether they should be different.

b ***Plant operation***

- Appropriate loading/resting cycles and desludging frequencies of batch-operated units should be determined and adhered to through adequate plant management.

- O+M guidelines and operators' manuals for FSTP should be developed and operators be trained accordingly.

- FSTPs should be adequately equipped (desludging and other equipment required for proper plant keeping). Conflicting views existed on the need/non-need for simple measuring/analytical equipment to be used by operators for performance control.

- Provide adequate facilities for plant operators (office space, bathrooms/toilets, storeroom, first aid kits). Conflicting views existed regarding the supply of electricity which might be uneconomical if the FSTP is located relatively far away from the nearest electrical grid. Solar panels might be installed in such cases.

- O+M requirements must be taken into consideration in plant design (e.g. to allow for easy loading and desludging; bypass conduits for ponds) *c* ***Institutional Aspects***

- Plant personnel should be provided training and opportunities for promotion

- FS management is to be made a component in training curricula at all professional levels, including engineering and urban planning

- Institutional arrangements should be made to ensure FSTP performance monitoring and the enforcement of forthcoming effluent/plant sludge quality standards

d ***Suggestions for Further Field Research***

- Assess traditional land application/agricultural use practices and carry out marketing studies (e.g. in relation to the use of PTS collected in Tamale)

- Carry out pilot and/or full-scale investigations on the following treatment processes and operations:
  - Pre-treatment of high-strength sludges (PTS) in anaerobic ponds
  - Pre-treatment PTS in anaerobic digesters
  - Evaluate the performance of sedimentation/thickening tanks with improved design.

Group 3

a ***Policy and Planning***

- Devise a sanitation policy/ordinance on a national level

- Assure that integrated strategic sanitation plans are developed for each city and town, including the spelling out of the roles of the various sectors (government; private; non-government)

- Cater for proper FSTP location and land acquisition *b* ***Institutional/managerial aspects***

- Each municipality should establish a separate unit responsible for liquid waste management (faecal sludges and wastewater)
- Flexibility should be introduced in institutional/managerial procedures, particularly as pertaining to FSTP operations
- The role of the private sector in excreta and wastewater management should be strengthened
- FSTP O+M should be adequately budgeted for
- A proper revenue/expenditure scheme should be devised, inclusive of cost recovery through appropriate public toilet user and septic tank desludging fees
- Plant monitoring and control should be drawn up making use of internal and external "actors"
- Proper record keeping of raw FS delivery quantities and types should be guaranteed
- Desludging of treatment units: operations to date have often been unsatisfactory as regards frequency of desludging, availability of equipment on the site and level of formation of plant staff. The following is therefore required:
    - Adequate budgeting
    - Smooth administrative procedures
    - Operators' training and back-up
- Devise an incentive scheme for FSTP operators

c ***Legal aspects***

- The legal securing of adequate land reserves for FSTPs should be done at the early stage of the urban planning process
- Appropriate guidelines/standards for franchise contracts with private entrepreneurs should be developed

d ***FSTP Infrastructure***

- Devising adequate access to the FSTP premises
- Providing operators' facilities, i.e. office; bathroom/toilets; electricity.

Results of the Workshop Regarding Further Field and Action Research on FS Treatment in Ghana

3. Suggestions for Further Field and Action Research on FS Treatment in Ghana

Outcome of a post-workshop meeting held between WRI, Carl Bro/Ghana, Colan Consults and SANDEC

In summarising the recommendations made by the Workshop discussion groups (see Chpt. 2 above) and in recognition of the current stage and technical support needs of UESP, the Meeting decided to put forward a list of issues on which field and action research should now be initiated. The list is a proposed action plan submitted to potential support agencies which may consider all or individual proposals for financial support as part of their assistance to the urban water and sanitation sector in Ghana.

- **Ammonia toxicity**: Reducing toxicity to algae caused by high levels of ammonia in faecal sludge liquor (suggested measures to be tested: surface aeration; ammonia stripping over cascades; effluent recirculation; lime dosing)

- **Anaerobic treatment**: Assessing the suitability of deep anaerobic ponds and of anaerobic digestion in treating FS, particularly high-strength, undigested sludges from unsewered public toilets and bucket latrines

- **Solids separation**: Monitoring FS settling/thickening tanks to be installed in FSTP currently being planned for. The tanks would be of the same basic type as those currently in use at Achimota, Teshie and Koforidua yet having an improved design and operational pattern

- **FS as a marketable product**: Assessing the current practice and socioeconomic implications of the traditional use of untreated FS in agriculture and its possible integration into improved FS management schemes

- **Hygienic quality of treated FS**: Helminth egg monitoring in existing FS treatment schemes to asses the degree of FS hygienisation achieved; enhancing the skills for helminth egg analysis.

Annex 1
Workshop Programme

Workshop on the Treatment of Septage and Faecal Sludge

Sogakope, 4th and 5th December 1997

Objectives

To disseminate the research findings of WRI/SANDEC
To review current experience in Ghana and the region
Make recommendations on technology and design criteria
Make recommendations on operating practices
Agree on priority areas for further research and development

Programme

Wednesday 3rd December, 1997		
16:00-19:00	Arrival and registration of participants; Dinner	

Thursday 4th December, 1997		
08:30-10:00	Opening session: Welcome address Opening statement Keynote address Chairperson's remarks Global overview of faecal sludge treatment	 MLGRD SANDEC M. Odei - CSIR Udo Heinss - SANDEC
10:00-10:30	Break	
10:30-12:30	History of faecal sludge treatment in Ghana Current situation in Ghana Faecal sludge treatment in Benin Faecal sludge treatment in Mali Faecal sludge treatment in Tanzania	Collins Annoh - Colan Peter Hawkins - Carl Bro Mr. Fidèle Tonon Mr. Mamadou Diarra Mr. Shabaan Mgana
12:30-14:00	Lunch	
14:00-15:00	Research findings + recommendations	Seth Larmie - WRI Martin Strauss - SANDEC
15:00-16:30	Group discussions	
16:30-17:00	Break	
17:00-18:30	Group discussions	

Friday 5th December, 1997	
08:30-09:00	Review of previous day's work (plenary)
09:00-10:30	Group discussions
10:30-11:00	Break
11:00-12:30	Group presentations
12:30-14:00	Lunch and check-out
14:00-15:30	Plenary discussion and conclusions: Design Operation Research and development
15:30-16:00	Closing remarks; Departure

Background

The treatment of faecal sludges from septic tanks and public toilets is a major problem in Ghana. Such effluents cannot be mixed with sewage for subsequent treatment by standard systems, as there is little sewerage in the country. They therefore have to be treated separately. Unfortunately, the nature of these wastes is such that the normal systems used for treating sewage (which is much more dilute) do not function properly. The end result is the production of odours and grossly polluted final effluents.

In recognition of this problem, WRI, supported by SANDEC (a Swiss foundation focusing on waste treatment for developing countries), has been undertaking research over the last few years into faecal sludge treatment (FST) systems. The current phase of research has now finished, and the findings will be presented. More questions still remain to be answered, however, so the workshop will consider the research results in the light of the current situation of FST in the region, and develop a prioritised list of research and development activities for the next few years. The workshop also aims to draw conclusions on improvements that can be made immediately in design and operating practices.

It should be recognised that Ghana is on the cutting edge of this work, and that success here will be of use to many other countries in the region and beyond. We hope that we will be able together to guide the development of FST towards substantial improvements over the next few years.

Annex 2
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