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Practical handbook

on

Technical Assessment and Planning Guidelines for Fecal Sludge Management

Asian Institute of Technology

Published and printed n Thailand

Practical Handbook on Technical Assessment and Planning Guidelines for Fecal Sludge Management

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ORGANIZATIONS

The Swiss National Centre of Competence in Research (NCCR) North-South was a 12-year research partnership programme which ended in June 2013. It was headquartered in Bern, and involved major research institutions in Switzerland and more than 40 countries in the global South. The network developed practical solutions to specific problems, and encompassed a network of more than 350 researchers in fields including epidemiology, sanitation, natural resource management, and peace studies.

Within the NCCR North-South, research was collaboratively conducted with special emphasis on the needs of developing and transition countries, since they are arguably under the most pressure due to the accelerated global processes of environmental, economic, and sociopolitical change. The NCCR North-South was co-funded by the Swiss National Science Foundation (SNSF), the Swiss Agency for Development and Cooperation (SDC), and the participating institutions.

The Asian Institute of Technology promotes technological change and sustainable development in the Asian-Pacific region through higher education, research and outreach. Established in Bangkok in 1959, AIT has become a leading regional postgraduate institution and is actively working with public and private sector partners throughout the region and with some of the top universities in the world.

Environmental Engineering and Management (EEM) at AIT began in 1964 with the need for sanitary engineering to address the problems of providing adequate water supplies and sanitation facilities. The overall program looks for solutions to environmental problems including wastewater treatment and disposal systems; air pollution engineering and management; solid and hazardous wastes; waste minimization and life cycle assessment; environmental impact assessment and management; and environmental toxicology.

AUTHORS

Dr. Thammarat Koottatep

As an Associate Professor at the Environmental Engineering and Management division of the School of Environment, Resources and Development, Dr. Thammarat is part of an outstanding pool of environmental expertise, with regional influence. He has served as a Regional Coordinator in Southeast Asian region of the Swiss-funded National Center for Competence in Research North-South (NCCR) program during 2002 - 2013. Dr Koottatep is presently leading several international and national environmental-related projects. One of the ongoing projects is awarded from Bill & Melinda Gates Foundation within the framework "Reinventing the Toilets" program. The project – officially titled "Sustainable Decentralized Wastewater Management in Developing Countries. Design, Operation and Monitoring" – uses Market-driven Approach to ensure the innovative decentralized systems be saleable and affordable to the urban poor. In 2013, the Faculty of Engineering, Chiang Mai University awarded him as an "Outstanding Engineering Alumni".

Dr. Atitaya Panuvatvanich

Researcher at AIT, Atitaya Panuvatvanich has 10 years of relevant experience in environmental engineering, wastewater treatment, decentralized sanitation technologies and Faecal sludge management. Throughout her works, she has published 8 articles in international-refereed journals and international seminars and 2 book chapters. As a management position, Dr. Panuvatvanich is presently a project manager of the ongoing projects is awarded from Bill & Melinda Gates Foundation with a budget of 5 million USD within the framework "Reinventing the Toilets" program. The project – officially titled "Sustainable Decentralized Wastewater Management in Developing Countries. Design, Operation and Monitoring" – uses Market-driven Approach to ensure the innovative decentralized systems be saleable and affordable to the urban poor.

Paul Jacob

Working as a researcher for 2 years in the Environmental Engineering and Management program at AIT. Paul has worked on various environmental related projects funded from Asian Development Bank, Asian Pacific Network and various private companies. His field of expertise lies in advance wastewater treatment using membrane technology, solid waste management, material flow analysis at country levels and GHG mitigation strategies for sanitations system in the Asian region. He has also received awards for his research work at both national and international platforms for his research work.

About this Manual

This manual is prepared with a motive of providing a practical guidance to assess and plan for fecal sludge management, where onsite sanitation is being practiced.

Septic tank and other onsite sanitation systems are used for storage and pre-treatment of excreta released from households in many developing countries. But most of these countries are not been paying enough attention on fecal sludge management. Even where fecal sludge management is being practiced, yet fecal sludge is not yet properly managed properly. As a result, huge amount of fecal sludge is generally discharged on to surface and water bodies without any treatment, which has become an alarming concern and threat to the environment and public health.

Generally, the extent of fecal sludge management in a country depends on the government policies, accessibility and availability of infrastructure. Many developing countries are deprived of such facilities and regulatory provisions and are often labeled as having a poor state of fecal sludge management. We also need to keep in mind that having such facilities and provisions do not indicate a good fecal sludge management on the ground level. In many countries fecal sludge management facilities are available, but due to mismanagement these facilities run below their original running capacity. Thus resulting in a huge volumes of open dumping without any treatment.

Fecal sludge management involves a combination of activities. Many factors such as considering fecal sludge as a part of sanitation by planners and policy makers, enforcement of policies, mobilization of funds, technical knowledge, public awareness, participation and etc can affect its management. Therefore, aspect multi dimension approach is required to address this issue. Even though planners and local authorities wish to manage fecal sludge, but they often fail due to lack of essential skill set in management, uninformed choices and inadequate experience.

This manual has been developed and designed to provide practical guidelines for planners and municipalities to effectively treat and manage fecal sludge. This manual illustrates sets of activities, results and practical experiences used while developing an effective fecal sludge management strategies in Bahn-Klang (Sub-district),Lamphoon Province, Thailand.

The manual contains four sections. The first chapter is the introduction, which explains about the basic definition of fecal sludge and the importance of its management. In the second chapter, the guiding principles for fecal sludge assessment are explained. The third chapter illustrates the planning process of fecal sludge management with examples in details. Fecal sludge treatment options and examples of best treatment practices around the globe are mentioned in the last chapter.

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Chapter I
INTRODUCTION

1.1 What is fecal sludge ?

Septic tanks and other onsite sanitation systems are used to collect black water and/or grey water, where separation of solid and liquid fraction occurs. The liquid part are drained into the adjoining drain field or discharged into the sewer system, whereas the solid parts is accumulated at the bottom and partially digested as a result of microbial activities. The solid part that is the partially digested and settled at bottom of the onsite sanitation systems is known as fecal sludge (FS).

The sludge comprises settleable fecal solids, as well as other non-fecal matters with different concentrations. Similarly, sludge's also vary in biochemical stability, which is gained through anaerobic digestion, depending upon the ambient temperature, storage period, and inhibition or enhancement due to the presence of other non-fecal substances.

Figure 1.1 Fecal sludge inside commercial septic tank

Table 1.1

Fecal sludge from various on-site sanitation systems in tropical countries

Type	High- Strength "Type A"	Low-Strength "Type B"	Sewage (for comparison)
Example	Public toilet or bucket latrine sludge	Flush toilet	Tropical sewage
Characterization	Highly concentrated, mostly fresh FS; stored for days or weeks only	FS of low concentration: usually stored for several years	-
COD	20,000-50,000 mg/l	<10,000 mg/l	500-2,5000 mg/l
COD:BOD	5:1-9:1	2:1-5:1	2:1
NH4-N	2,000-5,000 mg/l	<1,000 mg/l	30-70 mg/l
TS	≥3.5%	<3%	<1%
Helminthes egg	20,000-60,000/l	≤4,000/l	300-2,000/l

1.2 Fecal sludge characteristics

FS characteristics differ from place to place and time to time. Its composition is influenced by several factors such as type of disposal units, emptying methods, duration of storage, ambient temperature and groundwater infiltration. In general, fecal sludge is broadly characterized as Type "A" and Type "B" as seen in Table 1.1. The Type "A" sludge is rather fresh and exhibit high concentrations of organics, ammonium and solids. It originates from non-flush or pour-flush public toilets and bucket latrines. The sludge categorized under Type "B" is of relatively weak strength. The solids are normally collected along with flush and the grey water retained in the tank. The sludge is relatively stabilized due to long period of storage.

Figure 1.2 Sampling fecal sludge from onsite sanitation system

1.3 Why is fecal sludge management important ?

Onsite sanitation systems are widely used for collection and pretreatment of excreta in urban and rural areas of the developing countries. A huge amount of fecal sludge generated under such systems is currently being disposed haphazardly, and it has caused severe problems related to the environment and public health. The major impacts and potential risk of improper FS management is shown in Table 1.2. As a result, management plans/strategies are necessary to overcome such negative consequences resulting from unplanned or improper FS management practices.

Figure 1.3 Sludge accumulation in cesspool

Table 1.2:

Impacts and risks caused by disposal of fecal sludge in environment

Impact	Type of risk
Surface and groundwater	Actual surface water pollution High risk of potential groundwater pollution
Transmission of excreta related infections	Potential risk of increased levels of disease prevalence; Scientific proof of actual risks attributing to the disposal of untreated FS and high levels of pathogens "floating" within the urban environment are obtained on the basis of extensive epidemiological studies
Unpleasant odors and eyesore	Impact felt by residents near the disposal sites and passers-by

1.4 When is the plan for fecal sludge management necessary ?

Fecal sludge management planning is a part of sanitation plan, which must be included during the development and planning stage for any community. However it is usually neglected during the early sanitation planning process. Ideally, fecal sludge management planning should be considered and developed once the city or country rely extensively on the onsite sanitation systems.

The need for fecal sludge management is urgent when the negative effect resulting from improper fecal sludge disposal practices becomes more severe. FSM becomes mandatory in urban areas where open spaces are limited and population density is quite high. Additionally, planning of fecal sludge management should be conducted to improve the existing management system. This is possible with the identification of current problems and need of the areas.

Chapter 2
ASSESSMENT OF FECAL SLUDGE MANAGEMENT

Fecal Sludge Management Assessment is a process intended to determine the current state of fecal sludge management in a particular area/ region/country. It primarily involves the collection of information regarding the existing situation of fecal sludge. The process allows us to understand constraints and opportunities in a particular area, which is the pre-requisite information for developing suitable fecal sludge management strategy. The assessment is also important as it can evaluate the performance of the on-going fecal sludge management activities in the area.

The fecal sludge management constitutes a series of activities, whereas several factors are interconnected and affecting overall management status. The major factors that are closely related and often examined during assessment are explained here.

Figure 2.1 Septage from fecal sludge

2.6 billion of the world's people lack basic sanitation.

2.1 Prevalence of onsite sanitation

Onsite sanitation is used for the collection and pretreatment of domestic black water and/or grey water. The number of residents in an area who do not have access of sewerage system and rely on onsite sanitation reveals the level of need for fecal sludge management in the area. A proper management plan with a significant number of treatment facilities is required to manage the huge amount of fecal sludge generated where onsite sanitation is prevalent. In general, fecal sludge management plans are necessary in places where a form of onsite sanitation systems is used. However, the level of urgency increases with the percentage share of onsite sanitation system in a given community/region.

Figure 2.2 Commercial available septic tank

Figure 2.3: Operational onsite sanitation

2.2 Fecal sludge collection and treatment capacity

Due to the limited storage capacity of onsite sanitation systems, fecal sludge should be removed periodically from them. Whereas the presence of high levels of pathogen in the sludge needs further treatment and safe disposal. Thus the presence of public or private service to empty the onsite sanitation units using mechanized and hygienic methods are important. Similarly, available treatment facilities, and their capacities are imperative to determine the potential gaps in FSM in a given area. Therefore, the availability of fecal sludge collection services, methods used in its collection and transportation should be taken into consideration while assessing the status quo of FSM in a particular area.

2.3 Policy frameworks and enforcement

A sustainable operation and management for FSM is completely depended on the existing regulatory policies for the country. The existence of policies and development of legal and institutional frameworks for FSM reflects on the level of awareness and willingness of policy makers, planners and social workers towards the issue. It has been generally observed that there is a lack of such polices, legal and institutional frameworks in many developing countries where onsite sanitation is being practiced. It is also true that some countries have such regulatory policies but with very limited implementation. The execution of such policy is vital for general public health and safety. Similarly, delineation of responsibility among various stakeholders should also be considered for the existing FSM plan.

Figure 2.4 Policy level meetings with government

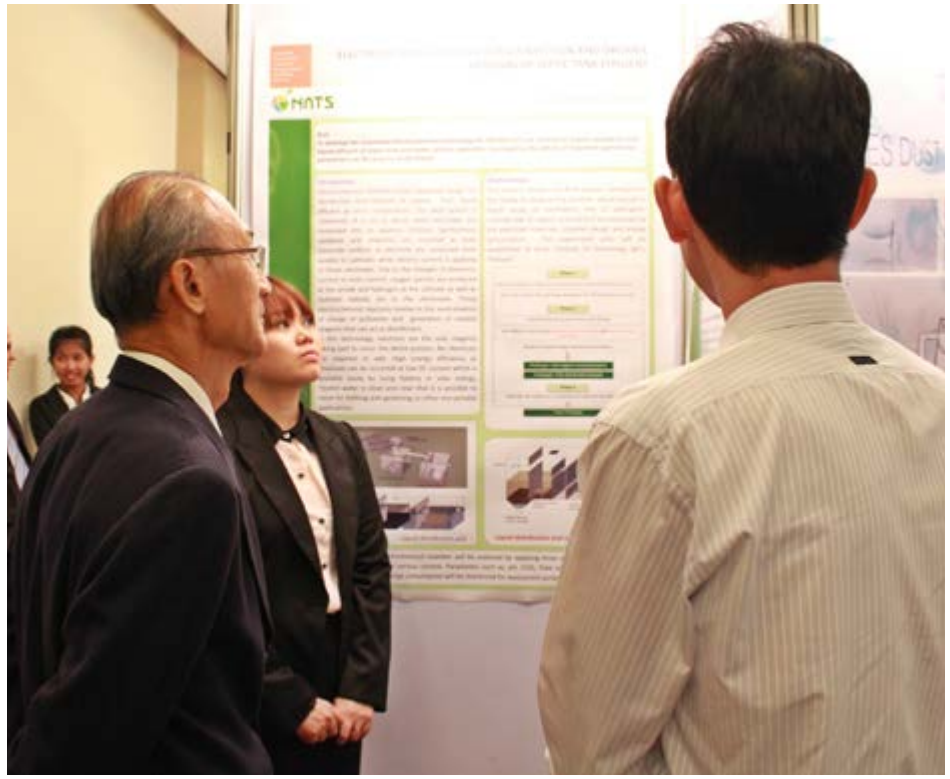


Figure 2.5 Conference and seminars for scientific community

2.4 Human and institutional capacity

Human resource is particularly important for assessing the local context and development of the suitable FSM plan for a particular area. Whereas the institutional capacity plays a significant role in the effective execution of the plan. Lacking human resource in many developing nations have made them to rely on the external experts for designing treatment facilities and the developing of overall plans. In this case, frequent need for assistance even for small maintenance arises, which hampers sustainable management. Therefore, the availability of human and institutional capacities reflect on the potential strength of a region / country towards proper fecal sludge management.

2.5 Stakeholder awareness

The level of awareness among various stakeholders such as policy makers, planners, local authority officers, community leaders and residents is generally associated with the effectiveness of proper sustainable FSM. Higher levels of awareness amoung the stakeholders for the needs and benifits of fecal sludge management leads to more effective and sustainable operation of the same. The activities of responsible authorities, in raising public awareness is also important. The involvement of stakeholders during the planning process is a way of raising awareness during the developmental plans for FSM.

Figure 2.6 Panel discussions

2.6 Funding capital and operational costs

Funds are always crucial for the successful implementation of any plan. A considerable amount of funding is necessary for effective fecal sludge management (FSM). Therefore allocation of budget for this by the concerned authority/country is significant, and determines the commitment and the priority given to FSM in that area. It is usually difficult to manage the fecal sludge if the countries have limited funds and rely on the external financial supports for sanitation programs. The available funds and the financial arrangement for operation should be taken into account during the development and assessment of FSM in a given area.

Chapter 3
PLANNING FOR FECAL SLUDGE MANAGEMENT

The planning process involves set of activities which are carried out in a logical sequence. The steps involved in the planning process are schematically shown in Figure 3.1. It is important to understand that the planning process is not a single stage process but a circular process. The plan needs to be revised and modified based on the experience gained during planning and/or monitoring, and evaluation of the implemented plans. The planning process is generally very subjective to a given area and many factors such as social, economical and environmental factors should be taken into consideration.

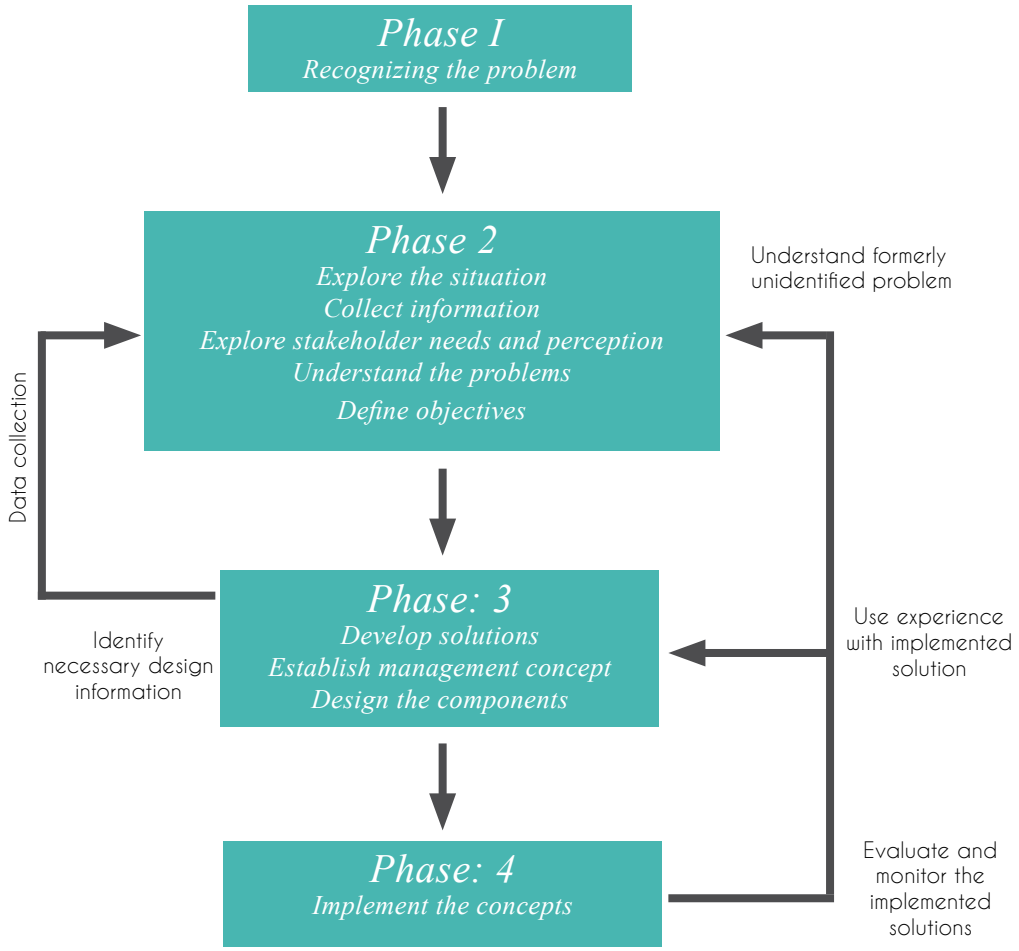


Figure 3.1: Schematics for the planning process

3.1 Phase 1: Develop consensus on the need to plan

A plan must be developed by consensus among all stakeholders. The plan will not be effective unless and until the responsible organizations are familiar and convinced need for developing FSM plan. It is important to make a general agreement on the need and benefits before going further on the planning process. Frequent discussion and good understanding among the decision makers, implementing authorities such municipality and local representatives are mandatory at the first phase of planning.

A case study in Bahn-Klang sub district, Lamphoon Province, Thailand

A case study of fecal sludge management carried out by JCS-SEA in Bahn-Klang sub district, Thailand is described, in order to provide a practical guidance. Septic tanks and other on-site sanitation systems are being practiced for storage and pretreatment of excreta in Bahn-Klang. Vertical Flow Constructed Wetland (VFCW) units were installed by Asian Institute of Technology (AIT) in collaboration with Thai Pollution Control Department (PCD) in the area for fecal sludge treatment. It was also considered as a testing site and expected to replicate the system in other areas upon its good performance. However, the system and overall fecal sludge was not managed very well, though the policy and other physical facilities were already in existence. Therefore, this study is carried out to identify problems in the existing system and develop coping strategies for proper fecal sludge management.

3.2 Phase 2: Explore the situation

Information of the prevalent onsite sanitation system, available physical facilities, and existing rules and regulations should be gathered in detail at this stage. The information will be helpful to evaluate the current sanitation situation and identify problems of the existing system. The data/information available in the form of reports, articles and official records should be collected by browsing electronic databases or libraries, or directly visiting relevant organizations. Similarly, household surveys can be also carried out to collect primary information about the existing system. Additionally, public awareness, operation cost, willingness to pay fees and the potentiality of re-use of treated fecal sludge should be explored in detail, by the end of this phase.

Figure 3.2 Fecal sludge emptying truck

Case Study: Bahn-Klang, TH

Bahn-Klang Sub-district is situated in northern part of Thailand. It lies in Mueang Lamphoon District under Lamphoon Province. Covering 22 Km^2 / 13,750 Rai. The area is located along the Kuang River bank, where agriculture is the dominant land use. The total population is roughly 48,702, among which, 8,702 are registered residents with 8,493 households. Where as more than 40,000 people are non-registered. The Bahn-Klang Sub-district is further subdivided into 12 villages (Muban). The district comprises industrial estates, departmental stores, hotels, apartments and fresh markets along with the educational and government offices.

Collection of information

A detailed literature review for existing FSM coupled with household survey were carried out to assess the baseline.

Literature review

Technical and institutional arrangements for FSM were obtained by reviewing reports from previous studies conducted in the in municipality. Additional information for institutional arrangements were obtained from Department of Health, Ministry of Public Health, Thailand.

Household Questionnaire Survey

The Household Questionnaire Survey is a multi-purpose continuous survey. It was conducted to collect information on a range of topics, from people living in single households, in Bahn-Klang Sub-district. Summary of the findings are presented in Table 3.1

Table 3.1
Onsite site sanitation systems emptying frequencies for households in the study area

Frequency	Percentage of households (%)
Six months	*23.75*
1 year	*45.25*
2-3 years	*24.25*
> 3 years	*2.25*

Prevalining onsite sanitation and FSM system

I. Toilet facilities

Pour flush was the dominant latrine type, which covers 88 % of total toilets in use. Due to availability and personal preference of the household members, Pour squat facilities constituted 8 % of total toilets in use. While flushing type of latrine covers only 4 %.

II. Existing Onsite sanitaiton facilities

There were mainly four types of treatment facilities observed in the study area, which are described below:

i) Conventional cesspool

It is a pit latrine consisting of three concrete rings, 80 cm in diameter and 40 cm in height. The rings was placed on the top of each other to form a tank. This system has an open bottom and perforated walls to allow liquids to seep into the soil. The retaining solid excreta were digested in an anaerobic condition and were observed to be settled down as sludge. Once the cesspool was full, sludge was removed using a vacuum truck. This was the most widely used treatment facility, accounting for 67.5 % of total households.

ii) Double-pit cesspools in series

This system consists of two tanks, each installed by two concrete rings. The liquid in the first unit was transferred to the second unit. This type of treatment facility accounted for only 7 % of total households in the study area.

iii) Septic tank

A modified water tight cesspool was used as septic tank in the study area. It consists of three concrete rings, 80 cm in diameter and 40 cm in height. The septic tank was made watertight with a concrete-paved bottom chamber. 17.8 % of the households used this treatment facility.

iv) Commercial package unit

A commercial package unit consists of a settling chamber and an anaerobic filter. The human excreta was separated as settable solids, where effluent flows in an upward direction through a pack filter media. The use of a commercial pack unit accounted for only 0.3 % of total households in the study area.

The uses of both conventional cesspool and conventional pack units also existed along side the dominant four facilities, but coverage was only about 0.5%.

III. Fecal sludge production and management practices

i) Fecal sludge production

The average annual fecal sludge production is 36,000 m^3. Out of which 32,400 m^3 came from community area which led to a BOD loading of 28,640 kg/year. The remaining portion i.e. 3,600 m^3 corresponding to BOD loading of 3,180 kg per year came from industrial estate located in northern region of the study area.

ii) Fecal sludge emptying, collection and haulage

Private companies were involved in providing fecal sludge management services, which include emptying, collecting, hauling and disposing. The service fee was fixed and did not exceed 250 Baht/m^3 ($ 8) for the first cubic meter and 150 Baht/m^3 ($ 4.5)for each subsequent cubic meter for the households. The charges were inclusive of the costs for all three phases i.e. emptying, collecting and hauling.

The service fees were fixed at 100-150 Baht ($ 5) for the community zone and 250-280 Baht (~$9) for the industrial zone by the involved stakeholders.

iii) Emptying frequencies of onsite sanitation systems

The average sludge volume was about 2.4 m^3 during each emptying service, whereas the frequencies of emptying vary with the households. The average percentages of households emptying frequencies are shown in Table 3.1.

iv) Prevailing FSM facility providers

In the study area, two private companies were involved in fecal sludge management. Licenses were granted these companies from the municipality. These 2 companies provided service to residents independently under the supervision of Bahn-Klang municipality.

v) Perception of residents towards the existing service

More than half of the residents (56.5 %) were highly satisfied with the existing fecal sludge management service. But nearly 40 % of the residents had variable opinions on the FSM practices prevailing in the municipality, their opinions ranged from good to dissatisfaction.

vi) Fecal sludge treatment and disposal

The major volume of the sludge i.e. 35,040 m^3/year was mostly discharged in the agricultural fields, aquaculture ponds and bare land without treatment. The effect of this disposal on human health and food was not assess in this study but needs to be studied carefully for any future FSM plans adopted for any area. Only 960 m^3/year of fecal sludge was disposed at the pilot scale of Constructed Wetlands units for treatment.

IV. Prevailing rules, regulations and responsible organization for FSM in Bahn-Klang

The regulations relevant to fecal sludge management in Bahn-Klang Sub-district are;

- *Public Health Act B.E. 2535 issued by Ministry of Public Health, Thailand.*
- *The Enhancement and Conservation of the National Environmental Quality Act, B.E.2535 issued by Ministry of Natural Resources and Environment, Thailand.*
- *The Cleanliness and Orderliness of City Act, B.E. 2535 issued by Ministry of Interior, Thailand.*
- *Municipal law of Bahn-Klang Sub-district, B.E. 2539 entitled collection, haulage and disposal for fecal sludge or solid waste.*

To sum up, all these rules and regulations clearly detail the provision of sanitary toilets, specific methods of fecal sludge management etc. The rules and policies have also provided power to local municipality to undertake necessary actions to uphold public interest by properly treating and disposing FS.

Responsible organization for FSM

The local administrative organization or municipality is directly responsible for emptying, collecting, hauling and disposing fecal sludge. The Ministry of Public Health is directly responsible for controlling and supervising fecal sludge management practices.

Department of Health with Regional Health Promotion Center and Provincial Health Office are agencies who follow the legislations from The Ministry of Public Health. The Provincial Health Office directly coordinates with the local administrative organization to enforce the Public Health Act. The Ministry of Natural Resources and Environment provides support to the local administrative organization for investment cost of the fecal sludge treatment system. The local administrative organization has to develop an environmental plan, which includes the fecal sludge management, which is evaluated by the Provincial Natural Resources and Environment Office who then endorse it and pass it over to the Regional Environment Office and Office of Environmental Policy and Planning of Thailand for budget approval.

V) Additional information

Public awareness

About 91% of the Bahn-Klang population were aware of the existing pilot scale of construction wetlands units for treatment of fecal sludge in the area. They were aware that improper fecal sludge management had direct health, economic and environmental effects.

Public participation

The majority (74%) of respondents have never participated in community activities or the planning process for FSM. The reasons stated for not participation were:

- Details about who can attend the activities were not communicated. They also were not aware of the objectives of the activities. This indicates the poor mechanism of information sharing and dissemination.

- Lack of available time to join the activities due to pre-engagment.
- Lack of law enforcement due to lack of enhanced social learning processes on sanitation management.

Similarly, those who have participated (only 21%) did so because of:

- Personal interest
- Duty or an opportunity to gain benefits

Involvement of stakeholders in FSM

Stakeholders were observed to divided into two groups, namely the direct group and the indirect group.

The direct group includes private agencies (local communities, northern region industrial estates and license holding fecal sludge collection companies) and governmental agencies (Bahn-Klang Municipality, Lamphoon Provincial Health Office, and Lamphoon Provincial Natural Resources and Environment Office).

The indirect group includes governmental agencies, namely Lamphoon municipality, Mueang Haa municipality, Ma-Khuor Jaa municipality and Paa Sak Tambol administrative.

Educational institutes includes Asian Institute of Technology (AIT) and Chiang Mai University (CMU) who supervise and provide technical backstopping.

3.3 Phase 3: Developing solution

The problems of the existing fecal sludge management and their causes should be determined by this phase via data analysis from the collected data and information. Problem identification is a crucial step at this phase. Although there are various data analysis tools which are used for identifying the problems. Focus group discussion can be a very effective tool in the field of community development. Focus group discussions are based on the brainstorming technique. It involves all stakeholders and seeks their feedback to find out problems and develop coping strategies/solutions in interactive way.

The key principle of focus group discussion is sharing information as well as critical self-awareness of participants. It also provides platform for cross-checking result with other tools that may have been used for the same. At this stage the community should have an overview of the potential options for improving over the existing management system or developing new fecal sludge system.

Figure 3.3 Wetland for sludge drying

Problem identification method

Focus group discussion: The tool for problem identification

Focus group discussions were used as a tool to identify problems in the existing FSM in Bahn-Klang. All relevant stakeholders participated during the discussion and recognized the main problems. The stakeholders here were community leaders, volunteer group leaders on public health, leaders of the ladies groups, licensed companies for fecal sludge management operation, partners/owners from industry within the northern region industrial estate, partners/owners of hotels / apartments, partners/owners of entertainment and food shops, partners/owners of fresh markets.

Agendas for the focus group discussion

Following agenda items were provided to the focus group;

- Discuss, analyze the problems and potential solutions on the existing situation of FSM.
- Prioritize problems related to the existing FSM.
- Suggest action plans for proposed solutions and strengthening networks for implementing the solutions.

Procedure of the focus group discussion

The following procedure was adopted;

- Explain the overview of the project.
- Explain the objectives of the discussion and expected outcomes.
- Identify the problems, comments, solutions and needs related to the existing situation from stakeholders in each group
- Prioritize problems and needs to obtain priority issue required to deal with.
- Analyze network/cooperation among the stakeholders in FSM and external bodies.

Group formation

Key personnels in the focus group were divided into 5 groups which are:

- Group 1: Volunteers group leaders on public health and leaders of the ladies groups (10 people).
- Group 2: community leaders (5 people), consisting of 4 men and 1 woman.
- Group 3: Partners/owners from industry within the northern region industrial estate and partners/ owners of hotels/apartments (8 persons) consisting of both men and women.
- Group 4: Partners/owners of entertainment, food shops and partners/owners of fresh markets (7 persons) comprising of 4 men and 3 women.
- Group 5: Private companies involves in fecal sludge management (5 persons) comprising 4 men and 1 woman.

In total, there were 35 participants, among which 18 were men and 17 were women.

Identification of major problems

After the discussion, following problems were identified

- Inefficient operation of on-site systems in either households or commercial buildings.
- Poor municipal administration.
- Unavailability of fecal sludge treatment units.
- Lack of public participation.

Solutions proposed by stakeholders

Solutions proposed by stakeholders were categorized into three aspects:

(1) Technology:

Provision of proper on-site systems for individual households or buildings according to local conditions, proper fecal sludge treatment systems and enough number of vacuum trucks in operation.

(2) Institutional arrangement

Allocation of local budget for fecal sludge management

(3) Economic and social:

Provision of monthly compensations to licensed companies by the municipality in order to reduce the service fees, open-bidding on licenses, social learning enhancement by building the monitoring network on fecal sludge management and dissemination of data information on fecal sludge management operation to local people or stakeholders

Factor affecting the existing fecal sludge management

SWOT analysis was applied to interpret

and narrow down information by classifying the factors as external and internal at the municipality. Classified factors are detailed below:

i) Internal factors

- Lack of attention to solve the fecal sludge related problems
- Lack of strategies, action plans, budget allocations and staff for the operation of fecal sludge management activities.
- Lack of data records on fecal sludge management performance including frequencies of emptying, collecting and hauling; and quantities of fecal sludge per day from the emptying service.
- Poor sanitation systems such as (i) Most of the latrine facilities were conventional cesspools, (ii) Most untreated fecal sludge was discharged into agricultural fields and (iii) Sludge treatment systems were not widely available.
- Having the industrial estate in the municipal area caused high fecal sludge generation due to non-registered population.
- Lack of monitoring and evaluation systems for performance of licenced companies dealing with FSM.
- Low level of awareness among the local people due to lack of information disseminations by the local authority on this issue.
- Fewer participation in developing solutions for the existing problems.
- Low satisfaction on the part of the local community towards service fee.

ii) External factor

- Limited contribution from academia or the central governmental authorities regarding knowledge generation and technology transfer for fecal sludge treatment systems.
- Fecal sludge management service fee for emptying, collection, haulage and disposal was limited.
- Lack in characterization for disposal standards for fecal sludge before discharging into nature.

3.4 Phase 4: Implementation of solutions

An overall plan for fecal sludge management should be developed in this phase. The plan must include and specify what is to be done, where it is to be done and how it is to be done. At this final stage, it is important to re-examine the vital issues thoroughly and if every issue is addressed and then the plan can then be implemented.

Monitoring and evaluation of the system should be carried out throughout the life span of the plan or constructed units. It helps to evaluate whether or not the defined objectives are achieved during the implementation of the system. Similarly, the process of monitoring and evaluation helps to keep the system on track. Thus useful amendments can be be made to the system for better performance.

Figure 3.4 Leachate collection

Coping strategies for FSM

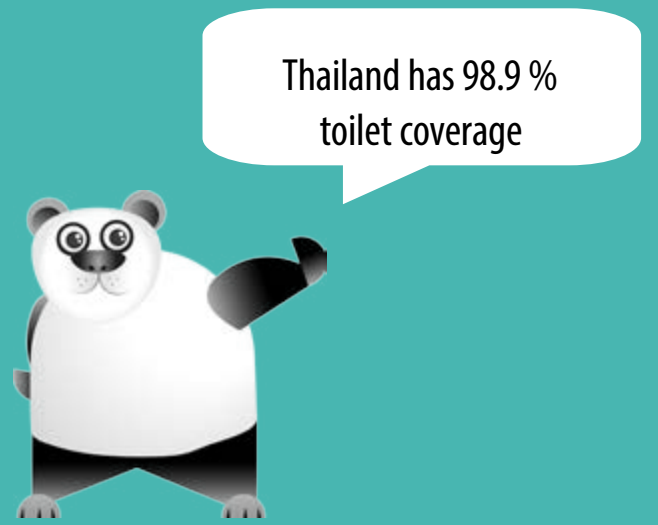
The following four major coping strategies were developed for better fecal sludge management in Bahn-Klang sub district.

Strategy 1: Capacity building for local authorities

Policy	Activities
Develop an administrative system within authorities	1. Place FSM strategies into the local development plan. 2. Establish a central unit of FSM database network among central government authorities, regional authorities, provincial authorities, local authorities, academic authorities and research institutions.
Develop personal capacity on FSM	Develop the Key Performance Indicators (KPIs) of FSM practice into good governance evaluation for local authorities.
Allocate local budget in FSM	1. Provide effective action plans for FSM 2. Set the annual budget of local authorities for FSM. 3. Provide public hearing to operate FSM. 4. Request additional budget from Provincial Natural Resources and Environment Office.
Develop FSM service system	1. Provide the data base on FSM service. 2. Provide a local call centre for FSM service.

Strategy 2: Providing suitable FSM practices

Policy	Activities
Decrease the volume of FS at origin	1. Set standard design of on-site systems to treat FS. 2. Provide the action plan to install on-site systems to treat FS for individual households or buildings.
Systematic operation of emptying, collecting and hauling	1. Provide suitable service on FSM according to the local conditions. 2. Provide an adequate number of vacuum trucks.
Operate effective fecal sludge treatment units	1. Build individual fecal sludge treatment systems with the budget from local authorities. 2. Build clustering fecal sludge treatment systems with the budget from Provincial Administrative Organization or Provincial Natural Resources and Environment Office
Systematize charging of FSM fees	1. Set the criteria to collect the service fee for emptying, collecting and hauling. 2. Set methods and criteria to collect the FS treatment and dispose fee.

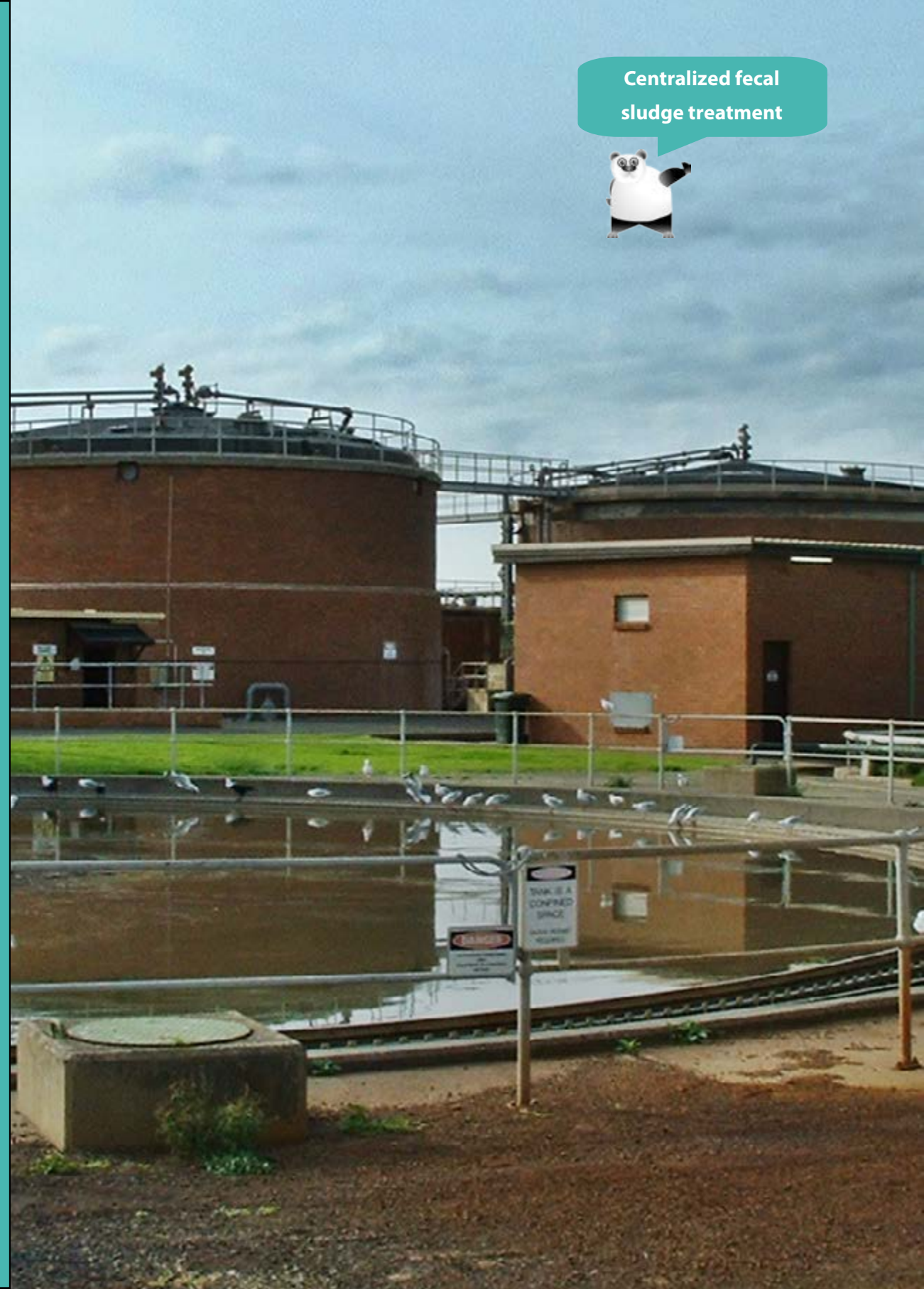


Strategy 3: Enhance social learning process on FSM

Policy	Activities
Build the monitoring network for FSM	1. Establish the monitoring network including local people, academic and research institutes for FSM with personal welfare.
Promote dissemination of the information and news on FSM to increase awareness	1. Disseminate the outputs of FSM practices to local people via multi-media channels. 2. Encourage the FSM stakeholder dialogues every 6 months to hear about the current problems and their solutions.

Strategy 4: Provide the monitoring system on fecal sludge management

Policy	Activities
Develop monitoring systems and evaluate FSM practices of local authorities	1. Establish a team of local authorities to monitor and evaluate the action plan on FSM performance. 2. Establish action plans to monitor and evaluate emptying and collecting of FS. 3. Establish the action plan to monitor, evaluate treatment and disposal of FS.
Provide access to database of FSM for the public	1. Enhance the ways to access database of fecal sludge management such as websites, or monthly or annual reports



Chapter 4
FECAL SLUDGE TREATMENT OPTIONS

Fecal sludge can be treated separately or together with sewage. FS are typically rich in water and pathogen concentrations. Therefore, primary treatment involving stabilization of the sludge, separation of solid and liquid phases should be carried out at the early step in most of FS treatment options. Following the primary treatment, the separated liquid and solid portions must be treated further during post treatment. Many FS treatment systems are available, and among these, each has its own merits, demerits. There is no single technology that fits all and can perform well in every case. Therefore, identification and selection of suitable treatment options by taking into account the local needs and available resources of a particular area is an important process in a long-run, and it can ensure durability of the selected treatment option.

An overview of different treatment options is schematically shown in Figure. 4.2. The brief discussion of major advantages and disadvantage of each treatment options is provided in Table 4.1.

Figure 4.1 Fecal sludge management through wetland application

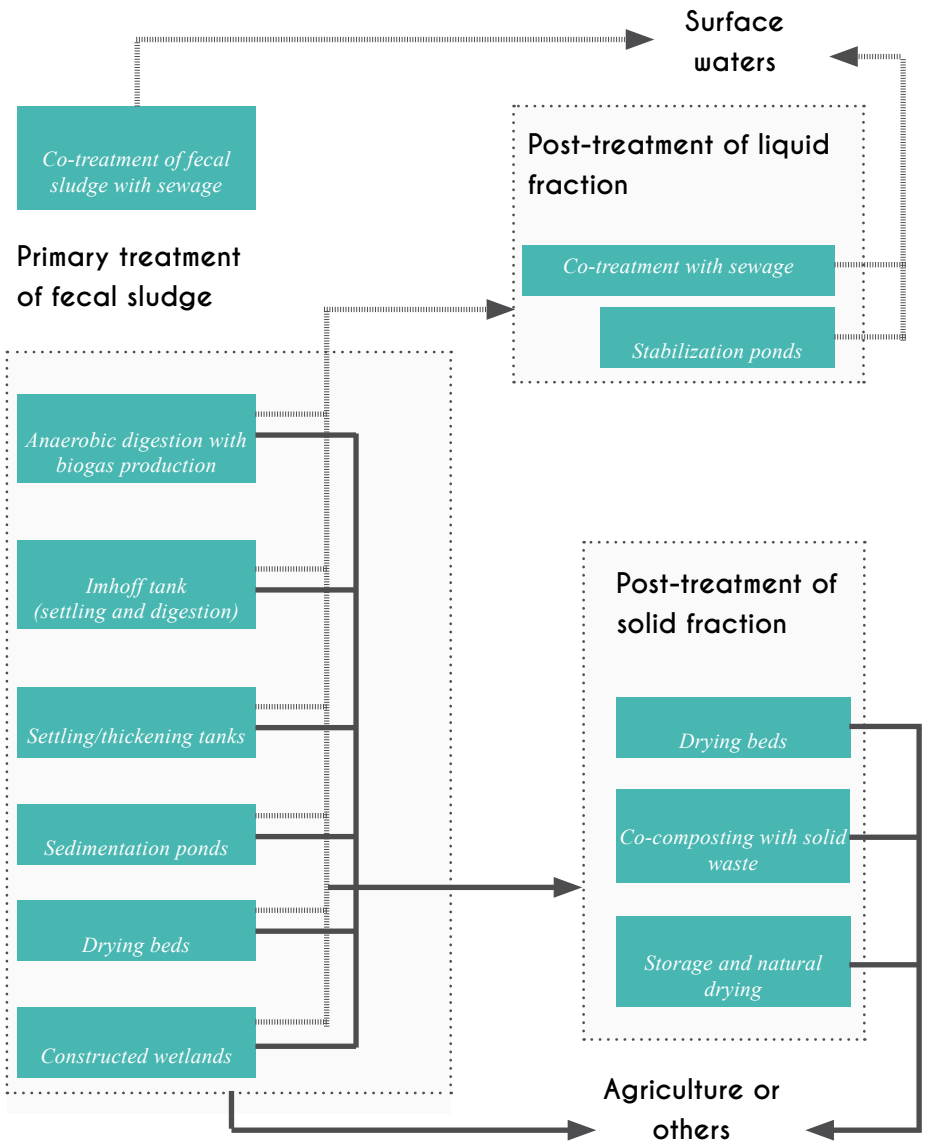


Figure 4.2: An overview of fecal sludge treatment processes and some possible combinations

Table 4.1 Major advantages and disadvantage of various fecal sludgetreatment options

	Treatment options	Description	When to use	Advantage	Disadvantage
1	Co-treatment of raw fecal sludge (FS) with sewage or sewage sludge	Treatment of FS together with sewage. FS is mixed with sewage before treatment or with sewage sludge before sludge treatment	Presence of sewage treatment plant (STP) STP should have enough capacity to receive the additional FS	Economic Treat at once, do not require sludge stabilization and post treatment	Reuse of fecal sludge, as resource will not be possible
Primary treatment of fecal sludge					
2	Anaerobic digestion and biogas production	Fresh sludge that contains biodegradable organic matter is digested anaerobically either alone or mixed with animal dung or vegetable waste Methane gas will be produced and utilized for cooking or lightening	Potential for use of biogas Fresh fecal sludge such as that collected from public toilets is necessary Animal dung or vegetable waste is necessary for mixing	Energy can be generated Fresh sludge can be stabilized Less area is required	Higher cost of installation Additional treatment is required Difficulties in removing settled and thickened solid
3	Settling and digestion (Imhoff tank)	It is developed for pre-treatment of wastewater in small treatment systems. Solids will accumulate on the bottom, be stabilized by digestion and thicken	When conditions are not favorable for biogas digesters and when no space for stabilization ponds is available	Settling and digestion in a single step. Less land is required.	Expensive structure Risk of blocking of sludge draw-off pipe Frequent removal of sludge
4	Settling/thickening tanks	Solid part of sludge will be accumulated at the bottom. The clarified supernatant effluents will be further treated. The accumulated sludge needs to be removed periodically.	Partly stabilized sludge such as that from septic tanks	Simple and reliable process Less area required	Not suitable for fresh sludge
5	Sedimentation/ stabilization ponds	Similar with settling tanks. However, the ponds are larger, and the sediment removal interval is longer	Sufficient land is available Used for fresh sludge	Simple in operation, Less cost of construction Sedimentation and stabilization capacity is better than the settling tanks	Large area is required

6	Drying beds	Consist of a gravel-sand filter, and have a drainage system. Water is removed by percolation	Used for dewatering of partially digested raw or pre-settled FS. Can be used as second stage of dewatering of settled sludge of options 3, 4 and 5	Low moisture content in dried sludge Technology is reliable	Dried sludge will not be completely free of pathogens. It has to be further treated if it is to be reused Not suitable for fresh sludge unless it will not be diluted
7	Constructed wetlands	Consist with a drained gravel and sand filter and marsh plants. The sludge loaded in bed will be dewatered by percolation in the filter and evapotranspiration by plants. The long solids retention period favors further mineralization and pathogen die-off, and allows direct reuse of solids in agriculture	If sludge is planned to reuse	Complete system -the process of dewatering, stabilization and hygienization will be achieved Sludge will be free of pathogen and ready to be reused	Need to care for plant growth
Secondary treatment of liquid fraction					
The liquid and solid obtained after the primary treatment of sludge will not be completely free of pathogens thus requiring further treatment for their safe disposal. Therefore, secondary treatments are required. The options for secondary treatments of the solid and liquids fractions are tabulated below;					
Post treatment of liquid fraction					
1	Co-treatment with sewage	Effluents from primary FS treatment will be mixed and treated together with sewage	Presence of sewage treatment plant (STP) STP should have enough capacity to receive the additional FS	The solids fraction is separated during the primary treatment and can be reused in agriculture	
2	Stabilization ponds	The pond can be anaerobic depending upon the organic load in effluents. The remained part of the sludge in the effluents will be accumulated on its bottom which needs to be removed periodically	Sufficient land is available	It is simple, well known and reliable	Require large area The release of NH_3/NH_4 in presence of fresh FS may hinder well function of ponds

Post treatment of solid fraction					
1.	Drying beds	Consist of a gravel-sand filter, and have a drainage system. Water is removed by percolation (Note: it can be used as primary treatment of sludge or as post treatment of solid waste)	Used as second stage of dewatering of settled sludge of options 3, 4 and 5 (primary treatment)	Low moisture content in dried sludge Technology is reliable	
2	Co-composting with solid waste	Pre-treated FS is composed together with organic solid waste	When compost is desired and is to be utilized Sufficient amount of qualitative solid wastes are available	Offer soil conditioner Utilizes of both sludge and solid waste	Contaminants of solid waste deteriorate quality of compost
3	Storage and natural drying	Storage over at least 6 months allows natural pathogen die-off in dewatered sludge from settling facilities or drying beds. Further drying of sludge contributes to pathogen die-off and increases the safety of the method	When fecal sludge is to be reused in agriculture but the methods of co-composting or constructed wetlands are not favored	Method is cheap and simple	Large area is necessary

Figure 4.3 Circular sedimentation tank

Figure 4.4 Sludge sedimentation tank

4.2 Examples of commonly used treatment system

1. Constructed wetlands

Constructed wetlands are a natural, low-cost, eco- technological biological wastewater treatment technology, which are designed to replicate the processes found in natural wetland ecosystems. The shape of constructed wetlands may vary based on design. However, it is a shallow basin filled with some sort of filter material known as substrates, which is generally sand or gravel.

A constructed wetland typically comprises following components: a basin, substrates, vegetation, liner and inlet/outlet arrangement system. During treatment, the waste water/fecal sludge are fed into the basin filled with substrates and planted with vegetation. The waste water flows over or through the substrate depending upon the type of constructed wetlands. During the movement of waste water, it will be subjected to physical, chemical, as well as microbial interactions, where it will be treated. The treated effluent is discharged through the outlets (UN- Habitat 2008).

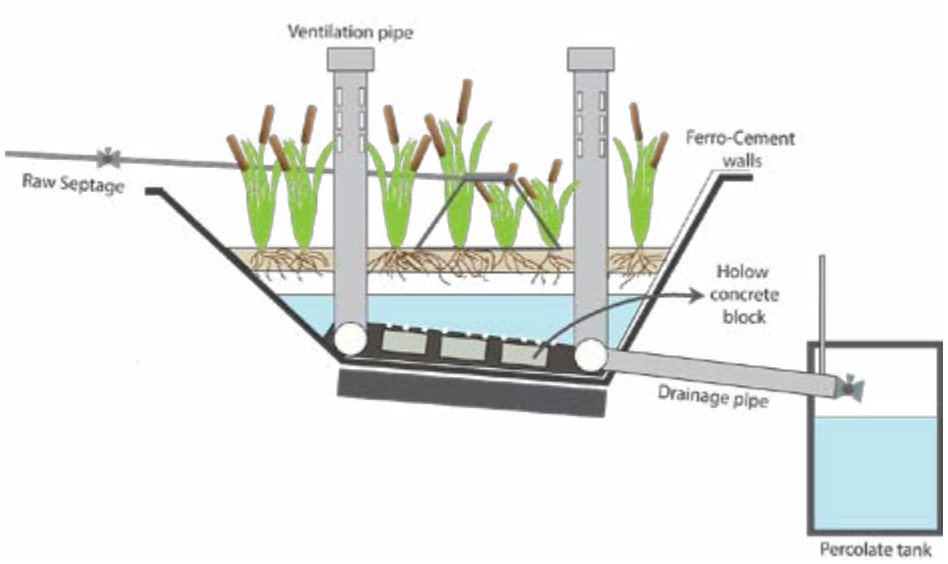


Figure 4.5 Schematics of a constructed wetland

At the early stages of operation, attention is required mainly on the growth of planted vegetation on constructed wetlands. The contamination level and organic load will be much higher in fecal sludge and needs to be acclimatized slowly. Therefore, a proper and complete process needs to be carefully followed during the startup of constructed wetlands for fecal sludge treatment (Ecological treatment system, AIT).

The optimum loading rate is considered as 250 kg total solids (TS) per m^2 year, and resulting sludge accumulation is about 20 cm per year. Constructed wetlands are being used in waste water/fecal sludge treatment in several countries. Wetlands are being used in Bahn-Klang Sub-district (site of the case study described in earlier sections) and many others places of Thailand.

2. Sedimentation/thickening Tanks

This method consists of series of ponds and involves the separation of solid and liquid from fecal sludge at the primary phase. The supernatant effluents

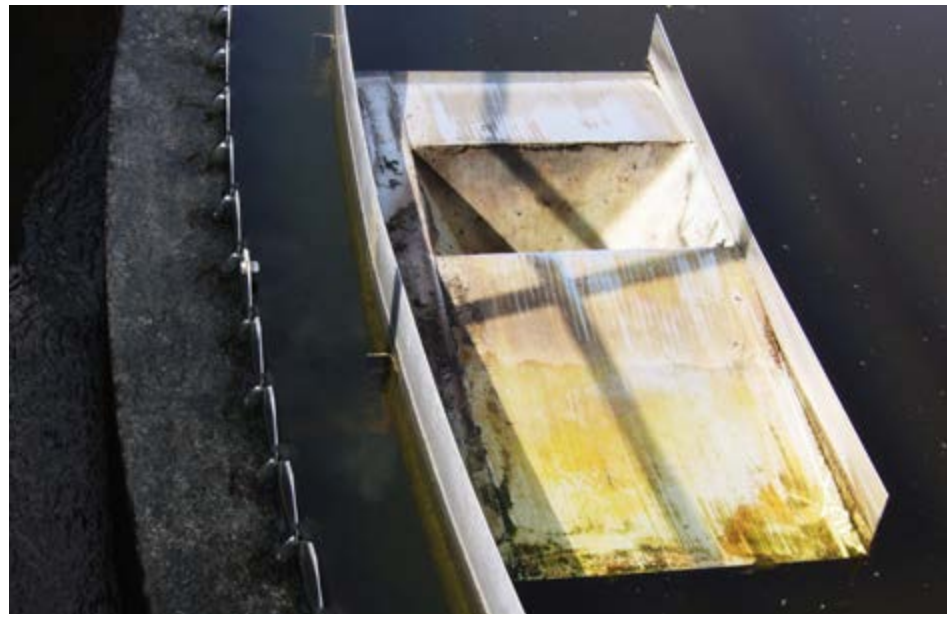


Figure 4.6 Sedimentation tank

move to the adjoining ponds where it gets further separated, and more clarified effluent passes into the subsequent ponds. The accumulated sludge will be removed periodically. The field study of the method was carried out from 1993-1997 in Accra, Ghana, and the set up was designed for 150 m^3 fecal sludge per day and the method was successful for fecal sludge treatment.

Drying beds consist of a gravel-sand filter and contain a drainage system. A drying bed separates solids from liquids by the process of drainage and evaporation. The separated solid get deposited in the bed. Two types of drying beds, namely unplanted and planted, are commonly used. The sludge obtained from drying beds is not free of pathogens especially helminthes eggs. However, it can be used either as a soil conditioner or fertilizer in agriculture under proper design and operation (such as extending the drying period in beds or a few days of storage in open land areas)

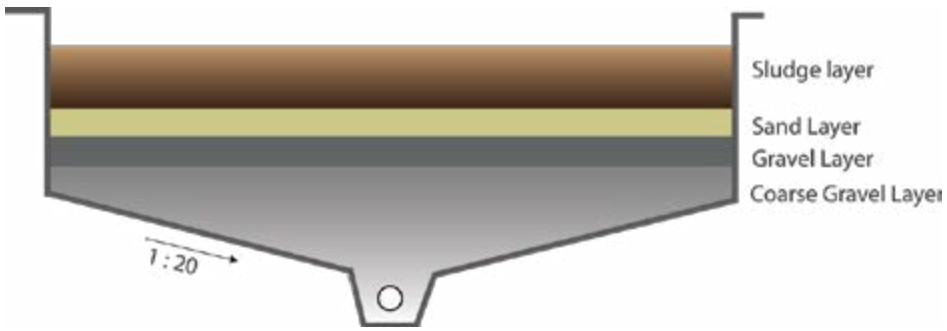


Figure 4.7: Unplanted drying beds

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