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ON-SITE MANAGEMENT FOR DOMESTIC WASTEWATER IN THAILAND

1. Introduction

Water pollution is a major environmental concern and greatly affects the health and livelihoods of the public. The water quality of Thailand's rivers varies from low to extremely low, especially for major rivers such as the Chao Phraya River, Tha Chin River and Mae Klong River. One of the main reasons for this deterioration is the unmanaged discharge of untreated domestic wastewater effluent flowing directly into water resources. Moreover, increases in population and economic development have led to expansion of activities at the community level, such as residential communities, tourism, trade and services, which can all exacerbate water pollution.

In the past, domestic wastewater management was focused on the construction of community-based combined wastewater treatment systems, mainly as centralized wastewater treatment systems. However, present governmental policy promotes the construction of cluster wastewater treatment systems owing to their lower construction cost and ease of management. On-site sanitation was viewed as an informal and temporary infrastructure. As a result, on-site sanitation facilities such as septic tanks have become major sources of surface water and groundwater pollution, and have significant impacts on the environment, public health and economy.

To better understand the status of on-site treatment technology and management in Thailand, an assessment of on-site management of domestic wastewater was conducted. The aims of this paper are to identify the state of on-site treatment facilities and lessons learnt from on-site management of domestic wastewater in Thailand.

2. Overview of on-site treatment facilities

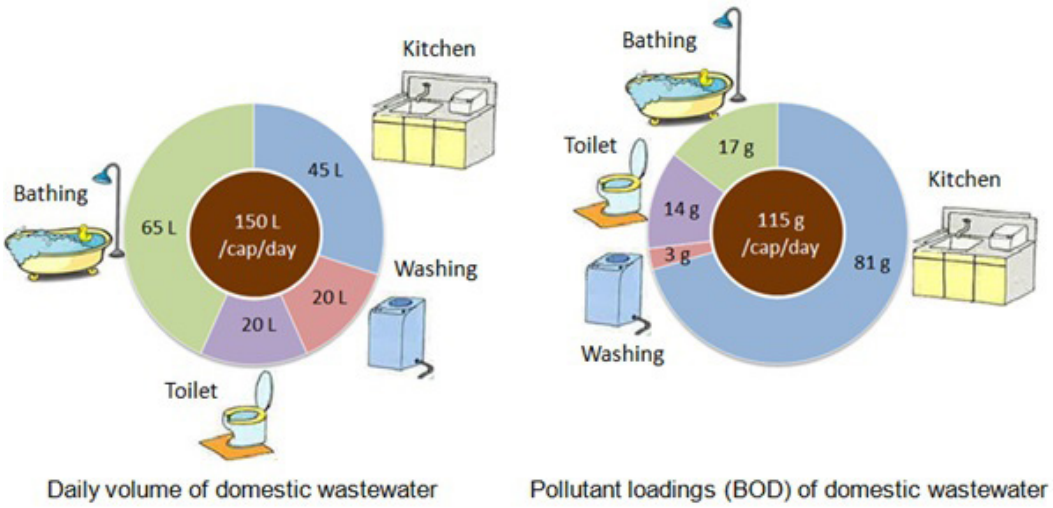
In Thailand, approximately 10 million m^3/day of wastewater is generated by the population. There are 100 wastewater treatment plants with a combined treatment capacity about 2.7 million m^3/day, equivalent to about 27% of total wastewater generated (Wilasinee Sastaywin from Pollution Control Department (PCD), personal communication, March 29, 2013). For Bangkok city, approximately 2.6 million m^3/day of wastewater is generated against a treatment capacity of about 1 million m^3/day, equivalent to about 40% of total wastewater generated (Faculty of Architecture, Chulalongkorn University, 2010). There are three major domestic wastewater treatment systems in Thailand, which can be classified into centralized, cluster and on-site treatment systems.

On-site treatment facilities, including septic tanks, are conventionally used even in wastewater treatment plant service areas, and constitute the basic means of sanitation for each household, as regulated by the Building Control Act, B.E. 2522. The combination of an on-site treatment facility and wastewater treatment plant is considered to be the typical form of domestic wastewater treatment in Thailand (Tsuzuki et al., 2009).

On-site sanitation systems offer sanitation at the source of human excreta generation, such as septic tanks and cesspools with soaking pits. Most households in Bangkok city are equipped with septic tanks, from which liquid waste can seep into the soil, groundwater or surface water. Septage has to be regularly removed by vacuum trucks (Department of Environment, 2010).

Table 1 shows the characteristics of wastewater from four main sources within the house: kitchen, washing, toilet, and bathing. BOD loadings were calculated based on the wastewater volume data from the Manual of Wastewater Management for Household (PCD, 2012) multiplied by BOD concentration from A Study of the Domestic Wastewater and Water Pollution Problem in the Bangkok Metropolitan Region (Pansawat and Office of National Environment Board, 1987). Daily volume and pollutant loading are presented in figure 1. Black water is discharged at 20 L/cap/day from 150 L/cap/day of wastewater from households. The highest BOD loading comes from the kitchen as grey water at 81 g/cap/day from 115 g/cap/day. This means that the portion of BOD loading from grey water (87.8 %) is much higher than that from black water. Therefore, both grey water and black water need to be simultaneously considered for management.

Figure 1



Daily volume and pollutant loadings of domestic wastewater

Table 1

Wastewater source	Volume [1] (L/cap/day)	BOD concentration [2] (mg/L)	BOD loading (g/cap/day)
Kitchen	45	1800	81
Washing	20	150	3
Toilet	20	700	14
Bathing	65	260	17
Total	150	-	115

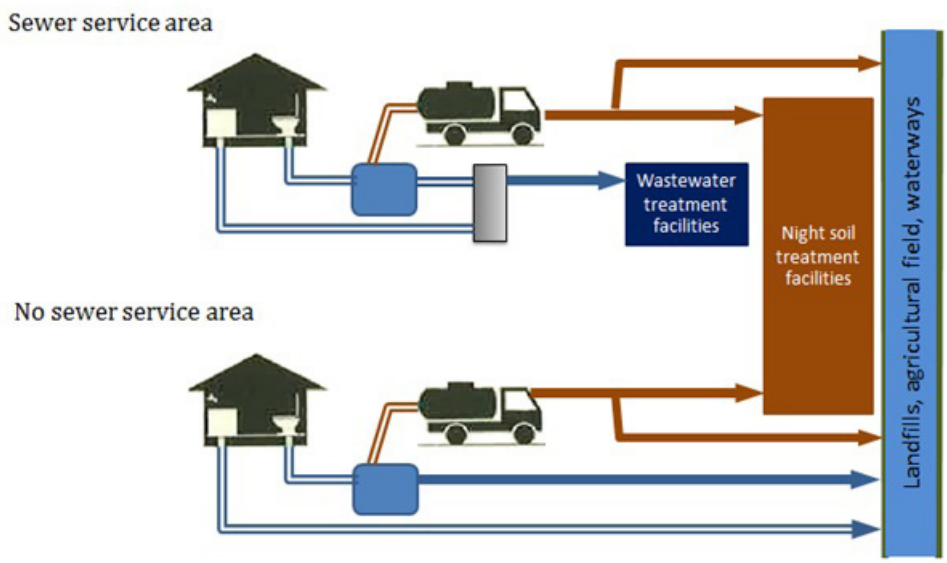
Characteristics of wastewater from households

Sources: (1) PCD, 2012
(2) Pansawat and Office of National Environment Board, 1987

2.1 Coverage of on-site treatment facilities in Thailand

Improved sanitation facility distributes to 98% of household population and be stable continuously (Bureau of Environmental Health, 2012). In most cases, however, black water enters the septic tank and liquid effluent flows into sewer lines or canals; grey water enters the sewer lines or canals directly. The use of septic tanks is ubiquitous throughout the country, even in areas served by wastewater treatment plants. As shown in figure 2, in the sewer service area, centralized and cluster wastewater treatment plants collect grey water and black water through sewer lines. In the case of households not covered by the sewer service area, grey water is directly discharged into soil and waterways. Septic tanks are installed in households to collect only black water. Septage is collected by vacuum trucks and taken to septage treatment facilities or disposed of in the environment. Trucks need to be requested to collect septage. AECOM and Eawag (2010) estimated that approximately 70% of collected septage is disposed of in the environment.

Figure 2

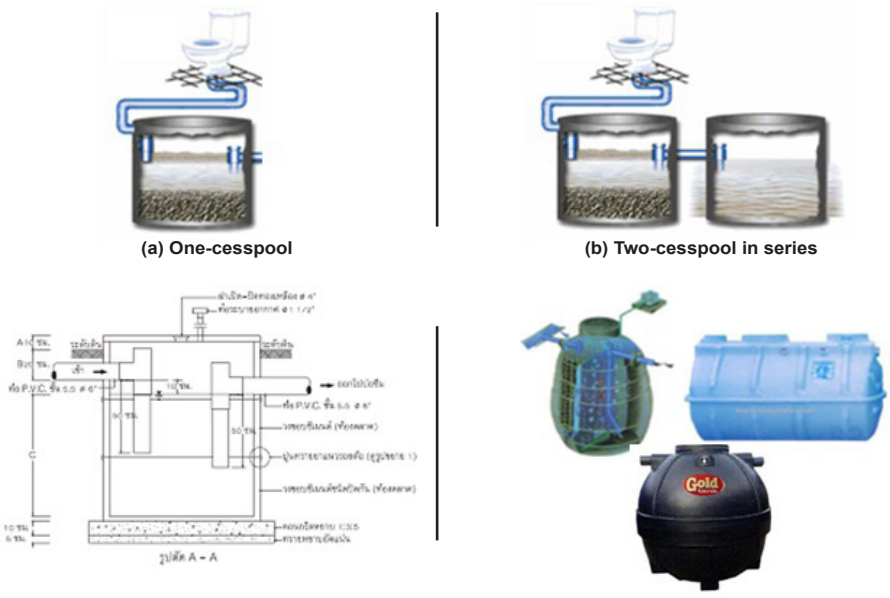


Major wastewater treatment systems in Thailand

In Thailand, on-site treatment facilities can be classified into four types: (a) one cesspool, (b) two-cesspool in series, (c) concrete septic tank and (d) commercial septic tank (Koottatep et al., 2012), as shown in figure 3. Actually, however, systems (a)–(c) cannot be called 'proper' septic tanks since they have open bottoms, which can lead to groundwater contamination in urban areas due to the concentration of on-site facilities. In Bangkok city, soakage pits often do not function as intended because the soil consists of low-permeability clay and the groundwater table is high, which raises the potenti a l for groundwater contamination and septic tank overflows.

Historically, cesspool systems were constructed using brick walls and modified to the 'concrete ring' type later on. Therefore, if it is properly sealed and an outlet pipe for supernatant is added thereto, this configuration can correctly be called a septic tank. In Thailand, the concrete ring type is popular, but so are the more modern commercialized types which feature a closed system, longer periods before sludge emptying, environmental protection, and lightweight polyethylene bodies. Although they are more costly than traditional septic tank systems, they are easier to install. Further, they can now be made domestically, and at lower cost than previously. Many competing products and brands of tank are available on the market (Koottatep et al., 2012).

Figure 3



(a) One-cesspool

(b) Two-cesspool in series

(c) Concrete septic tank

(d) Commercial septic tank

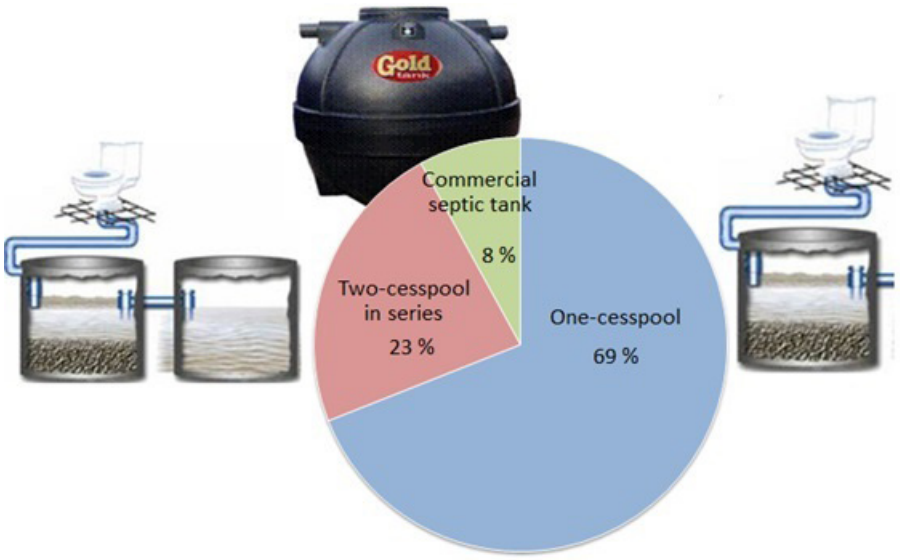
On-site treatment facilities

Sources: Waterindex, 2007; PCD, 2004; Pornvaree, 2012

Dulyakasem, et al. (2013) conducted questionnaires and interviews of 171 households covering on-site treatment facilities in three municipalities defined as urban poor areas: Bangbuatong, Pakkret and Saima municipality in Nonthaburi province, Thailand. The study found that three types of on-site treatment facility are used: one cesspool system (69%), two-cesspool system (23%) (both used concrete rings) and commercial septic tank (8%) made of polyethylene, as shown in figure 4.

Most households in rural and urban poor areas used a cesspool as their on-site treatment facility. In contrast, newly developed areas such as housing estates and new houses in Bangkok use commercial septic tanks due to their wide availability and competitive market price.

Figure 4



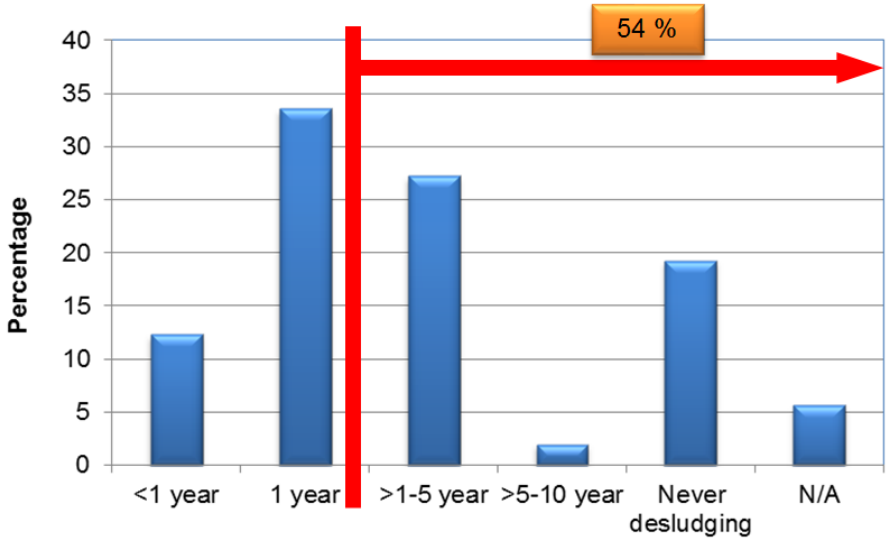
Percentage of on-site treatment facilities in urban poor areas of Nonthaburi province
(Adapted from Dulyakasem, et al., 2013)

2.2 Operation and monitoring

Owners or occupiers of each building are obligated to manage their wastewater treatment systems or rely on private companies for such management. The maintenance systems differ according to the type and scale of on-site treatment required.

According to the Public Health Act, B.E. 2546, responsibility for septage management at on-site sanitation facilities is assigned to Local Government Organizations (LGOs), who have adopted local regulations requiring septage to be properly collected and treated before disposal. However, the regulations do not require on-site treatment facilities to undergo regular maintenance. Households usually desludge only when problems arise. For example, in Nakhon Lampang municipality, septage collection is handled by the private sector under control of the municipality and the truck service is requested directly from households when needed. In Nonthaburi municipality, the process of requesting septage collection is handled by the office of Public Health and Environment and an official request form must be submitted (Koottatep et al., 2012). In Bangkok city, the Bangkok Metropolitan Authority (BMA) provides septage services through the Department of Environment's Solid Waste, Hazardous Waste and Night Soil Division. This division provides septage collection in each of the city's 50 districts, and residents call local BMA offices to request desludging. The BMA also owns two septage treatment plants, one of which operates under a private concession, and both use activated sludge technology. Together, these two plants can treat 1,200 m^3 of septage per day.

Figure 5



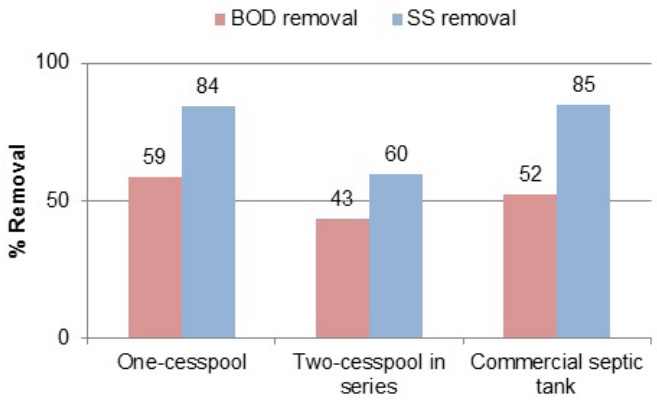
Desludging period of septage at on-site treatment facility

As shown in figure 5, our research team surveys of water supply, wastewater discharge and septage collection from 301 households in 50 districts of Bangkok city in 2013 reveals that the most common (34%) period over which septage is accumulated at on-site treatment facilities is one year; next longest was 1–5 years (27%). On-site treatment facilities are not regulated and not required to be regularly maintained, and only when they are full, the septage trucks is called to empty them. Further, tissue paper and sanitary napkins often clog-up septic tanks, which affects the desludging period. In the case of 'Never desludging', household interviewees described that black water had deeply penetrated into the surrounding soil. However, some household owners desludge by themselves and use the septage as fertilizer or permanently seal full septic tanks and then purchase an additional one. Further, the number households practised desludging within one year was less than half of the total (46%).

Monitoring of system implementation is the responsibility of the owner or occupier of each building to ensure that the system is effective and can treat wastewater according to the effluent standards. Monitoring by the government sector for legal enforcement is carried out by pollution control officers that have roles and responsibilities prescribed by the Enhancement and Conservation of National Environmental Quality Act, B.E. 2535. However, to date the control of effluent quality has focused only on building types A and B. General and small households are not yet controlled in terms of treatment operation and effluent quality.

Figure 6 provides graphic representation of results from a study carried out by Dulyakasem, et al. (2013) on the quality of influent and effluent at on-site treatment facilities. The study collected samples from 60 households at two sampling points, the wastewater inlet (influent) and wastewater outlet, using supernatant under the scum layer (effluent). The BOD removal efficiencies of one cesspool, two-cesspool in series and commercial package septic tanks do not differ significantly, and range between 43 and 59 %. The average concentration of BOD in effluent of all types ranged from 849 to 1436 mg/L, suggesting that the need for proper domestic wastewater management is urgent in Thailand since the maximum permitted values of BOD in effluent for building Types A, B, C, D and E are 20, 30, 40, 50 and 200, respectively.

Figure 6

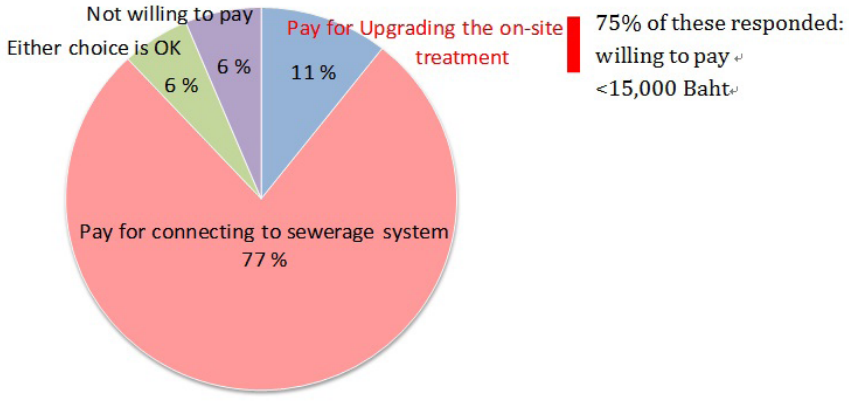


Wastewater quality of on-site treatment facilities
(Adapted from Dulyakasem, et al., 2013)

Then, based on the results of our 2013 survey that we conducted interviews with the respondents to ask under the assumption that if they were to be regulated and controlled for discharging domestic wastewater to the environment according to the effluent standards, what choice they opt for: either "sewerage connection" or "individual upgraded on-site treatment tank". In the case of "installation of individual upgraded on-site treatment tank", they would have to provide the installation cost and cost for septage collection. For "sewerage connection", they would have to pay a monthly wastewater collection and treatment fee.

Figure 7 presents the surveys result that 77% of household interviewees (250 persons) chose the option of having a sewerage system (factors such as suitability for rented accommodation, knowledge of technology, construction feasibility and convenience in paying fees such as monthly solid waste collection fees were also taken into account). The option of "Individual upgraded on-site treatment tank" was chosen by 11% of household interviewees (49 persons). It is believed that the preferred option of upgraded on-site treatment, despite being more costly in general than a sewerage system, was chosen by household interviewees due less to concern over financial issues and more to concern over environmental issues. The 49 household interviewees who choose upgraded on-site treatment were asked to state their maximum budget for self-funded construction. Less than 15,000 Baht is shown as the main answer at 75% of household interviewees. In comparison with the upgraded on-site treatment package using the aerobic treatment system, more than 30,000 Baht is required (Premier products, 2011). Therefore if the government wants to promote the on-site wastewater treatment concept in any desired area, a subsidy programme for upgraded on-site treatment installations must be considered. The "best practise" for on-site treatment for domestic wastewater is the Johkasou system in Japan. With the introduction of subsidy programmes, small-scale Johkasou spread rapidly in suburban areas and rural areas unsuitable for constructing sewerage systems. As a result, small-scale Johkasou became feasible as a countermeasure against various kinds of water pollution due to domestic wastewater and led to a vast improvement in the water environment and water recycling in Japan (Ministry of the Environment of Japan, 2011).

Figure 7

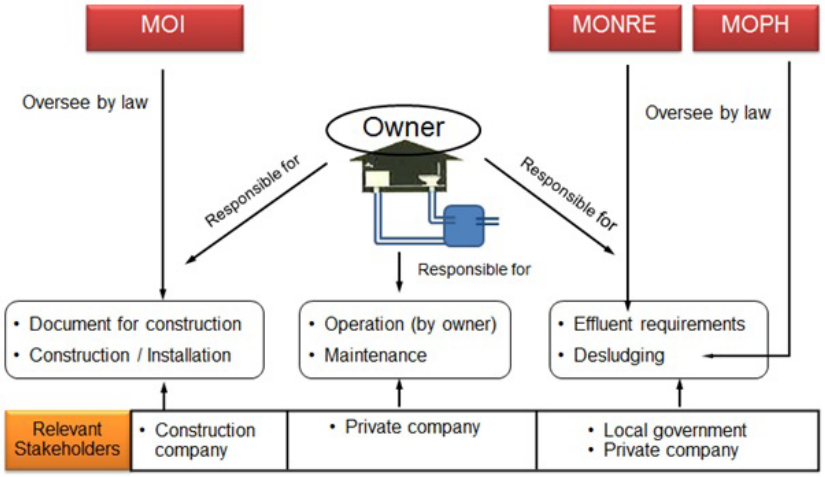


Willingness to pay

3. Issues and lessons concerning on-site treatment management

There are three ministries related to laws and regulations for on-site treatment facilities, as shown in figure 8: (1) Ministry of Interior (MOI); (2) Ministry of Natural Resources and Environment (MONRE); (3) Ministry of Public health (MOPH). It is the key responsibility of household owners to document all construction, installation, operation, maintenance and desludging for on-site treatment. Relevant stakeholders include companies for construction and installation of septic tanks. Private companies are utilised for any repairs. Local government organizations and private companies are both involved in desludging; however, it was found that on-site systems for wastewater treatment are only controlled by the government at the start of construction and at the end of desludging, but the entire operation and maintenance period in between lacks any form of control. Concurrently, and more importantly, Thailand has no laws or standards covering the manufacture of septic tanks, operation, maintenance and annual water quality examinations, which are key factors in maintaining appropriate functionality in on-site management.

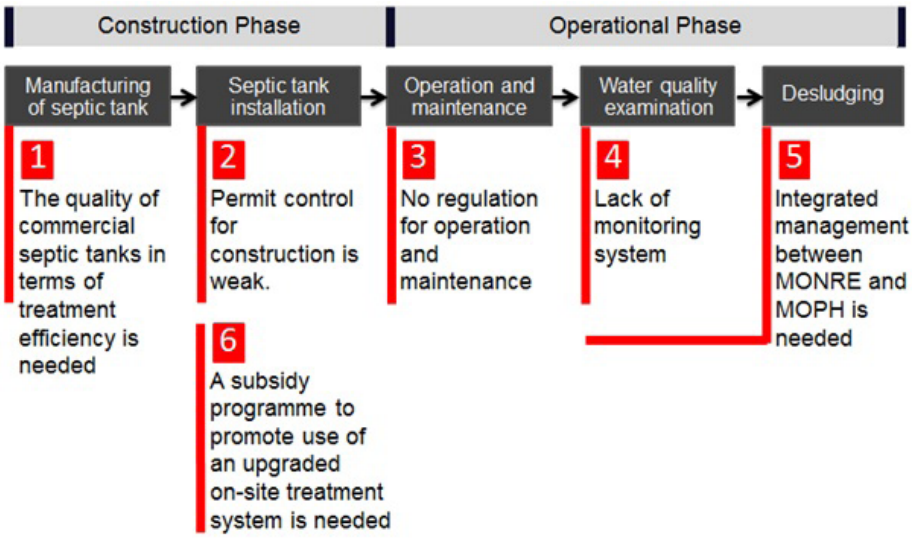
Figure 8



Stakeholders and their responsibilities

Figure 9 summarises the key issues for management and institutional aspects of on-site management for domestic wastewater according to the construction and operational phase, which is comprised of five major steps: manufacture of septic tank, installation of septic tank, operation and maintenance, water quality examination and desludging.

Figure 9



Key issues for management and institutional aspect of on-site management for domestic wastewater

3.1 Issues and Lessons in Construction Phase

Standard of products for commercial septic tanks

Commercial septic tanks are increasingly being used in households of Thailand, especially in Bangkok city. To date, standards for commercial septic tanks are only focused on the strength of materials used, such as Thai Industrial standard TIS 816-2538, which covers the standard of polyethylene material. Therefore, a system to verify the quality of commercial septic tanks in terms of treatment efficiency is needed. Further, a system of support or encouragement for industry to produce products meeting the standards is required.

Permit control for construction

The MOI requires house owners to submit drawings of on-site treatment installations for approval before construction of the building; however, inspections during and after installation are less controlled. In addition, control over construction permits is weak, which results in incorrectly made septic tanks that are also difficult or impossible to access for maintenance thereafter. The guideline of PCD-MONRE recommends treating both black water and grey water using an on-site treatment system. However, in reality only black water is treated. Therefore grey water management is the key issue for improving the state of the water environment.

Subsidy programme for upgraded on-site treatment system

To resolve the water environmental problem in Thailand, wastewater control at the source should be promoted, for which an upgraded on-site treatment system would be a practical option. However, a subsidy programme to promote use of an upgraded on-site treatment system is needed as the cost of the upgraded one is higher than the willingness or ability to pay of house owners.

3.2 Issues and Lessons in Operational Phase

Regulation of operation and maintenance

The widespread use of septic tank installations falling short of standards increases problems during operations and maintenance access. It is thus a critical issue to provide regulations that cover the operational and maintenance phase. The development and installation of advanced technology will be much more meaningful if the systems can be controlled and managed during the operational and maintenance phase.

Water quality monitoring and examination system

An effluent standard for buildings and households was created and adopted, which ensures water quality monitoring and examination of water environments such as surface water and groundwater are performed regularly. However, there is no system to monitor and analyse the effluent of septic tanks. To ensure the efficiency of treatment during operation, water quality monitoring and examination are required.

Integrated management between relevant organizations

The management of water, wastewater and septage by different organizations such as MONRE, MOPH, MOI and other regulatory organizations creates difficulties for coordinated management. Lack of communication between sectors even in the same ministry creates gaps of knowledge and information, slowing progress. Therefore, integrated management strategies free of institutional boundaries should be concerned systematically.

4. Recommendations

The overall key issues and recommendations based on the study a re as follows:

- Under current circumstances, only black water is treated by concrete or commercial septic tanks. However, BOD loading from grey water is much higher than that from black water. Grey water management is the key issue for improving the state of the water environment.

- A subsidy programme for upgraded on-site treatment installations must be considered. Introducing a subsidy programme would greatly accelerate uptake of on-site treatment systems in suburban areas and rural areas unsuitable for constructing sewerage systems.

- Laws and regulations specific to on-site treatment systems (septic tanks) are needed and should cover the whole scope of processes: manufacture, registration and approval, construction, installation, operation and maintenance, water quality examination and desludging.

- The management of water, wastewater and septage by different organizations including MONRE, MOPH, MOI and other regulatory organizations obstructs integrated management. Therefore integrated management strategies less constrained by institutional structure should be implemented systematically.

- Maintenance to ensure correctly functioning systems in on-site treatment is of key importance. Treatment systems exist but the operation and maintenance are weak. Public-private partnership for system management is a potential option. A training and capacity-building programme for staff and residents should be conducted.

- Knowledge transfer and activities to create public awareness for residents should be implemented. Initially, the public needs to be made aware of the present state of water pollution and improvement measures. Thereafter, any implemented options regarding either upgraded on-site treatment or sewerage service charges can be expedited more smoothly.

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