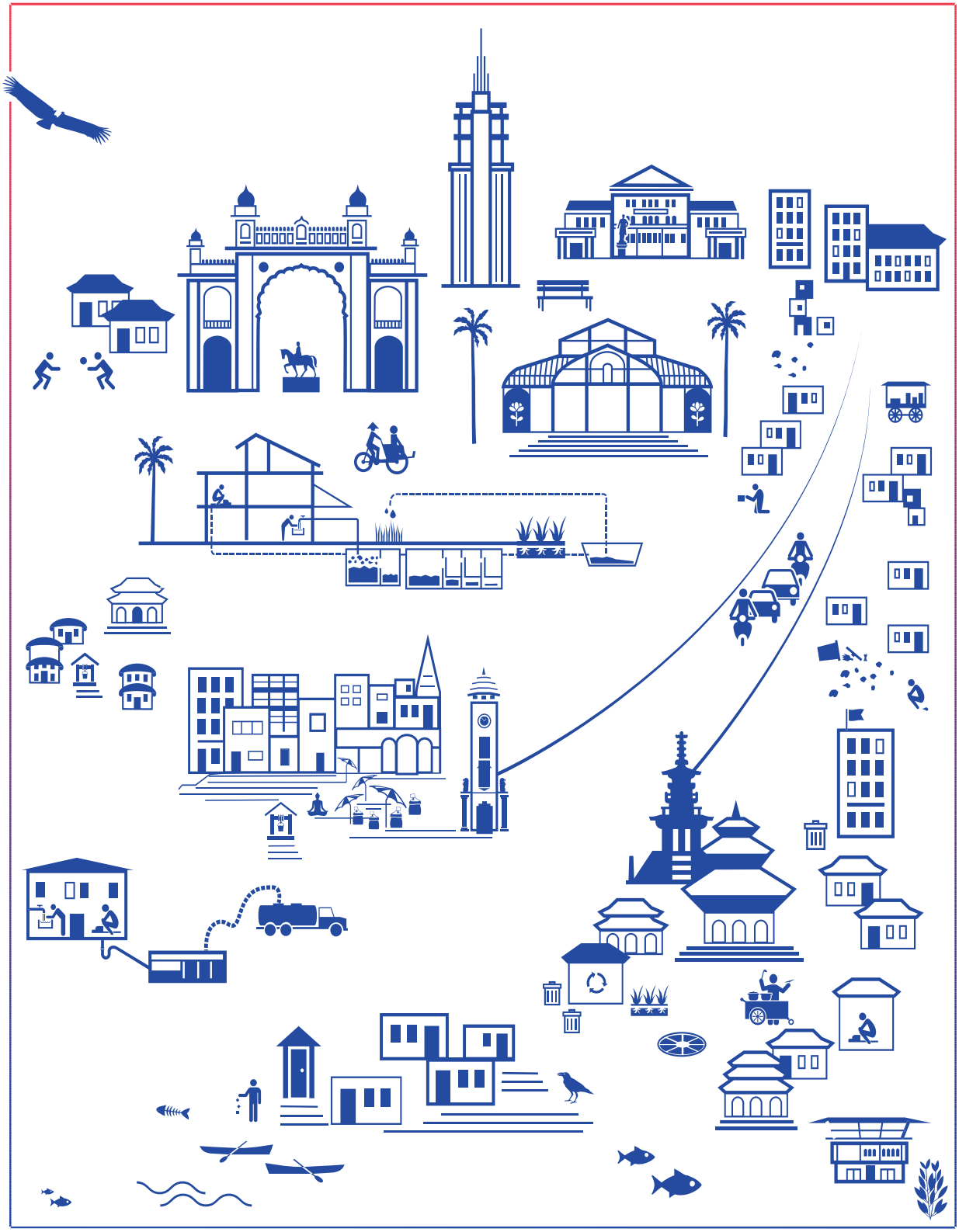
BORDA

Sustainable Protection of Water Resources in Southeast Asia

Improvement of Decentralized Wastewater Treatment Plants



Sustainable Protection of Water Resources in Southeast Asia
- Improvement of Decentralized Wastewater Treatment Plants -

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1 Introduction

1.1 Brief Introduction

Despite rapid economic growth and development in Asian developing countries, the population lives under poor condition and is not connected to central public supply related to sanitation such as clean water supply, waste management, wastewater management, and safe faecal sludge management. Mostly population discharge untreated wastewater and faecal sludge to the environment. Besides, the government often faces inefficiency such as the operation of inadequate centralized wastewater treatment plants. Those issues create negative externalities as pollution of surface and groundwater, and affect the quality of life unavoidably. As a result, Decentralized Wastewater Treatment (DEWAT), which can maintain lower-cost technology in terms of operation and maintenance than the centralized wastewater treatment, has been widely encouraged in the development of innovative technology, and in increasing the quantity of production. DEWAT should be preferably installed at single households or small communities.

Presently in Thailand, septic tanks are designed according to owners theory and hypothesis, and there may be technical staff for maintenance in certain periods.

It is a fact that there are too few testing institutions and standards for material test and treatment performance of prefabricated septic tank in the completely ASIAN region. By now manufacturers can only get the results in durability and organic matter reduction of septic tanks. Also, septic tanks are not covered in the scope in terms of production quality and application in many countries. Hence, it is necessary to verify treatment performance that both users and manufacturers can benefit according to quality production and an increasing level of quality and performance. Therefore developing and improving standards in future is fundamental.

The future standard protocol in Thailandfor treatment performance considers prefabricated septic tanks and DEWAT, which will implement guidelines for verification based on related documents, particularly design, material testing and treatment performance from both domestic and international accredited institutions. In addition, the standard protocol should be an accepted and ratified document to all parties. Testing results shall assure that prefabricated treatment systems can be used appropriately by homeowners.

The collaboration between Asian Institute of Technology (AIT) and Bremen Overseas Research and Development Association (BORDA) aims to establish a testing centre capable of valuating performance and material of on-site sanitation systems and to establish a

demonstration and training centre for capacity development purposes as well as show case well performing on-site sanitation to the public.
The collaboration of AIT BORDA involves PIA-Prüfinstitut für Abwassertechnik GmbH, which is dedicated to providing technical assistance for establishing the testing centre. PIA is located in Aachen, Germany, it operates a facility capable of testing the performance of wastewater treatment plants and materials.

1.2 Project partner

AIT
Asian Institute of Technology (AIT) in Thailand is a leading regional postgraduate university institution. After its establishment in 1959, the postgraduate study program on Sanitary Engineering was introduced in 1964. The faculty has been internationally recognized as a pioneer institution for the development of sanitary and environmental engineering professionals in the region. Wastewater treatment and management are one of the priority research areas of the present academic program namely Environmental Engineering and Management (EEM). During the last 5 decades, EEM has gained immense experience and expertise in research and development of wastewater treatment technologies and management practices. Beyond the experimentation in the lab, EEM-researchers have extensive experience in the field applications of new-developed DEWATs technologies to solve the sanitation problems at the point of origin. AIT has been working with several regional and international organizations.

BORDA
Bremen Overseas Research and Development Association e.V. (BORDA) is a not-for-profit organization with relevant experience, competence and capacity in promoting policy that enables a system-based approach for the implementation of DEWATs service packages. During the last 8 years, the BORDA partner network facilitated thousands of DEWATS implementations in Southeast Asia, most of them in Indonesia but also in Vietnam, Cambodia, Lao and the Philippines. The BORDA SEA program dedicates its work and resources 100% for the dissemination of DEWATs in Southeast Asia. It avails a network of longstanding governmental and non-governmental partnerships in each country of the region working on the topic of DEWATs dissemination.

PIA
In early 1999, the Development and Assessment Institute in Waste Water Technology **(**Prüf- und Entwicklungsinstitut für Abwassertechnik an der RWTH Aachen e.V.**)** was founded as a not-for-profit organization. Since October of the same year, PIA has been accredited as an affiliated institute of the Faculty of Civil Engineering at RWTH Aachen University.
The goal of the organization is to promote research and training in the fields of wastewater technology and environmental protection. The Ministry of Environment and Conservation, Agriculture and Consumer Protection of the State of North Rhine-Westphalia significantly sponsored the setup of infrastructure at PIA.

2 Status Quo

2.1 Brief Description on Domestic Wastewater Management Practices in Thailand

Domestic wastewater consists of grey water and black water. Greywater is wastewater from washing activities and produced from facilities such as kitchen, laundry, and bathroom. Blackwater is generated from the toilet where it mostly contains faecal material and water. It is estimated that 14 million m^3 of domestic wastewater generated per day in Thailand. Only about 3 million m3 of wastewater is treated and this mainly in urban areas. Greywater constitutes about 80% of total domestic wastewater, which equals about 8.64 million m3 per day (excluding the 3.2 million m3 per day disposed to the treatment plants), and is being discharged directly into ditches and water bodies. Almost 80% of all domestic wastewater in Thailand is generated in areas where sewer networks and centralised wastewater treatment plants are absent.

Separation of black water and greywater is practised by house owners in Thailand. Blackwater constitutes 20% of total domestic wastewater, which is an estimated 2.16 million m3 per day and is commonly treated by cesspools or cesspits and septic tanks. Cesspools are vertically arranged hollow concrete rings that collect and allow infiltration of black water to the soil. One to two cesspools in series is commonly applied. A 4”-pipe connects the toilet outlet to the cesspool. Cesspools are utilised by 80% of house owners in Thailand.

Septic tanks are made of concrete rings or a rectangular shape concrete. Other than the on-site constructed tank, a prefabricated septic tank is also available commercially. Prefabricated septic tanks gain popularity in the wake of new real estate or housing units development. Developers opt for prefabricated septic tanks for easy and quick installation and better material quality rather than constructing concreted septic tanks.

House owners hardly maintain cesspool. Visual damages such as tight manholes, broken walls, broken inlet pipe, and accumulation of rubbish inside the tank are reported by an empiric AIT study[1]. House owners maintain using cesspool despite the damage and therefore foul odour is reported by owners due to exposed septic wastewater. Desludging of accumulated sludge in the tank was only done when house owners encounter clogging.

The Government of Thailand has been promoting the construction of centralised wastewater treatment plants since 1990. As of to date, there are currently 101 wastewater treatment plants all over Thailand operated and managed by Local Administration Organisations (LAO). The initial project was implemented in Bangkok Metropolitan Administration with full support from the central government. As of today, only the 10 latest constructed plants treat black water and greywater. The rest receives grey water only.

A discussion with the government officials revealed that most of, if not all, effluents of existing centralised wastewater treatment plants meet the Thailand discharge standard. However, it is important to note that the plants’ performance is influenced by the overly designed capacity and receive a lower organic load. The official also mentioned that the lack

[1] Sustainable Decentralized Wastewater Management in Developing Countries; Design, Operation & Monitoring, July 2013, Asian Institute of Technology Thailand

of skilled operators and high electricity cost burden the operation of centralised wastewater treatment plants operated by local administrative organisations.

2.2 Types of governments in Thailand

There are three types of government in Thailand: central administration, provincial administration and local administration. The central government consists of ministries and departments. Currently, there are 19 ministries and 1 Office of the Prime Minister. The government of Thailand is controlled by the Prime Minister.

The provincial administration consists of provinces, districts, sub-districts and villages. The provincial administrations are led by a governor, appointed by the Minister of Interior. The provincial administrations reflect a decentralised concept in which central administration delegates selected authorities to its officers working in the provinces and districts.

The local administrations reflect the concept of decentralisation that encourages people to participate in local affairs under concerned laws and regulations. One of them allows people to participate in a selection of governor of the province. There are two types of local administrations: the special type and general/ordinary type of administration. Bangkok Metropolitan Administration and Pattaya City Administration are part of special type administration. The general type administration consists of provincial administration organisation, municipalities, and sub-district administration organisation.

2.3 Institutional mapping of wastewater related organizations

i. Wastewater Management Authority (WMA), is an enterprise under the Ministry of Natural Resources and Environment established to provide services in managing wastewater to the local administration organisations in Thailand. The enterprise has three main tasks that are to provide design of wastewater treatment, operation and maintenance management as well as research and development.
ii. Department of Public Works (DPW) of the Ministry of Interior is responsible for designing and supervising the construction of government buildings. It also provides supports to local administration organisations by formulating and supervising land-use policies, relocation systems and infrastructure. The department is also responsible to set standards for settlements and infrastructure to ensure public safety as well as quality buildings.
iii. Department of Sewerage and Drainage (DSD) of the Bangkok Metropolitan Administration (BMA) is responsible to, one of them, connect houses within the administration of Bangkok to centralised wastewater treatment system to further treat their wastewater. Currently, there are 8 wastewater treatments managed by BMA out of 30 expansion plants. The department is also responsible to maintain the cleanliness of sewerage.
iv. Office of the Natural Resources and Environmental Policy and Planning (NREPP) of Ministry of Natural Resources and Environment assists the local administration organisations through verifying completeness and correctness of municipalities'

construction plan of wastewater treatment facilities before administration to the ministry of finance.

v. Environmental Research and Training Centre (ERTC) of the Ministry of Natural Resources and Environment, is established to carry out research and to provide technical support in the implementation of natural resources and environmental policy and initiatives. ERTC also provides training and technology transfer on natural resources and environmental management and pollution control.
vi. Office of the Real Estate Promotion (OREP) of the Department of Land, Ministry of Interior, is charged to release approval for construction for house developers. Before approval, developers must gain permits from various agencies such as Water Work Authority for supplying water and Bangkok Metropolitan Authority for collection of wastewater and solid waste, as well as engineer association for the designed wastewater treatment facilities.
vii. Pollution Control Department of the Ministry of Natural Resources and the Environment formulates national policy and plans for the promotion and conservation of environmental quality with respect to pollution control. It is also charged to recommend environmental quality standards and emission effluent standards.

2.4 Tasks of wastewater related institutions

The table below presents tasks of interviewed institutions. The policies are classified into pre-construction, construction and post construction or operation and maintenance to define intervention. In line with AIT BORDA collaboration, a policy regarding testing the quality of wastewater treatment products will be identified.

Table 1: Tasks of wastewater related institutions

Institutions	Pre-construction	Construction	Operation & Maintenance
Wastewater Management Authority	Assist LAOs in designing a centralised Waste Water Treatment Plant (WWTP)	Assist LAOs in supervising construction of a centralised WWTP	Assist LAOs in operating and maintaining of a centralised WWTP Research and develop
Office of Real Estate Promotion, Department of Land	Verify preparatory documents to release construction permit for developers	-	-
Department of Public Works, Ministry of Interior (MOI)	Enforce building codes and discharge standard Design government office buildings	Supervision of construction of government office buildings	-
Office of the Natural Resources and	Provide assistance to LAO in preparing proposal for construction of	-	Monitor effluent quality of centralised WWTP of LAOs

Environmental Planning and Policy, Ministry of Natural Resources and the Environment (MONRE)	centralised treatment, Provide assistance to LAOs in benefiting from environmental fund		
Department of Sewerage and Drainage, Bangkok Metropolitan Administration	Design for upscaling household connection to sewerage for centralised treatment plants Release construction Permit	Construct a centralised WWTP and connect houses to sewerage	Operate centralised WWTPs Assist district office in solving problems related to the environment
District office	Construction permit	Inspect construction	Monitoring of cases within district administration area, consult BMA for potential solutions to a problem
Pollution Control Department, Ministry of Environment	-	-	Discharge standard for 5 type domestic waste generator

As presented in the table above, three institutions play a substantial role in verifying designs submitted by individuals or developers.

(1) The Office of Real Estate Promotion verifies documents submitted by developers which cover wastewater treatment plants. Installation of a prefabricated septic tank for each housing unit and a secondary treatment receiving effluent of septic tanks are commonly practised by developers. Installation of secondary treatments is deemed necessary by developers to meet the discharge standard.

(2) The Ministry of Interior, Department of Public Works and Country Planning enforces building codes to individuals and developers. The building code specifies that a septic tank or soakaway or other suitable treatment must be installed. However, no further details are provided. Meanwhile, the department regulates a discharge standard for domestic wastewater effluent.

(3) Bangkok Metropolitan Administration and its district offices stipulate construction permits and building permits which are translated from the National Building Code. Implementation wise, the two institutions play a crucial role in ensuring that only proper septic tanks are installed. Despite the current applied system which does not fully avoid and a potential collaboration may be introduced with the LAOs.

3 Concept and Vision of the Testing Centre

3.1 Projecting the vision and concept

Improving the quality of effluent discharged to the environment as well as to provide a healthy living environment for the population require proper installation of certified septic tank products. This should be achieved through governing sanitation that encourages every responsible institution, such as a national or local, private or public institution. This is necessary to ensure that quality and certified septic tank products are sold and installed in Thailand.

No single agency is responsible for all aspects of sanitation today. AIT can establish a platform for coordinating sanitation governance within institutions. AIT has been recognised as a resource centre for promoting policy for Decentralised Wastewater Treatment (DEWAT) worldwide and therefore it should play a major role in coordinating sanitation governance in Thailand.

Where septic tank products are manufactured, Government of Thailand must ensure that they meet the performance required or as stipulated in Ministerial Regulation No. 51 (1998) released by the Ministry of Interior. As well, the Government of Thailand must control the point of wastewater discharge through licensing, inspection and enforcement. All this do not only require a major change in sanitation governance but also communication to manufacturers and public who can directly make a difference.

Developing a policy that regulates manufacturers to prove the performance of prefabricated septic tank products before market distribution is a substantial start. With this respect, Thailand Industrial Standard Institute plays a leading role in developing this standard. Supported by institutions involved in the coordinating body, a protocol for performance test must be defined to further prove that effluent of septic tank products meets the discharge standard stipulated by Ministerial Regulation No. 51 (1998). A progressive approach for improving the standard must be introduced to avoid the creation of disproportionate standards, which is very hard for manufacturers to meet. Such standard would not support good products but rather turn down any potential for development for manufacturers.

TISI must also release a policy that recognises and accredit independent institutions for product performance and material testing. The institutions must also be eligible to submit results for certification purposes. A workflow must be set up to ensure that septic tank products are tested, results are submitted to TISI, and certificates are granted by TISI. Once a product is certified, district offices responsible for granting construction permits must be able to see the list of certified products to further evaluate submitted plans by house owners.

The main clients of a testing centre are manufacturers of prefabricated septic tanks and treatment systems. Some manufacturers print false certification marks such as ISO 17025 or

ISO 9001, which is not a proper product certification mark. This fact shows that manufacturers may understand the importance and necessity of certification.

Starting collaboration with prefab septic tank manufacturers, governmental agencies, academicians, to establish a demonstration and training centre is crucial. Testing is just a small part of a grand system of policy which involves national and local administrative organisations as well as private institutions. Testing won't be necessary if manufacturers can sell their products without a mandate to undergo the testing process. Testing won't be necessary if house owners can still buy any septic tank products without paying attention to the certification of products. Testing won't be necessary if house owners can still install uncertified and inappropriate cesspools.

Developing a policy for testing may take years to be issued. An approach to the manufacturers by offering space to demonstrate their technology before introducing testing may benefit the projects as well as the manufacturers. This approach may offer free installation of DEWAT in demo site for the first year. AIT BORDA with the support of PIA may open opportunities or new potential markets in South East Asia countries through training courses on Decentralized Wastewater Treatment Systems. Within this collaboration, AIT BORDA may start introducing performance test such as Environmental Technology Verification (ETV). By starting basic tests, we create confidence of the manufacturers that their product can perform well while progressively introducing an integral testing and certification procedure.

AIT BORDA offers expertise in developing a standard as well as to propose an amendment to the Building Code. There are several points to be included in the Building Code; (1) regulating prefabricated septic tanks, (2) maintenance contract: desludging, discharge quality monitoring 1/annum, reporting, (3) Operation and maintenance guidelines.

Within this context, AIT BORDA introduces a digitized 'systematic permit declaration' process through a web-based platform check system and assist in using it. Only tested septic tanks are approved for installation and permit may be released when house owners show selection skills and order certified prefabricated septic tanks. Discharge quality tests have to be done once a year by manufacturers and should be reported through the same system. District director refers to this web platform to confirm septic tank design before the release of a construction permit.

3.2 Testing and Demonstration Centre

AIT and BORDA with the support of PIA started a collaboration to start up a testing centre that measures consistency performance of Decentralised Wastewater Treatment (DEWAT) products. This collaboration also intends to establish a demonstration site to showcase well-functioning pre-fabricated DEWAT products.

In the context of this project, PIA is a key resource partner when it comes to

1) Conceptualization of the Testing Center for Decentralized Wastewater Treatment System DEWATS
2) Advisory on the technical layout of the testing site
3) Introducing operational guidelines as well as maintenance routines
4) Advisory on development of technical guidelines and performance requirements - Standardization

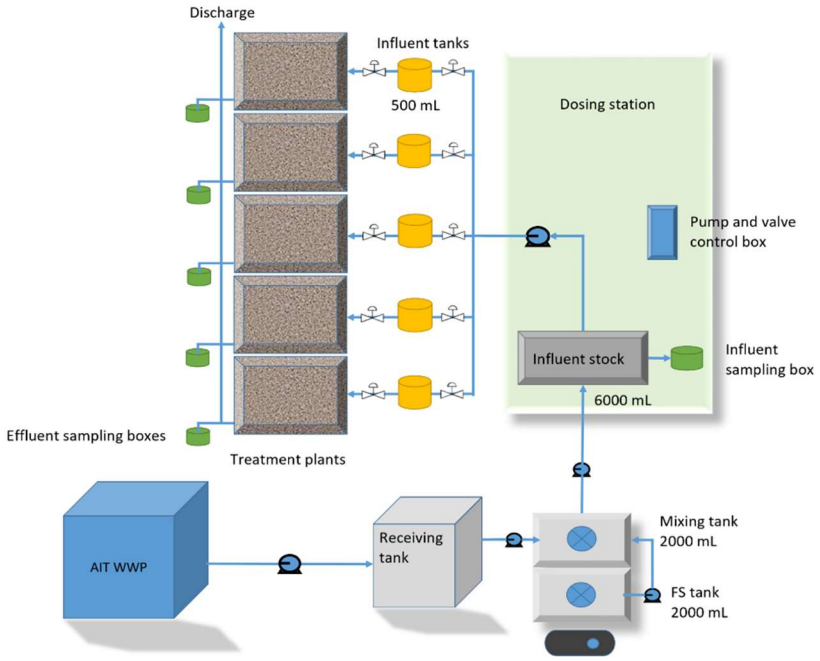
Moreover, PIA's involvement is not strictly limited to the work packages laid out above. As a leading sector player that has implemented similar "testing sites for wastewater technology" successfully across the planet before, PIA's experience is central to achieve a state of the art testing site and is therefore considered as a project partner accompanying the project across all phases.

Certifications of both material and performance of prefabricated DEWAT products are not regulated in Thailand. Thailand Industrial Standard Institute (TISI) has been working with related stakeholders to develop standards and certify products. Unfortunately, standards for DEWAT products has not been defined by now. During the initial study of septic tanks fabricated in Thailand, a manufacturer of prefabricated septic tanks claims that its products confirm the material standard (ICS 435 – 2548) that is stipulated for materials of water tanks. This raises the question whether a material standard for prefabricated wastewater treatment is available or adjustable and there is only missing a standard for performance testing.

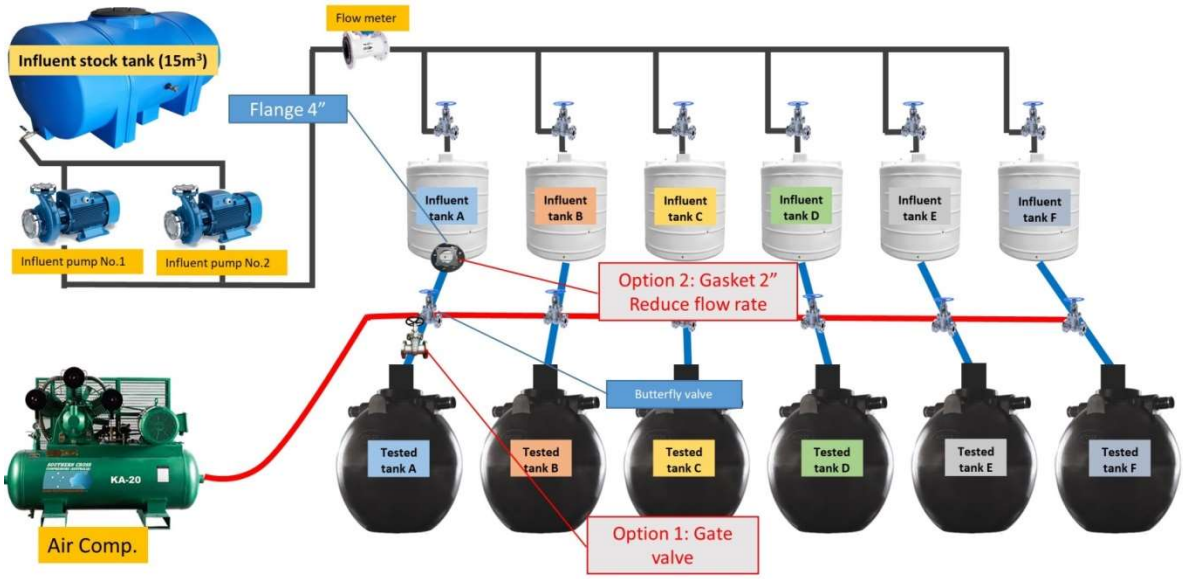
Government' officials from Ministry of Natural Resources and Environment, Department of Land, Department of Public Works, Bangkok Metropolitan Administrative share a common understanding that Thailand needs to develop and apply such standards for DEWAT products. More than 80% of households in Thailand used cesspools or cesspits while newly developed residential house projects install prefabricated septic tanks for individual houses. Septic tanks remain the option for individual households and therefore, regulating a standard test for measuring the consistency of performance and material before commercial marketing may help to close the gap.

While advocating the development of standard performance test to the governments, manufacturers, and other relevant entities, an establishment and operation of a testing centre is a priority within the context of AIT-BORDA collaboration. A 1,200 sqm area is prepared by AIT for the testing site. A two-storey container is constructed and designated as an office building for staffs of the testing centre. A connection pipe has been constructed to supply wastewater from AIT dormitories to the testing site. Electricity has also been installed on the site to run pumps and other installed equipment. The AIT BORDA team installed the dosing station to regulate wastewater influent during the testing period.

The layout design for the testing centre is shown below. All wastewater treatment plants performing tests will be located in the warehouse. The warehouse assures security that authorised persons can only access it and it is also equipped with proper ventilation.



Picture 1: Performance infrastructure



Picture 2: Dosing infrastructure

Picture 3: Technical realization of dosing infrastructure

Picture 4: Test hall

4 Policy and Standardization fundamentals

4.1 Interaction between government levels in organizing sanitation

Bangkok Metropolitan Administration (BMA) is one of the two special local administration organisations and is led by a governor. It is taken as an example to present the relationship between the provincial government and the central government and its districts. BMA is charged to formulate and implement policies to manage Bangkok which includes transportation services, urban planning, waste management, housing, roads and highways, security services, and environment protection. For wastewater management, they are obliged to provide the connection to a centralised wastewater treatment to houses in the provinces. The institution only provides a citywide wastewater treatment plan and does not have any policy or work regarding individual or household wastewater treatment. BMA currently manages 8 centralised treatment plants which treat wastewater of 200,000 connected houses. Until 2030, BMA aims to operate a total number of 30 wastewater treatment facilities.

For planning and budgeting purposes of new wastewater treatment facilities, BMA submitted their planning documents to the Office of the Natural Resources and Environmental Policy and Planning of Ministry of Natural Resources and Environment (NREPP). A city or municipality usually proposes a plan for a facility to treat 1,000 to 2,000 m3/day of wastewater. The role of NREPP is to check and verify the completeness and correctness of municipalities' construction plan of wastewater treatment facilities before administration to the ministry of finance. There are 14 documents submitted by a municipality, few of them are documents proving public participation, bill of quantities, land acquisition, feasibility study report, proposed technology, and economics of scale. Other than verifying documents, NREPP also surveys to confirm land availability and hearing with the local administration leaders. As granted clearance by NREPP, proposals then submitted to NERDB for approval before administration to the Ministry of Finance. As approved by the Ministry of Finance, BMA may start the construction works. A regional office of natural resources and environmental policy and planning is testing effluents quality of the plants in the operation and maintenance period.

Other organisations which assist the local administration organisations is Wastewater Management Authority. WMA maintains three roles: design and operate wastewater treatment plants for municipalities, as well as research and development. WMA currently manages 23 treatment plants in the country. However, those treatments only receive greywater from households.

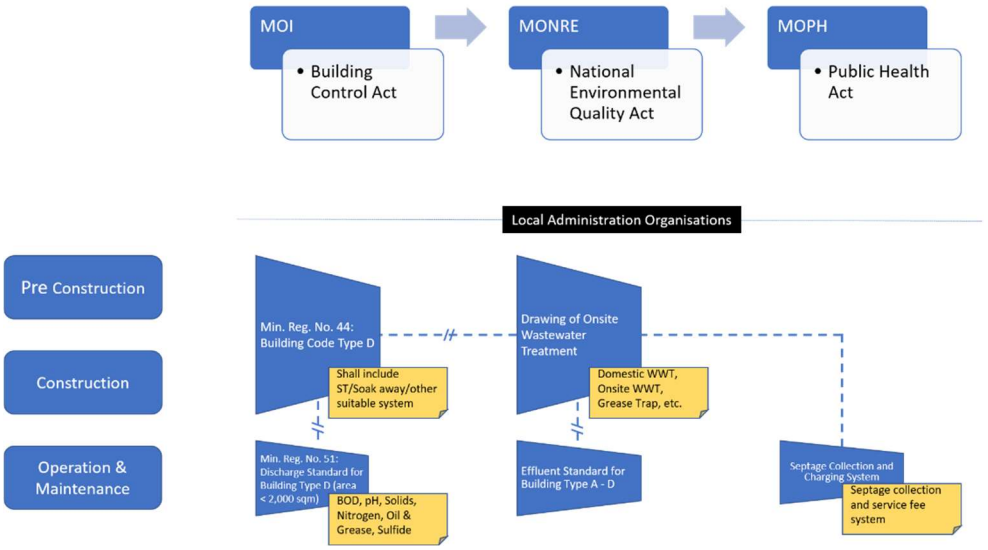
Within a province, the district offices are charged to enforce the national law stipulated by ministries such as public health act, environmental act to individual houses, small and medium businesses like restaurants. A district office is led by a Secretary of District Offices and work under the direction of a governor. An individual must seek approval from the district office and department of public work for the building plans. The plans are submitted to get a permit for construction. Without signature from the offices, any work can be deemed illegal. During construction, the district office will check the conformity of construction to the signed plan and impose a penalty when found deceptive. Other than

that, the district offices also respond to complaints from residents regarding environmental-related nuisance. The district offices are authorised to address the issue and consult to BMA for potential solutions.

An enterprise or residential developer has to seek construction permission before construction. The role of OREP is to check and verify the completeness and correctness of real estate developers' plan documents. They check whether approval or agreement from relevant authorities to provide services like water connection, solid waste collection, disposal of treated wastewater, and site approval are in place. The office will then release a final approval for the developer to start the project. During this consultative mission, the developers are requested to prove the availability of a wastewater plant by presenting detailed designs or technology information signed by a design engineer. A developer usually installs a prefabricated septic tank in every house. However, they are required to install secondary treatment receiving septic tanks' effluent to further treatment before discharge to the environment. This approach is mandated in case the developers are unsure of the septic tank performance.

4.2 Environment related policies

Three major policies released by the Government of Thailand in relation to wastewater management have been implemented by three ministries: Ministry of Interior (MOI), Ministry of Natural Resources and Environment (MONRE), Monistry of Public Health (MOPH). In reality, the three ministries have well followed up the plan and taken necessary planning documents and activities to pursue the goal of the acts.



Picture 4: Environmental related governmental system in Thailand

4.2.1 The Building Control Act (BCA)

Released in 1979, BCA controls townhouses, house, homes, halls, shops, rafts, warehouses, offices and other constructions, which people may live in or utilize, and other types of building stipulated in. BCA charged the Ministry of Interior (MOI) to control the execution of the act and to issue a ministerial regulation to (1) prescribe fee, (2) prescribe forms of license application, license, certificate, substitute, as well as other order or any form for use in the implementation of this Act and (3) prescribe other affairs for the implementation of this Act. In response, the Ministry of Interior released Ministry Regulation No. 44 (1995) concerning Building Code type D that control building with an area less than 2,000 sqm. Ministry regulation No. 44 (1995) stipulates that every building must own a septic tank or soakaway or another suitable system to receive domestic wastewater. The Ministry of Interior also released Ministry Regulation No. 51 (1998) concerning discharge standard quality for type D building. Considering Ministry regulations No. 44 (1995) and 51 (1998), the discharge standard as presented in the table below specify the effluent quality that has to be met by house owners in Thailand.

Table 2: Effluent standard for wastewater discharge of Building Type “D”

Effluent Standard	Building Type "D" Standard
1. pH	5-9
2. BOD (mg/L)	< 50
3. Suspended Solids (mg/L)	< 50
4 Total Dissolved Solids (mg/L)	< 500
5 Settleable Solids (mL/L)	< 0.5
6 Total Kjeldahl Nitrogen (mg/L)	< 40
7 Organic Nitrogen (mg/L)	< 15
8 Ammonia Nitrogen (mg/L)	< 25
9 Oil and Grease (mg/L)	< 20
10 Sulfide (mg/L)	< 4.0

4.2.2 National Environmental Quality Act (NEQA)

Released in 1992, NEQA has been intended to preserve the environment. It mandates the establishment of a National Environment Board (NEC) led by the Prime Minister and allows them to, one of them, propose policies and plans for the enhancement and conservation of national environmental quality to the Council of Ministers for approval. NEQA also mandates provision of environmental fund within the Ministry of Finance for the following matters (1) as grants to a government agency or a local government for investment in and operation of a central wastewater treatment or waste removal system as loans to a local government or a state enterprise for the provision of air pollution control, wastewater treatment, or waste removal systems or other equipment to be used specifically in the activities of such local government or state enterprise (3) as loans to a private entity in the case where every person has the legal duty to provide for treatment of polluted air and wastewater facilities, or waste removal, (4) as aids or grants to support any activity concerning the enhancement and conservation of environmental quality (5) as expenditures for administering the Fund. In implementing NEQA, NEB entrusts the Office of the National Environmental Policy and Planning (ONEP), Pollution Control Department (PCD) of the Department of Environmental Quality Promotion under the Ministry of Natural Resources and the Environment. In response, PCD regulates effluent standards for building type A to type D as well as providing typical drawings for domestic wastewater treatment, onsite wastewater treatment, grease traps, etc. The ONEP assists local government in the process of preparing centralised wastewater treatment for its administrative area.

4.2.3 Public Health Act (PHA)

The PHA was released in 1992, amended in 2007, regulates management which includes the collection of faecal sludge, treatment, the involvement of private companies and fee of sewage or faecal sludge. It also stipulates the establishment of the Public Health Committee to assist the Prime Minister on the improvement of law, rules, regulations, and orders on public health and issuance of local provisions as well.

PHA charged the Ministry of Health to execute the act. In response, the ministry regulates service fee from collection, transportation and disposal of sewage and solid waste.

5 Thailand Testing Standard for prefabricated wastewater treatment systems

The collaboration of AIT BORDA has put the development of a standard for testing performance of packaged or prefabricated decentralized wastewater treatments 'on the map'. Since inaugurated by the Asian Institute of Technology and Bremen Overseas Research and Development Association in 2017, the project dedicated to installation of a testing centre facility and advocation of the need for the standard testing procedure to the manufacturers, the relevant government officials in Thailand and other select Association of South-East Asian Nations (ASEAN) member countries in its first operational year. By end of inauguration year, the project reached a consensus with the manufacturers and relevant government officials in Thailand that a third-party laboratory should certify a decentralized wastewater treatment product with acceptable standards before installation in a building or selling in the market.

The consensus marked the turning point in the establishment of a standard for testing performance of a wastewater treatment product in Thailand. In 2018, the Thailand Industrial Standard Development (TISI) formed an academic committee representing academia/technical experts, manufacturers, and consumers/users. It appointed a senior official standing for the Department of Public Works of the Ministry of Interior as the chairman of the academic committee. The 'Regenerative Sanitation Hub' project took part in the committee through the representation of Asian Institute of Technology. TISI charged the committee to review the drafts of "Fibreglass reinforced plastics tanks for domestic wastewater treatment: Physical characteristics" and "Polyethylene tanks for domestic wastewater treatment: Physical characteristics", designated for material behaviour testing. TISI demanded the academic committee to draft a procedure for testing performance.

By the end of 2018, the technical committee reached a consensus on the content of the standard draft. The committee submitted the draft to the Industrial Product Standards Council for approval before signed by the minister of industry for formalisation in the Royal Gazette. In nearly a year of interaction, the technical committee conducted numerous meetings and public hearings to develop, review and revise the first draft. The representative of AIT substantially contributed to the standard drafting process by providing proven methods to justify the performance of wastewater treatment and its monitoring parameters. Other than that, we influenced TISI that the standard should be commonly applied for all type of treatment processes and TISI should approach for gradual improvement and progressive implementation of the standard. The committee members agreed on the procedure to test performance and material as well as the parameters. Performance of a wastewater treatment product is determined through measurements of Biochemical Oxygen Demand, Suspended Solids, and Total Kjeldahl Nitrogen. For the material test, the draft standard specifies required tests for material suitability such as tensile strength, tensile strain, bending resistance, and other tests such as water tightness, nominal capacity, vacuum test, top-loading test and baffle test. The Thailand Industrial Standard Institute published the standard in July 2019.

Table 3: Comparison of EN12566 part 3, NSF/ANSI 40 and Thailand testing standard based on ERTC report

Item	EN12566 part 3	NSF/ANSI 40-2018 Residential Wastewater Treatment System	Thailand Industrial Standard Institute TIS. 2962-2562
Scope	For packaged and/or site assembled domestic wastewater treatment plants (including guest houses and businesses) used for populations up to 50 inhabitants	For residential wastewater treatment systems having capacities 1,514 – 5,678 L/day	For prefabricated wastewater treatment tanks for residential buildings with the capacity not exceeding 10,000 l/d.
Tank materials	Concrete, Glass reinforced plastic (GRP), Polyethylene, steel	All kind of material	fiberglass or polyethylene
Installation, testing site	The plant shall be installed in a way that is representative of the normal conditions of use	According to manufacturer's instruction Cover with soil to achieve normal installation depth	According to manufacturer's instruction
Parameters (Monitored and tested)	BOD, SS, Temperature, Power consumption, daily hydraulic flow	pH, TSS, BOD, CBOD, color, odor, oily film and foam	BOD, TSS, TKN
Influent characteristics	BOD = 150-450 mg/L or COD = 300-900 mg/L SS = 385-565 mg/L TKN = 25-75 mg/L or NH3-N = 22.5-67.5 mg/L TP = 5-15 mg/L	BOD = 100-300 mg/L TSS = 100-350 mg/L Alkalinity > 175 mg/L as $CaCO_3$	BOD = 150 – 500 mg/l TSS = 200 – 700 mg/l TKN = 25 – 100 mg/l
Hydraulic loading	Based on volume of the daily hydraulic capacity of the system	Based on volume of the daily hydraulic capacity of the system	Based on volume of the daily hydraulic capacity of the system

Daily flow pattern for testing

Time of day	% of daily flow
6:00 – 9:00	30
9:00 – 12:00	15
12:00 – 18:00	0
18:00 – 20:00	40
20:00 – 23:00	15
23:00 – 6:00	0

Time of day	% of daily flow
6:00 – 9:00	35
11:00 – 14:00	25
17:00 – 20:00	40

Period (h)	% of daily flow
3	30
3	15
6	0
2	40
3	15
7	0

Test schedule

No	Characteristics	Time elapsed
1	No sampling Biomass establishment	X weeks *
2	Routine sampling Steady state performance	10 weeks
3	Power breakdown stress test	2 weeks
4	Routine sampling Steady state performance	6 weeks
5	Routine	2 weeks

The system shall be evaluated for 26 consecutive weeks, including,
Design loading 16 weeks
Stress loading 7.5 weeks (52 days)
Design loading 2.5 weeks (18 days)

** Stress loading includes wash-day stress, working-parent stress, power/equipment failure stress and vacation stress

Sampling: composite sampling, minimum 96 data days

No	Sequence	Daily Flow	Time elapsed
1	Biomass establishment	Nominal	X
2	Nominal (on week 1 to 6)	Nominal	6
3	Underloading (on week 7 to 8)	50% of nominal	2
4	Nominal (on week 9 to 10)	Nominal	2
5	Power Breakdown at first 24 hours of the week (on week 11)	Nominal	1
6	Nominal (on	Nominal	3

		sampling 50% nominal organic load with 50% nominal hydraulic daily flow				week 12 to 14)		
	6	Routine sampling 200% nominal organic load with 200% nominal hydraulic daily flow	2 weeks		7	Low occupation stress (on week 15 to 16)	No	2
	7	Low occupation stress test	2 weeks		8	Nominal (on week 17 to 22)	Nominal	6
	8	Routine sampling	6 weeks		9	Overloading at first 48 hours of the week (on week 23)	Overload	1
	9	Power breakdown stress test	2 weeks		10	Nominal (on week 24 to 26)	Nominal	3
	10	Routine sampling	6 weeks		11	Power breakdown at first 24 hours of the week	Nominal	1
	11	Low occupation stress test	2 weeks		12	Nominal (on week 28 to 30)	Nominal	3
	12	Routine sampling	8 weeks		13	Underloading (on week 31 to 32)	50% of nominal	2
					14	Nominal (on week 33 to	Nominal	6

	* time required to reach steady state conditions Note: 1. Routine sampling: composite sampling 24 hr taken every 15 days 2. Power breakdown and Low occupation stress test: composite sampling 24 hr taken 2nd and 5th day after test		38)

5. Outcome and outlook

From the project idea to set up a testing centre for prefabricated decentralized wastewater systems in Thailand at the Asian Institute of Technology (AIT) mid of 2016 to an ILAC ISO 17025 accredited independent testing centre several milestones were accomplished.

Another goal was to create a Standard for performance and material tests for decentralized wastewater treatment systems and to involve the whole ASEAN region to achieve acceptance and to improve in “Sustainable protection of natural resources in Southeast Asia”. The major outcomes and outlooks of the project are as follows:

- Create the first acting and capable testing centre for decentralized wastewater plants in the SEA Region with a quality management system
- Set-up a task group, formulating and publish a THAI Standard (through TISI committee)
- Set up an ASEAN demonstration platform for decentralized wastewater treatment
- Start a European and ASEAN wastewater knowledge exchange
- Organize Workshops (national and international)

6. Literature

Industrial Product Standard, PACKAGED WASTEWATER TREATMENT TANKS FOR RESIDENTIAL BUILDING TIS. 2962-2562 Thai Industrial Standards Institute.