

Good practices and technologies for

CLIMATE-FRIENDLY DOMESTIC WASTEWATER MANAGEMENT



























DISCLAIMER

This guidebook is an output of the Integrated Waste Management for GHG reduction (TGCP-Waste) Project under Thai-German Climate Programme. The project is jointly implemented by the Pollution Control Department (PCD) of the Ministry of Natural Resources and Environment (MoNRE) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and funded by IKI of the Federal Ministry for Economic Affairs and Climate Action (BMWK). The data and information presented in this book reflect comprehensive study work on low carbon MSW and DWW management systems in Thailand and abroad conducted between April to December 2021.

Due to the limited details given in the e-book, the responsible implementing agencies, PCD and GIZ together with the Project Management Unit (PMU) strongly recommend to consult with experts in municipal solid waste and domestic wastewater management to ensure the practices demonstrated in this book are properly understood and applied in the specific context

INTRODUCTION

Thailand has ratified the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) since 2016. Under the Paris Agreement, parties are required to make efforts related to climate change including reduction of greenhouse gas (GHG), climate change adaptation, building climate-resilience, and to submit plans for climate action known as nationally determined contributions (NDCs) every 5 years. From the 26th session of the Conference of the Parties (COP26) in Glasgow, the United Kingdom in 2021, Thailand has announced the target of 20-25% GHG reduction by 2030 or 40% reduction subject to provided international supports. Thailand also aims to become carbon neutrality by 2050 and to achieve Net Zero Greenhouse Gas Emission by 2065.

The Pollution Control Department (PCD) is the main agency responsible for formulation of GHG reduction measures in the waste sector, providing technical supports to other implementing agencies, and providing supports for Measurement Reporting and Verification (MRV) of municipal solid waste (MSW) management and domestic wastewater management for Thailand. PCD, in cooperation with the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), under the Thai-German Climate Programme - Waste Sector (TGCP-Waste), have commissioned the King Mongkut's University of Technology Thonburi (KMUTT) and Kasetsart University to study and compile good practices and best available technology on climatefriendly and low-carbon MSW and domestic wastewater management to disseminate good examples of GHG reduction in the waste sector in Thailand.

In addition to data compilation, there is an implementing mechanism based on the working group known as the Project Management Unit (PMU). PMU comprises experts representing various agencies including Office of Natural Resource and Environment Policy and Planning (ONEP), Department of Environmental Quality Promotion (DEQP), Department of Local Administration (DLA), Thailand Greenhouse Gas Management Organization (Public Organization) (TGO), Wastewater Management Authority (WMA) and Bangkok Metropolitan Administration (BMA). These experts provide technical support by giving recommendations on GHG calculation methodology, selection of reference sources and on the results of the study to improve data quality through monthly meetings.

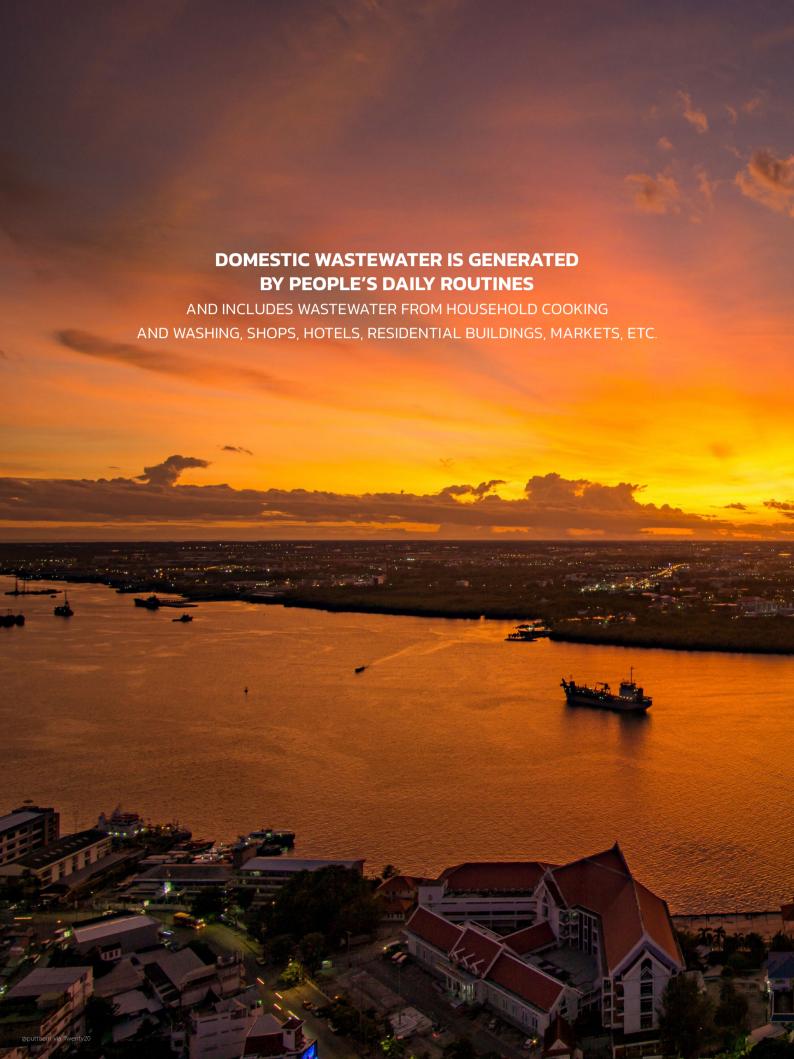
The Pollution Control Department truly wishes that basic knowledge from this document can be utilized as a guidance for local administration organizations to study good practices and best available technology on GHG reduction from MSW and domestic wastewater management and to consider waste management options that are climate friendly and in accordance with the national GHG reduction targets.

Pollution Control Department

Ministry of Natural Resources and Environment

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1

TERMS AND DEFINITIONS OF GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY DOMESTIC WASTEWATER MANAGEMENT

1.1 TERMS AND DEFINITIONS

In this document, the terms and definitions of good practices and technologies for climate-friendly domestic wastewater management are defined as follows.

GOOD PRACTICES FOR CLIMATE-FRIENDLY DOMESTIC WASTEWATER MANAGEMENT

This refers to actions or activities implemented onsite and/or at a central treatment unit that limit climate deterioration by emitting low levels of greenhouse gases or reducing greenhouse gas emission compared with the baseline and not generating environmental pollution.

Good practices are likely to be implemented at the wastewater source, such as reducing water consumption and discharge as well as reducing its toxicity.

TECHNOLOGIES FOR CLIMATE-FRIENDLY DOMESTIC WASTEWATER MANAGEMENT

This refers to technologies for onsite and/or centralised domestic wastewater treatment units that do not contribute to climate deterioration by emitting low levels of greenhouse gases or reduced greenhouse gas emissions compared with the baseline and do not create environmental pollution.

- Examples of climate-friendly technology for onsite domestic wastewater treatment are an aeration septic tank, etc.
- Examples of climate-friendly technology for a centralized domestic wastewater treatment unit are aerobic treatment technologies such as activated sludge and constructed wetlands, etc.



1.2 HOW THAILAND'S GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY DOMESTIC WASTEWATER MANAGEMENT SHOULD RESEMBLE

To determine the good climate-friendly practices and technologies for domestic wastewater management in Thailand, various elements must be considered according to the following criteria.

121 RELEVANT TERMS AND DEFINITIONS

Not affecting climate deterioration: the practice or technology should

- Reduce direct greenhouse gas emissions, i.e., methane and nitrous oxide, from the waste sector
- Reduce indirect/avoided greenhouse gas emissions from the other sectors such as saving electricity consumption or using biogas produced from wastewater treatment as an alternative to fossil fuels
- Have low carbon footprints or a low ratio of greenhouse gas emissions to unit volume of treated wastewater

Not affecting environmental deterioration: the practice or technology should

- Not create other environmental pollution, such as particulate matter
- Not create atmospheric or ecosystem pollution

1.2.2 SUPPORTING THE NATIONAL GREENHOUSE GAS EMISSION REDUCTION TARGET AND WASTEWATER MANAGEMENT POLICIES

Greenhouse gas emission reduction

The guidelines support implementations of technologies that can contribute to Thailand's greenhouse gas emission reduction targets, for example, the Nationally Determined Contribution (NDC) by 2030, the carbon neutrality by 2050, and the net-zero carbon emission by 2065.

COUNTRY POLICIES

Act as practical guidelines to support policies or strategic plans, roadmaps and the integrated management of the country's domestic wastewater action plans, such as:



Onsite wastewater treatment

- Reduce water consumption and effluent impurities with water-saving techniques and by reducing contaminants in water
- Promote the utilisation of high-efficiency wastewater treatment systems

Centralised wastewater treatment

- Expand the centralised wastewater treatment system service area and increase the amount of wastewater discharged to the centralised wastewater treatment system
- Increase the number of centralised domestic wastewater treatment plants that utilise aerobic treatment technology

1.2.3 APPROPRIATENESS AND TECHNOLOGICAL FEASIBILITY OF IMPLEMENTATION IN THAILAND

Practical guidelines or technologies must be considered for the following issues.

- Efficiencies of domestic wastewater treatment to reduce toxic pollutant discharge to the environment
- The area required to install domestic wastewater treatment technologies.
- The difficulty of operating and maintaining the system consistently; especially the selection

- of equipment or control systems that require skilled personnel.
- The difficulty of managing the waste generated through wastewater treatment, such as excess sludge that must be discharged from the system.
- The operational lifespan of systems or technologies that work continuously as well as their flexibility and adjustability to adapt to the changing amounts and characteristics of domestic wastewater.

1.2.4 SUPPORTING SOCIAL DEVELOPMENT TO ACHIEVE THE SUSTAINABLE DEVELOPMENT GOALS (SDGS)

Practical guidelines or technologies must be provided for the following issues.

- The perception and acceptance of people, community and society.
- Encouraging appropriate public participation in SDG implementation and activity.
- Having suitable investment and establishing benefits to people, community and society.
- Supporting local employment through the utilisation of areas or by-products obtained from local treatment systems.





SELECTION OF GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY DOMESTIC WASTEWATER MANAGEMENT IN THAILAND

2.1 DOMESTIC WASTEWATER TREATMENT IN THAILAND

There are two domestic wastewater treatment methods in Thailand. The first is onsite treatment, which is the treatment of wastewater at the origin or source, such as households, shops, offices and department stores. Examples of this system include septic tanks and anaerobic filter wastewater treatment tanks. The second method is the centralised wastewater treatment system, which is a larger unit than onsite units. Examples of the centralised system are stabilisation ponds, aerated lagoons and activated sludge systems.

Figure 2.1 Good management practices and technologies of onsite and centralised wastewater treatment systems. The technologies shown in blue have high potential and meet the criteria of climate-friendly technology.



Figure 2.1 Guideline and technology in domestic wastewater management in Thailand

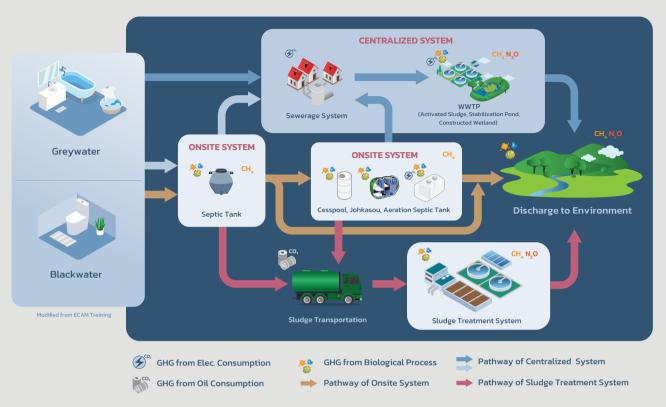


Figure 2.2 Layout of domestic wastewater management using guideline and technology in domestic wastewater management in Thailand

2.2 SELECTION OF GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY DOMESTIC WASTEWATER MANAGEMENT

2.2.1 CALCULATION OF BASELINE GREENHOUSE GAS EMISSIONS AND REDUCTIONS FROM IMPLEMENTING GOOD PRACTICES AND TECHNOLOGIES FOR WASTEWATER TREATMENT

The potential for greenhouse gas emission reduction is a significant factor in the selection of good practices and technologies for climate-friendly domestic wastewater management. The calculation of greenhouse gas emissions and reduction must be accurate and transparent. The methodologies used must refer to reliable sources such as the Intergovernmental Panel on Climate Change (IPCC), which is globally recognised for climate change

information or the Thailand Voluntary Emission Reduction Program (T-VER), which is verified by the Thailand Greenhouse Gas Management Organization (TGO). Other accepted methodologies may also be used, e.g., the Greenhouse Gas Protocol. However, each methodology has unique objectives and different calculation assumptions. The parameters of each methodology must, therefore, be understood before application. In general, there are two scenarios for calculating greenhouse gas emissions from domestic wastewater treatment, as follows.

Scenario 1: Greenhouse gas emission baseline

The facility emits greenhouse gases as usual without implementing mitigation measures or activities or adopting climate-friendly good practices or technologies. For this project, this means domestic

wastewater was treated with the typical treatment methods utilised throughout the country. The baseline of onsite wastewater treatment is a septic tank. For the centralised wastewater treatment system, the baseline is depended whether there is an existing system. If the centralized treatment system is existed, the stabilisation pond is used as the baseline. If there is no centralised wastewater treatment system existed, a septic tank is applied as the baseline.

The emission baseline is calculated by applying IPCC emission factors to the known domestic wastewater activity data, including the amount of wastewater and the concentration of organic materials in treated wastewater.

The calculated greenhouse gas emission baseline is mainly comprised of methane and converted into carbon dioxide equivalents for comparison to the expected values after adopting climate-friendly good practices or technologies.

Scenario 2: Greenhouse gas emission after the adoption of climate-friendly good practices and technologies

After adopting climate-friendly good practices and technologies, the emissions were calculated from domestic wastewater activity data. The approach is to apply IPCC or country-specific emission data of the selected technology to the known activity data.

The greenhouse gas, in this case, might include methane, nitrous oxide or carbon dioxide; these are converted into carbon dioxide equivalents to compare them to the baseline.

2.2.2 DIRECT, INDIRECT AND AVOIDED EMISSIONS

The changes in the amount of direct greenhouse gas emission describe the reduction in greenhouse gases emitted through wastewater management by adopting climate-friendly good practices and technologies compared with the baseline, e.g., a reduction in methane emission from treating domestic wastewater in constructed wetlands rather than a facultative stabilisation pond.

The changes in the amount of indirect greenhouse gas emission describe the reduction of greenhouse gases emitted through wastewater management by adopting climate-friendly best practices and technologies in other sectors, such as the energy sector. For instance, utilising an activated sludge system instead of a stabilisation pond system requires electricity for aeration, leading to greenhouse gas emissions in the energy sector to generate more electricity.

Avoided emissions

Avoided emissions are the amount of greenhouse gases reduced by using products recovered from treating wastewater to offset the fossil fuel consumption in the energy-generating sector, e.g., an anaerobic wastewater treatment system can generate biogas that can substitute for coal in electricity generation.

The avoided emissions can be calculated from the greenhouse gases emitted during electricity generation compared with the amount of electricity offset by biogas generation from anaerobic wastewater treatment. However, energy or electricity generation from centralised domestic wastewater systems in Thailand remains underdeveloped.

The assessment of direct, indirect and avoided greenhouse gas emissions will provide more comprehensive and holistic assessments of good practices and technologies for climate-friendly domestic wastewater management than the assessment of direct emissions alone.

2.2.3 TECHNICAL AND SOCIAL FEASIBILITY

The elements that support decision-making in selecting the appropriate best practice or technology according to each aspect were considered. The assessment was conducted with a scoring system developed by domestic wastewater management experts in which scores were ranked as low, medium or high. For example, a system that is difficult to operate and maintain is classified as low level.

2.3 SELECTED GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY DOMESTIC WASTEWATER MANAGEMENT

2.3.1 GOOD PRACTICE IN DOMESTIC WASTEWATER MANAGEMENT

Good practice in domestic wastewater management consists of the adoption of the 3R principles (reduce, reuse, recycle) to save water and reduce impurities in domestic effluent.

In calculating greenhouse gas emission reduction, the collected data were found to be insufficient to assess the emission reduction that would result from conducting 3R measures accurately; therefore, indepth data regarding this issue will not be provided in this document.

2.3.2 CLIMATE-FRIENDLY TECHNOLOGIES IN DOMESTIC WASTEWATER MANAGEMENT

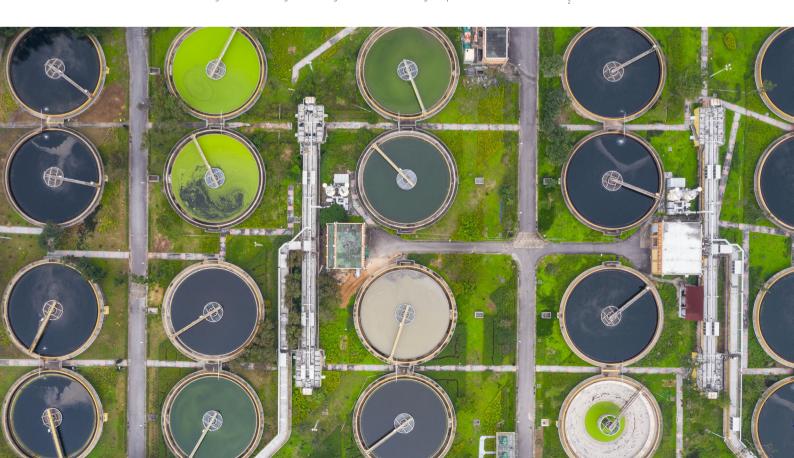
The calculated percentage of greenhouse gas reduction and ranking of technologies with high potential to reduce greenhouse gas emissions during wastewater treatment are shown in Table 2.1.

Table 2.1 Priority Setting: DWW CF Technologies. Exemption of N_2O emission from AS and TF

TECHNOLOGIES FOR CLIMATE-FRIENDLY DOMESTIC WASTEWATER MANAGEMENT		Greenhouse reduction percentage compared with the BAU (%)			Greenhous gas with	Technical	
		Inside waste sector	Outside waste sector	Total	avoidance percentage (%)	and social feasibility	Ranking
	Septic tank (Baseline)	-	-	-	-	-	-
Onsite Treatment	Onsite wastewater treatment system (Johkasou technology)	83.47	Increase*	28.92	28.92	High	High
	Aeration septic tank	83.47	Increase*	23.96	23.96	High	High
	Facultative stabilization pond	-	-	-	-	-	-
	Constructed wetland	52.70	О	52.70	52.70	High	High
Centralized Treatment	Activated sludge (Using facultative stabilization pond as baseline)	73.93	Increase*	64.41	64.41	High	High
	Activated sludge (Using septic tank as baseline)	88.98	Increase*	84.29	84.29	High	High
	Trickling filter** (Using facultative stabilization pond as baseline)	0.099	Increase*	28.75	28.75	Moderate	Moderate

Note: * see each technology's report for details.

^{**} Tricking filter has more greenhouse gas emission than using a septic tank as baseline due to $\mathrm{N_2O}$ emission







GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY DOMESTIC WASTEWATER MANAGEMENT

In the implementation of good practices and technologies for climate-friendly domestic wastewater management onsite, the results are likely to be slightly different from those predicted as the characteristics and situations of the implementation affect the potential greenhouse gas emission reduction. In addition, the calculated greenhouse gas assessment may differ from the actual measurement due to assumptions made in the calculations to adapt to a lack of actual data from the area.

The content in this chapter presents the calculation of greenhouse gas emission reductions from climate-friendly good practices and technologies implemented in Thailand and abroad by selecting good practices and technologies with high potential to reduce greenhouse gas emissions from onsite and centralised domestic wastewater treatment.

Currently, the collected data required to accurately assess the greenhouse gas emission reduction from adopting best wastewater treatment practices in Thailand are insufficient, so the calculated emissions reduction from adopting best practices in Thailand will not be presented.

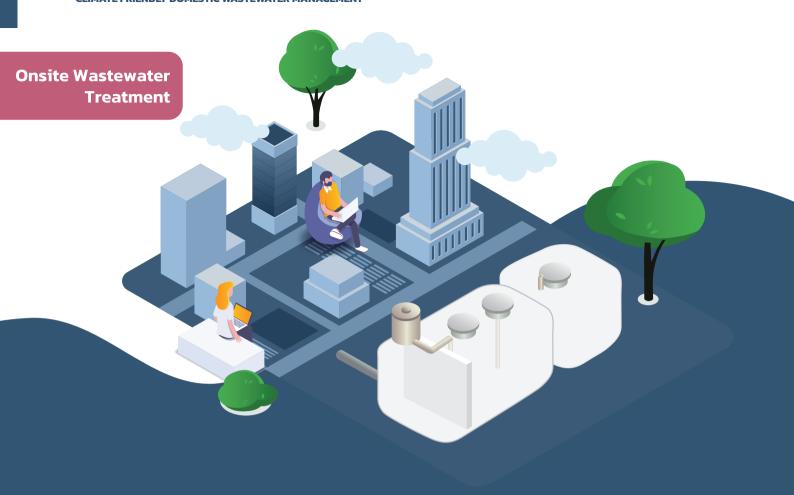
Examples of systems to assess for greenhouse gas emission reduction among technologies for climate-friendly domestic wastewater management consist of:

Onsite wastewater treatment

- Aeration septic tank system
- Johkasou system, a ready-made treatment tank developed in Japan

Centralised wastewater treatment

- Activated sludge process (AS)
- Constructed wetland (CW)



1. AERATION SEPTIC TANK **SYSTEM**

QUICK INFO



An onsite domestic wastewater treatment technology that is widely used in Thailand and generally used as a wastewater treatment system for commercial buildings and large buildings to be able to drain treated effluents that meet standard criteria.



Capable of reducing greenhouse gas emissions compared with septic tanks, which are the baseline.



Utilises aerobic biological wastewater treatment processes that efficiently degrade organic material.



Study area: An aeration septic tank system at the Department of Industrial Engineering Building, Faculty of Engineering, Kasetsart University. The assessment of greenhouse gas emissions through field measurements and calculations compared with the baseline indicates that greenhouse gas emissions were reduced by 35.26% and 24.65%, respectively.

TECHNOLOGY DETAILS

The aeration septic tank system is a small wastewater treatment system installed onsite at the source of the wastewater. It is similar to septic tanks but benefits from an aerobic biological process to degrade organic materials in the wastewater. This onsite wastewater treatment method should be used by small communities, communities without centralised sewage and drainage system and/or communities with decentralised domestic wastewater systems (Pollution Control Department, 2017). The aeration septic tank system is more efficient than common septic tanks that consume very little oxygen, thus providing better quality effluents and achieving the effluent standard.

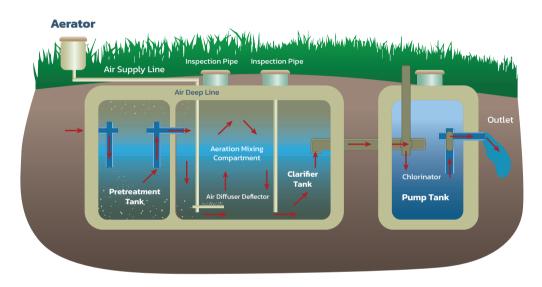


Figure 3.1 Treatment processes occurring within the Aeration Septic Tank system credit: https://www.bbpumpingtx.com/residential-septic-pumping-services

This type of wastewater treatment system is known as a ready-made wastewater treatment tank. It uses an aerobic biological treatment process, or activated sludge process, in the ready-made wastewater treatment tank. Each treatment unit was designed with specific operating characteristics. For example, the primary treatment unit precipitates and separates debris contaminating the influent before it enters the aeration unit where the organic materials

contaminating the wastewater are degraded by aerobic microorganisms; the air diffuser is commonly installed at the tank floor to provide sufficient oxygen for the microorganisms and to ensure complete mixing. The aerated wastewater will then flow through the settling tank where the flocculent will be removed and the treated water will ultimately be discharged from the tank.

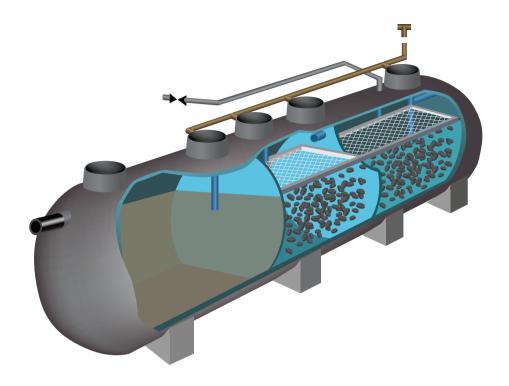


Figure 3.2 Aeration Septic Tank System
(Source : https://www.aqua.co.th/product/ถังบำบัดน้ำเสีย-aqua-compact-aeration-ac)

The treatment tank is commonly made from fibreglass-reinforced plastic (FRP), which is high-strength, lightweight, corrosion-resistant and versatile, making it easy and convenient to fix or change any parts and giving this kind of tank an advantage over treatment systems that must be constructed onsite. Aeration septic tank systems are widely used in Thailand currently to treat wastewater from buildings and households with consistent characteristics to achieve the effluent standards for wastewater before discharging it to public drainage waterways.

GREENHOUSE GAS REDUCTION MECHANISMS

The aeration septic tank treatment method utilises aerobic microorganisms to degrade organic materials in the wastewater. A previous study (Cakir and Stenstorm, 2005) found that this kind of tank is suitable to treat wastewater with BOD values lower than 300 mg/l and directly emits fewer greenhouse gases compared with anaerobic treatment, although it emits indirect greenhouse gases from the electricity consumption for the aeration process. However, the energy consumption could be controlled by adjusting the aerator to suit the amount of influent.

EXAMPLE OF TECHNOLOGY ADOPTED IN THAILAND

AERATION SEPTIC TANK SYSTEM

DEPARTMENT OF INDUSTRIAL ENGINEERING BUILDING, FACULTY OF ENGINEERING, KASETSART UNIVERSITY

This installation is the wastewater treatment system used to treat wastewater from the Department of Industrial Engineering, Faculty of Engineering, Kasetsart University. The building is used for teaching, learning and conducting research as well as office space. The system was operated for about 3 years, since 2018, by the Vehicle and Building Division, Faculty of Engineering, Kasetsart University, which is responsible for its operation and maintenance.



Figure 3.3 Location of technology adopting example

Basic Design Data

• Amount of influent: 65 m³/day

• Influent BOD: 250 mg/l

• Effluent BOD: 20 mg/l

• Treatment unit consisting of solids separation tank, aeration tank and sedimentation tank.

• Tank size: 2.5 m in diameter, 10.5 m long

• Size of aerator: 3.7 kW



Figure 3.4 Location of septic tank aeration system, Industrial Engineering building, Kasetsart University



Figure 3.5 Sampling area of septic tank aeration system



Figure 3.6 Gas sampling method from septic tank aeration system

COMPARISON OF GREENHOUSE GAS REDUCTION CALCULATION

The greenhouse gas emissions from the aeration septic tank system were assessed through field measurements using the closed flux chamber technique alongside the basic system data of the number of users and amount of wastewater, wastewater characteristics, area of the system and amount of electricity consumption. These were compared to the calculation of greenhouse gas emissions using the IPCC methodology. The comparison of both assessment methods of greenhouse gas emission from aeration septic tank system is illustrated in Chart 3.1.

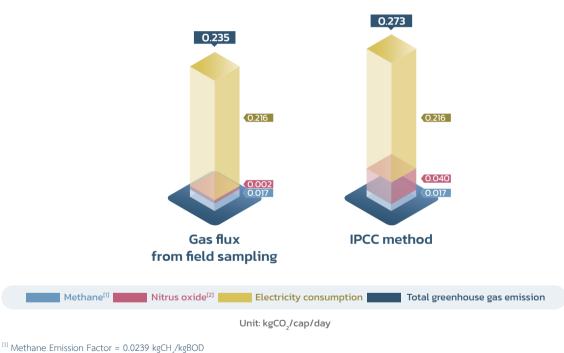


Chart 3.1 Greenhouse gas emissions from Aeration Septic Tank system

Note: Emission Factor fromfield sampling calculation.

From the field measurement, the greenhouse gas emission from the aeration septic tank system was found to be 0.235 kgCO_eq/person/day, whereas the calculated value according to the IPCC is 0.273 kgCO_eq/ person/day.

 $^{{\}rm ^{[2]}\ Nitrous\ Oxide\ Emission\ Factor}=0.0013\ mgN_{\rm _{2}}O-N/kgN\ (influent)\ and\ 0.005\ kgN_{\rm _{2}}O-N/kgN\ (effluent)$

Chart 3.2 Percentage of greenhouse gas emission reductions when comparing
(a) emissions from field measurement and baseline, and (b) emissions from IPCC calculation and baseline



However, when the direct greenhouse gas emissions from the aeration septic tank system from field measurement and calculation are combined with the indirect emissions from electricity consumption and compared with the baseline, the emission reduction is 35.26% and 24.65%, respectively.

LESSON LEARNED FOR TECHNOLOGY DISSEMINATION



Aeration septic tank systems are widely used in Thailand and are known as ready-made wastewater treatment tanks with aerobic biological treatment systems to degrade the organic materials in the wastewater.



The system is easy to operate. It does not require an expert but does require the consistent monitoring of equipment.



The system requires small installation area. The tank has high-strength with lightweight, corrosion-resistant and easy to maintain, fix or change parts.



The electricity costs for the aeration process and energy consumption could be reduced by adjusting the aerator to suit the amount of influent.



As the system must be consistently operated and maintained, these constraints must be considered before system installation by avoiding confined spaces, flood areas or areas close to natural water sources to prevent overflow in case of emergency.

CONCLUSIONS

The aeration septic tank system was installed and operated at the Department of Industrial Engineering Building, Faculty of Engineering, Kasetsart University. In comparing the greenhouse gas emissions from the field measurement and as calculated according to IPCC methodology with the baseline, the emission reduction is 35.26% and 24.65%, respectively.

The aeration septic tank system is easy to operate, has high treatment efficiency, is suitable for commercial and large buildings and requires a small installation area but requires electricity for the aeration process and consistent system operation and maintenance. Therefore, operation convenience and safety must be considered before system installation.

CONTACT INFORMATION OF THE STUDY AREA ORGANISATION

Project location:

Department of Industrial Engineering, Faculty of Engineering, Kasetsart University 50 Ngamwongwan Rd., Lat Yao subdistrict, Chatuchak district, Bangkok 10900

Telephone: 027970999 ext 1603 and 1607





Cakir, F.Y., Stenstrom, M.K., 2005. Greenhouse gas production: a comparison between aerobic and anaerobic wastewater treatment technology. Water Res. 39 (17), 4197–4203.

Pollution Control Department. (Online). **Onsite Treatment.** http://reo06.mnre.go.th/newweb/images/file/report2560/onsite wwtp.pdf (Cited date 30 June 2021)

IPCC 2019, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Calvo Buendia, E., Tanabe, K., Kranjc, A., Baasansuren, J., Fukuda, M., Ngarize S., Osako, A., Pyrozhenko, Y., Shermanau, P. and Federici, S. (eds). Published: IPCC, Switzerland.

Onsite Wastewater Treatment

2.ONSITE WASTEWATER TREATMENT SYSTEM (JOHKASOU TECHNOLOGY)

QUICK INFO



Johkasou is a Japanese term describing a cleaning tank or wastewater treatment tank that is installed onsite. It is widely used in Japan.



As the Johkasou system is not widely used in Thailand, assessment by reviewing the literature and calculating according to IPCC methodology indicates that greenhouse gas emissions are reduced by 34.43% compared with the septic tank baseline.



The system is easy to install and operate. There is a high investment cost as the system must be imported from Japan, as well as electricity costs for the aeration process and system operation and maintenance costs.



The system must be monitored for the operating condition of the aerator and excess sludge must be removed occasionally to avoid creating anaerobic conditions that could lead to methane generation.



TECHNOLOGY DETAILS

"Johkasou" is a Japanese term describing a cleaning tank or wastewater treatment tank that is installed onsite. It is widely used in households with drainage systems that are not connected to the centralised domestic wastewater treatment system. The wastewater from each household drains to the Johkasou treatment system that is installed underground. The treatment process is a combination of aerobic and anaerobic biological processes with an efficiency equivalent to the centralised domestic wastewater treatment system. There are 5 stages in the treatment process: sedimentation, anaerobic treatment, aerobic treatment, filtration and sanitisation.

Various types and sizes of Johkasou system are adopted in Japan depending on the source of the wastewater.

The types of Johkasou systems can be categorised into three scales according to the average number of users:

- (1) Small-scale system for 5–50 persons, maximum capacity of 10 m³/day
- (2) Medium-scale system for 51–500 persons, maximum capacity of 100 m³/day
- (3) Large-scale system for more than 501 persons, capacity of more than 100 m³/day

A small-scale Johkasou system has three stages of wastewater treatment that comply with Japanese standards. First, household wastewater flows through anaerobic filtration, followed by the contact aeration unit. It then flows through the sedimentation unit for solids separation and, lastly, the chlorine tab is added to sanitise the treated water before it is discharged to the environment.

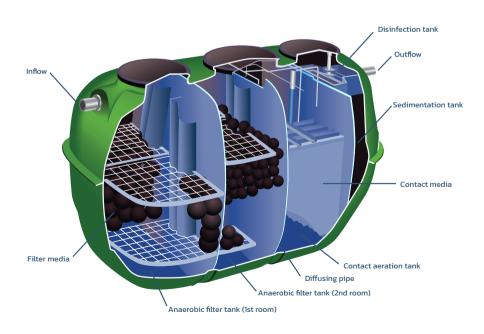


Figure 3.7 Small-scale Johkasou

The medium- and large-scale Johkasou systems can be divided into two groups according to the technology adopted: (1) Biofilm process: contact aeration, rotating biological contactor (RBC) and trickling filter; and (2) Activated sludge process.

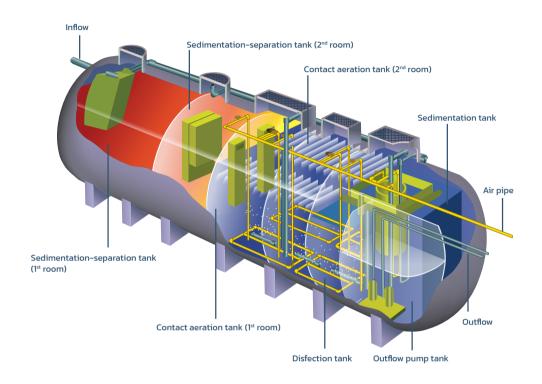


Figure 3.8 Medium or large-scale Johkasou

GREENHOUSE GAS REDUCTION MECHANISMS

The treatment mechanism of the Johkasou system is focused mainly on aerobic wastewater treatment, which is suitable to treat wastewater with a BOD value lower than 300 mg/l and emits fewer greenhouse gases than anaerobic treatment. Indirect greenhouse gases from the electricity consumption in the aeration process could be controlled by adjusting the aerator to suit the amount of influent. However, reducing energy consumption too much

in an aerated system could increase methane generation.

Furthermore, in operating a Johkasou system, the operating conditions must be strictly monitored and excess sludge must be removed appropriately to avoid generating more methane.

EXAMPLE OF TECHNOLOGY ADOPTED IN THAILAND

JOHKASOU SYSTEM

RUK SINGWADLOM DORMITORY, ENVIRONMENTAL RESEARCH AND TRAINING CENTRE PATHUM THANI PROVINCE

The Johkasou system in Thailand was installed and operated at the Ruk Singwadlom dormitory in the Environmental Research and Training Center. The dormitory was constructed over 20 years ago with 46 rooms. Most of the residents stay during the weekday and about half stay over the weekend. The average water consumption is about 160–170 litres/person/day.





Figure 3.9 Ruk Singwadlom dormitory, Environmental Research and Training Center, Pathum Thani province



Figure 3.10 Johkasou system for treating wastewater from Ruk Singwadlom dormitory

The wastewater load capacity of the system was designed to be about 10 m³/day. The installed ready-made tank has a maximum capacity of 15 m³/day at a BOD value of 250 mg/l.

The Johkasou system was affected by severe flooding in 2011 and was rehabilitated to operate normally. The efficiency assessment found that the system has average influent and effluent BOD values of 103 and 4 mg/l, respectively, which affirms a treatment efficiency of 95%. The effluent quality

meets the standard. In addition, the system can reduce the total coliform bacteria from 200,000 to 4,000 cfu/ml. The electricity consumption in operating the system is about 8 kW/day and is mainly used for aeration and pumping (ERTC, 2013).

COMPARISON OF GREENHOUSE GAS REDUCTION CALCULATION

As the Johkasou system is not widely used in Thailand, the greenhouse gas assessment was conducted by reviewing the literature. The gathered data include wastewater treatment stages, the type of system, the intensity of operation and the amount of nitrogen in wastewater calculated from the protein consumption of Thai people (National

Statistical Office, Thailand and Agricultural Census, 2013); the greenhouse gas emissions of Johkasou systems taken from Japanese research (GIO, CIER and NIES Japan, 2019) and the system's electricity consumption. The assessed greenhouse gas emissions of a Johkasou system with a wastewater load of 70 m³/day is illustrated in Chart 3.3.

Chart 3.3 Greenhouse gas emissions from Johkasou system

0.238

0.199

Johkasou System

Methane⁽¹⁾

Nitrus oxide⁽²⁾

Electricity consumption

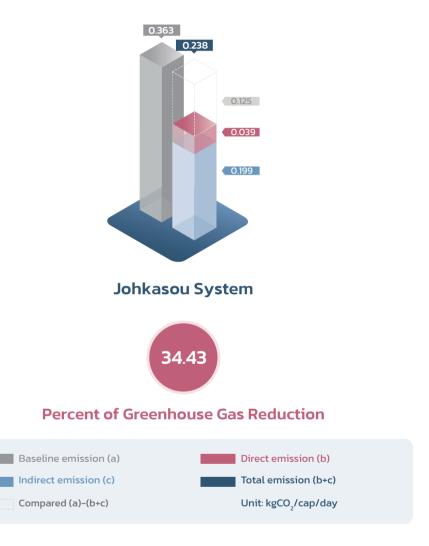
Total greenhouse gas emission

Unit: kgCO₂/cap/day

^[1] Methane Emission Factor = 0.0068 kgCH4/kgBOD

^[2] Nitrous Oxide Emission Factor = 0.005 kgN2O-N/kgN (effluent)

Chart 3.4 Percentage of greenhouse gas emission reduction comparing between Johkasou system and baseline of septic tank system



The calculation shows that the Johkasou system emits $0.238~kgCO_2eq/person/day$. Chart 3.4~compares the greenhouse gas emission reduction of the Johkasou system and the septic tank baseline. The total emissions of the Johkasou system, inclusive of indirect emissions from electricity consumption, were reduced by 34.43% compared with septic tank treatment.

LESSONS LEARNED FOR TECHNOLOGY DISSEMINATION



Johkasou is an onsite wastewater treatment system offering a complete treatment process in the tank with high treatment efficiency.



As the Johkasou system is not widely used in Thailand, the assessment was mainly conducted by reviewing the literature.



In Japan, standards and regulations for Johkasous system have been promoted and are widely used throughout the country.



A Johkasou system can substitute for septic tank or anaerobic wastewater treatment systems to treat wastewater onsite especially when the wastewater collection system is unavailable, as it provides an equivalent treatment efficiency to the centralised wastewater treatment system.



There are an electricity cost in the aeration process and system operation and maintenance costs, as well as having a high installation cost as it must be imported from Japan.



The system must be strictly monitored. Without proper operation and maintenance or the correct removal of excess sludge, the system can generate methane.

CONCLUSIONS

The Johkasou system is a wastewater treatment system that is widely used in buildings and households in Japan. Its efficiency in treating wastewater is equivalent to a centralised wastewater treatment system. The assessment by reviewing the literature and calculating according to IPCC methodology indicates that greenhouse gas emissions are reduced by 34.43% compared with the septic tank baseline.

Johkasou is a high-efficiency onsite wastewater treatment system that requires consistent and appropriate operation and maintenance. Therefore, specific training in Japan must be organised for the installer, inspector and plant operator. The system has a high investment cost as it must be imported from Japan, as well as having electricity costs for the aeration process.

CONTACT INFORMATION OF THE STUDY AREA ORGANISATION

Environmental Research and Training Center, Department of Environmental Quality Promotion Technopolis, Khlong 5 sub-district, Khlong Luang district, Pathum Thani 12120 Telephone: 025771136-7, 025774182-9

E-mail : ertc.help@gmail.com www.ertc.deqp.go.th





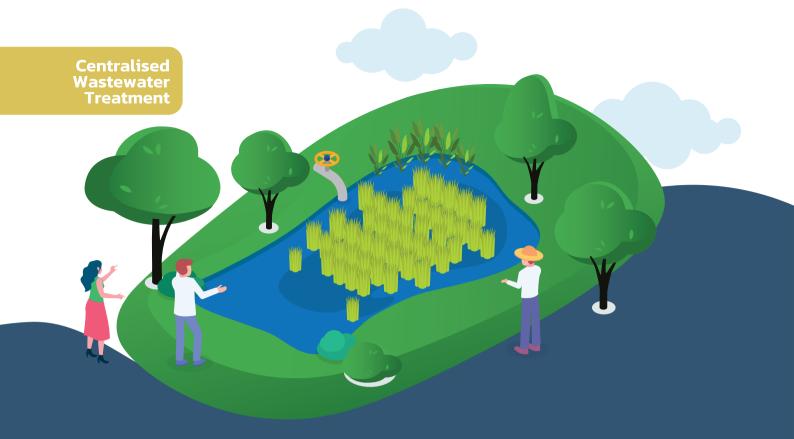
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3. CONSTRUCTED WETLAND

QUICK INFO



A constructed wetland is the wastewater treatment system that carries oxygen to plants' roots, where the microorganisms living around the roots and in the soil will aerobically digest organic materials, thus reducing the methane generation.



Study area: The royal-initiated Laem Phak Bia environmental research and development project is located in the Ban Laem District of Petchaburi Province. It is a constructed wetland that can treat wastewater efficiently. The average GHG emission is 0.034 kgCO₂eq/person/day, accounted as 45.49 % GHG emission reduction as compared to the baseline wastewater treatment by a facultative stabilization pond.



Constructed wetlands are easy to operate and maintain as they are natural wastewater treatment systems with low energy consumption and having low construction and maintenance costs.



The soil surface qualities must be monitored consistently and the plants in the system must be pruned regularly after flowering to support the plants' growth, treatment efficiency and control anaerobic conditions that generate methane.

DETAILS OF TECHNOLOGY/WASTEWATER TREATMENT SYSTEM

A constructed wetland is a wastewater treatment system that utilises plants for treatment. The plants' roots act as a medium for microorganisms that degrade the organic material contaminating wastewater.

To operate the system, the wastewater is collected in plant beds or flowed through the system and the flow rate is controlled for a retention time of at least 24 hours. The most common plants utilised in wastewater treatment are bulrushes, canna lilies and Cyperus papyrus.

TYPES OF CONSTRUCTED WETLAND (IPCC, 2014)

1. Constructed wetlands with surface flow

are systems that utilise the flow of surface water in an open area with growing aquatic plants. The water is shallow and these are commonly used for tertiary treatment of domestic wastewater for nutrient removal, e.g., nitrogen.

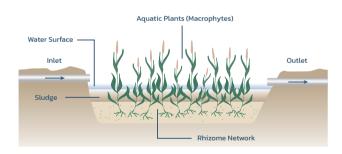


Figure 3.11 Constructed wetlands with surface flow (adapted from Patrick Onyango and Orodi Odhiambo,2009)

2. Constructed wetlands with subsurface flow

2.1 Horizontal subsurface flow (HSSF)

In HSSF, the wastewater flows slowly through a porous medium, e.g., gravel or sand. This kind of system usually employs emergent plants. The basin is sealed with a liner to prevent wastewater seepage. These systems are commonly used for secondary treatment to remove organic material from wastewater. The treatment is facultative; the upper portion is under aerobic conditions and the lower portion is anaerobic.

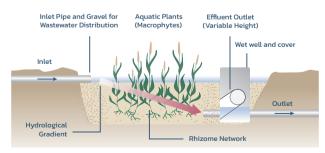


Figure 3.12 Horizontal subsurface flow (HSSF) (adapted from Patrick Onyango and Orodi Odhiambo,2009)

2.2 Vertical subsurface flow (VSSF)

In VSSF, the wastewater floods and percolates through the medium, e.g., gravel or sand, and growing plants support the treatment. When wastewater flows through the medium, air refills the spaces in the bed. These systems are commonly used for secondary treatment and provide more oxygen than systems with surface flow or horizontal subsurface flow.

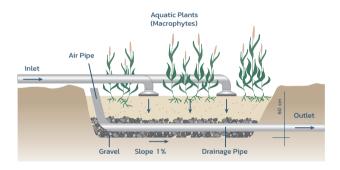


Figure 3.13 Constructed wetlands with vertical subsurface flow (VSSF) (adapted from Patrick Onyango and Orodi Odhiambo,2009)

In Thailand, constructed wetlands are popular secondary or tertiary wastewater treatment systems after stabilisation ponds. As these systems require large areas, they are usually located in suburbs.

About ten constructed wetlands are currently in operation; seven of them are constructed wetlands alone, two of them are combined with a stabilisation pond and one is used for tertiary treatment after

an activated sludge process. Additionally, one more project in operation is a research study area for developing constructed wetlands wastewater treatment systems and is also known as the royal-initiated Laem Phak Bia environmental research and development project.

GREENHOUSE GAS REDUCTION MECHANISMS

Constructed wetlands are usually designed to be shallow as they utilise plants to treat wastewater, so the amount of influent and water level must be controlled to suit the stem and root lengths of each kind of plant. Oxygen transfer between the water surface and plants' roots provides high levels of oxygen for the treatment conditions, thus the methane generation is lower than other wastewater treatment systems that have limited natural oxygen transfer, such as stabilisation ponds.

Furthermore, controlling plants' growth and harvesting at the appropriate times are necessary to support the plants' continuous growth in the system, better supporting oxygen transfer to reduce greenhouse gas generation.

EXAMPLE OF TECHNOLOGY ADOPTED IN THAILAND

THE ROYAL-INITIATED LAEM PHAK BIA ENVIRONMENTAL RESEARCH AND DEVELOPMENT PROJECT



The royal-initiated Laem Phak Bia environmental research and development project receives the wastewater from Petchaburi municipality to treat. The project has four types of wastewater treatment systems comprising an oxidation pond, plant and grass filtration, constructed wetland and mangrove forest filtration.

The constructed wetland includes seven surface flow beds; three are planted with bulrushes, three with Cyperus papyrus and one with canna lilies (The royal-initiated Laem Phak Bia environmental research and development project, 2021). The treated wastewater is further drained through the mangrove forest located in the project area.



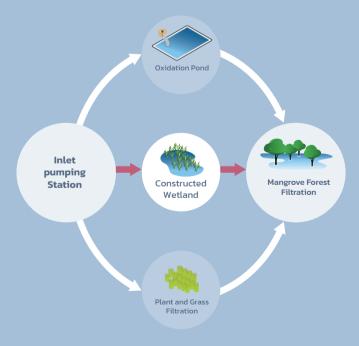


Figure 3.14 The royal-initiated Laem Phak Bia environmental research and development project



Figure 3.15 Constructed wetlands under the royal-initiated Laem Phak Bia environmental research and development project

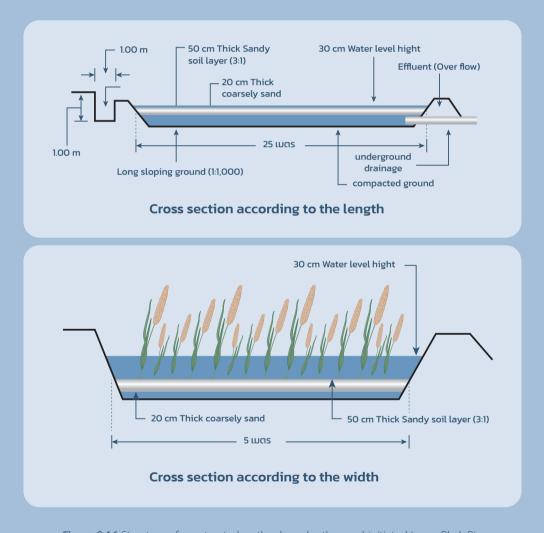


Figure 3.16 Structure of constructed wetlands under the royal-initiated Laem Phak Bia environmental research and development project

COMPARISON OF GREENHOUSE GAS REDUCTION CALCULATION

The greenhouse gas emission assessment was conducted by reviewing the existing data dating back 36 months. The greenhouse gas emissions were assessed directly from the wastewater treatment system at the plant growing area, which is the stage in which organic material is degraded. The details of the greenhouse gas assessment follow.

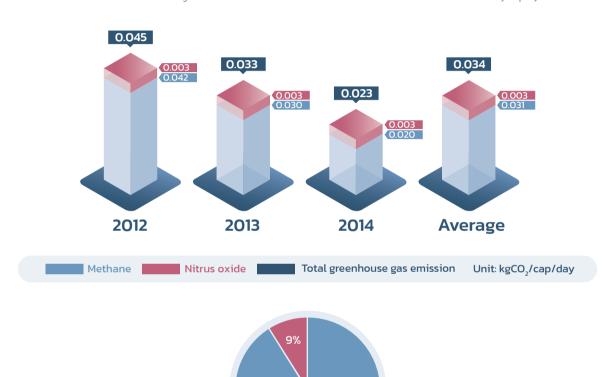


Chart 3.5 Greenhouse gas emissions from constructed wetlands of the Laem Phak Bia royal project

The wastewater treatment system of the royal-initiated Laem Phak Bia project was designed with surface flow and greenhouse gas emissions equal to 0.034 kgCO₂/person/day.

The greenhouse gas emissions from the constructed wetlands of the royal-initiated Laem Phak Bia project compared with the baseline of a facultative stabilisation pond are shown in Chart 3.6.

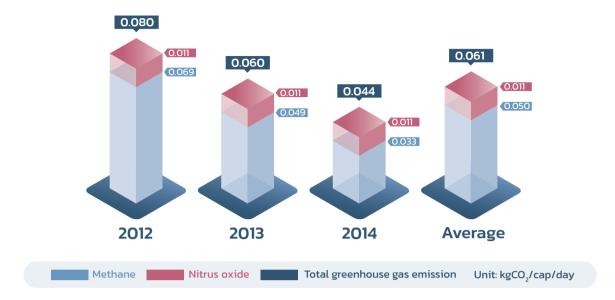


Chart 3.6 Greenhouse gas emissions from facultative stabilization pond

Chart 3.7 Percentage of greenhouse gas reduction from constructed wetlands compared to the baseline of facultative stabilization pond



From Chart 3.7, the amount of GHG reduction from the royal-initiated Laem Phak Bia project is 45.49% when compared with the compared with the baseline of a facultative stabilisation pond.

LESSONS LEARNED FOR TECHNOLOGY DISSEMINATION



Constructed wetlands utilise plants to facilitate wastewater treatment. They efficiently remove nutrients such as nitrogen and phosphorus. They are usually located in suburbs and have low construction and maintenance costs.



Constructed wetlands are a wastewater treatment system that consumes little energy, does not require much machinery or equipment and is in harmony with nature, thus creating ecosystem area due to the large planting area and improving the scenery compared with other wastewater treatment systems.



Before implementing these systems, the soil properties and suitable plant species must be studied and selected. In addition, the soil surface qualities must be maintained consistently and the plants must be harvested at the appropriate times to maintain system efficiency. The plants must be kept alive to preserve treatment efficiency as well as avoid the accumulation of plant mass, which is organic material in the system that can lead to anaerobic degradation and greater methane generation.



The products from constructed wetlands can be further utilised; for instance, the harvested plants can be used to produce basketwork, paper pulp and composted fertiliser. This can be considered another way to create benefits and income.



CONCLUSIONS

The example constructed wetland is the royal-initiated Laem Phak Bia project in Petchaburi Province. The project investigates both solid waste management and domestic wastewater treatment, as well as acting as a learning centre for interested people to learn about project implementation. The greenhouse gas emission assessment of the constructed wetlands found that the system can reduce greenhouse gases by 45.49% compared with the baseline of facultative stabilisation ponds.

Constructed wetlands are easy to operate with low construction and maintenance costs as they do not require electricity to operate. They are suitable for large spaces. There must be a consistent operation and maintenance to keep up the wastewater treatment efficiency such as maintaining the soil surface qualities and harvesting plants at appropriate times in order to support a plant growth and avoid the accumulation of plant mass, which could lead to greater methane generation.

CONTACT INFORMATION OF THE STUDY AREA ORGANISATION

Project location:

The royal-initiated Laem Phak Bia environmental research and development Project, Ban Paneon, Laem Phak Bia subdistrict, Ban Laem district, Petchaburi 76100

Telephone: 025792116 Email: lerd.in.th@gmail.com

Website: https://www.facebook.com/LERDProject







Project Coordination Office Area 1. (Online). Laem Phak Bia Environment Research and Development Project under the Royal Initiative Ban Laem District Phetchaburi Province. https://cutt.ly/RE4gFr0 (Cited date 30 June 2564)

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4. ACTIVATED SLUDGE PROCESS

QUICK INFO



The activated sludge process is a widely used wastewater treatment system in which microorganisms degrade organic material under aerobic conditions. The main treatment process is comprised of two stages, aeration and sedimentation.



Study area: Din Daeng wastewater treatment plant, Din Daeng District, Bangkok. The plant emits an average of 0.089 kgCO₂/person/day, with a reduction of 52.24% and 75.57% emissions compared with the baselines of facultative stabilisation ponds and septic tanks, respectively.



With constant aeration and mixing throughout the process, the treatment conditions have high oxygen levels, resulting in low methane generation. However, the indirect GHG emission is high due to energy and electricity consumption via the aerator and pump.



These systems must be monitored closely and maintained the equipment regularly by skilled operators.

Activated sludge systems are highly efficient in treating wastewater and have high loading capacities. The operating system can be adjusted to control a quality of effluent for wastewater standards compliance. The system requires a small area but has high construction and operating costs as it requires equipment including aerators, sludge scrapers and water and sludge pumps. In addition, excess sludge must be drained from the system and disposed of appropriately.

TECHNOLOGY DETAILS

The activated sludge process is a wastewater treatment system that is widely used to treat domestic wastewater. The treatment utilises aerobic microorganisms to degrade organic material under aerobic conditions. This system is highly efficient and requires a small area but has high construction and operating costs and requires skilled operators.

The activated sludge process can be categorised according to the operating pattern of each tank as follows:

- 1. Completely mixed process
- 2. Contact stabilisation process
- 3. Oxidation ditch process
- 4. Sequencing batch reactor process

The sub-processes of the activated sludge process can be divided into two main processes as follows:

- Aeration process: Increase the amount of oxygen in wastewater, supporting the microorganisms in biodegrading organic matter.
- 2. Sedimentation process: Separating treated wastewater from the aeration tank into sludge and clear water. The sludge will be further divided into two parts: (1) return sludge: will be pumped back to the aeration tank to maintain the microorganism concentration and (2) excess sludge: will be drained out of the system for further disposal (Pollution Control Department, 2015 and Santad, 2006).

In Thailand, activated sludge wastewater treatment systems are widely used throughout the country, especially in large communities. There are currently 48 activated sludge plants with load capacities ranging from 400–360,000 m³/day. Of these, 11 plants are located in Bangkok and three of them

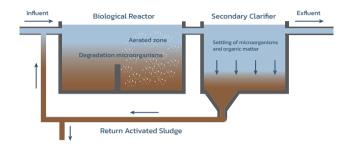


Figure 3.17 Wastewater treatment process in Activated Sludge System

are under construction (The Office of Natural Resources and Environmental Policy and Planning, 2021).

GREENHOUSE GAS REDUCTION MECHANISMS

The activated sludge process utilises oxygen for treatment by using an aerator as well as mixing the wastewater and microorganisms in the aeration tank. Thus, the microorganisms can completely use the oxygen to degrade organic material in the wastewater. As the process involves high levels of oxygen, it generates a very low amount of methane but indirectly emits greenhouse gases through the electricity consumption of the aerator and water and sludge pumps.

EXAMPLE OF TECHNOLOGY ADOPTED IN THAILAND

DIN DAENG WASTEWATER TREATMENT PLANT, BANGKOK





PROJECT DETAILS

Basic information

System type: Biological activated sludge process

with nutrients removal Catchment area: 37 km²

Treatment capacity: 350,000 m³/day Current influent: 234,264 m³/day (Average value from 2018 – 2020) Sewer pipe length: 63 kilometres Carrying capacity: 1,080,000 persons

Current carrying capacity: 438,037 persons

(Average value from 2018 - 2020)

The Din Daeng wastewater treatment plant in Din Daeng District, Bangkok is one of the plants operated by the Water Control System Office, Drainage and Sewerage Department, Bangkok Metropolitan Administration, which treats wastewater from community areas, households and commercial buildings. The system is a biological activated sludge process with nutrient removal.



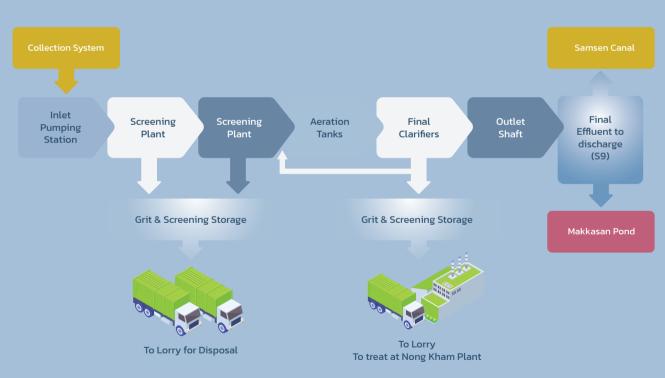


Figure 3.18 Din Daeng wastewater treatment plant, Bangkok

COMPARISON OF GREENHOUSE GAS REDUCTION CALCULATION

THE ASSESSMENT OF GREENHOUSE GAS EMISSIONS FROM DIN DAENG WASTEWATER TREATMENT PLANT

The greenhouse gas emission assessment was conducted by reviewing the existing data dating back 36 months. The greenhouse gas emissions were assessed directly from the wastewater treatment system at the aeration tank. As the activated sludge process involves high oxygen loading during treatment, the methane emissions were not assessed but the nitrous oxide generated by nitrogen transformation was. There are also indirect greenhouse gas emissions from the electricity consumption of aerator as well as water and sludge pumps. The assessment results are illustrated in Chart 3.8.

Nitrus oxide

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D.093

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Chart 3.8 Greenhouse gas emissions from activated sludge process of Din Daeng wastewater treatment plant

Greenhouse gas emissions from Din Daeng wastewater treatment plant

71%

Additionally, the data on the wastewater characteristics obtained from the Din Daeng wastewater treatment plant were used to calculate the greenhouse gas emission at baseline condition of a facultative stabilisation pond. Facultative stabilisation ponds include both aerobic and anaerobic conditions, so they emit both methane and nitrous oxide during the treatment process, but these systems do not consume electricity for aeration. The greenhouse gas emissions are shown in Chart 3.9.

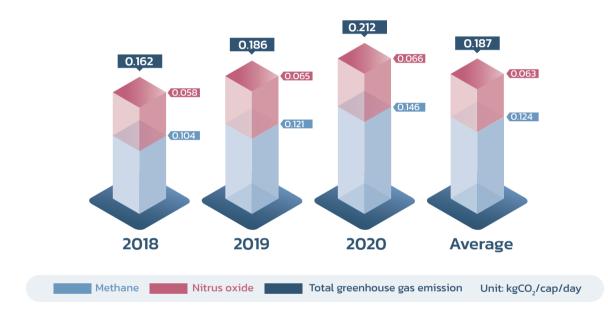
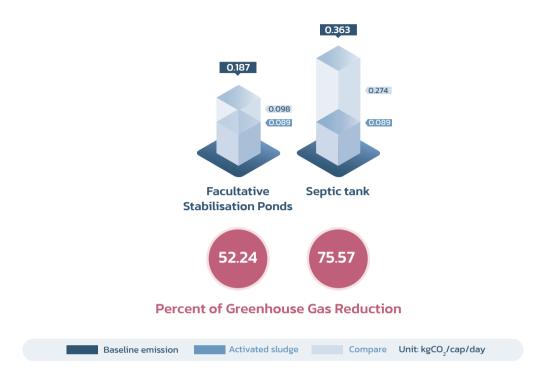


Chart 3.9 Greenhouse gas emissions from semi-aerated stabilisation pond

To assess the greenhouse gas reduction capacity of the activated sludge process as an alternative technology in centralised domestic wastewater treatment systems, the greenhouse gas emissions are compared with data from facultative stabilisation ponds and, cases of shifting from onsite wastewater treatment to centralised wastewater treatment, the

emissions are compared with data from septic tanks. The percentage of greenhouse gas emission reduction from adopting the activated sludge process is shown in Chart 3.10.

Chart 3.10 Comparison of reduction of greenhouse gas emissions from activated sludge process of Din Daeng wastewater treatment plant to facultative stabilization pond and septic tank



The data on greenhouse gas emission reduction from adopting activated sludge technology compared with the baseline can be summarised as follows:

- 1. Compared with facultative stabilisation ponds, the activated sludge process uses an aerator, which results in high oxygen levels and reduced methane in the system but emits indirect greenhouse gases from the electricity consumption. The activated sludge process can reduce greenhouse gas emissions by 52.24% compared with the baseline of facultative stabilisation ponds.
- 2. Compared with septic tanks in cases of onsite wastewater treatment, as there is no aeration in the septic tank, the methane is generated directly in the system; although there is no methane generation in the activated sludge process, it emits indirect greenhouse gases through electricity consumption.

The activated sludge process can reduce greenhouse gas emissions by 75.57% compared with the baseline of septic tanks.

In conclusion, the activated sludge process can reduce greenhouse gas emissions directly from the wastewater sector. However, due to its electricity consumption, the indirect greenhouse gas emissions would increase in the energy sector.

When considering adopting the activated sludge process, the wastewater treatment system area, efficiency of domestic wastewater treatment and the possibility of collecting wastewater in a central unit must be considered. However, the activated sludge process is an alternate climate-friendly technology for treating domestic wastewater.

LESSONS LEARNED FOR TECHNOLOGY DISSEMINATION



The activated sludge process is a widely used wastewater treatment system that requires a small area and has high treatment efficiency, but it requires electricity to operate equipment such as aerators and water and sludge pumps. Therefore, the construction and operating costs are higher than natural technologies such as stabilisation ponds.



The treatment conditions of the activated sludge process can be controlled according to influent characteristics.



Activated sludge systems require skilled operators to treat wastewater efficiently.



The activated sludge process may require some preliminary treatment such as static screen filters and grit removal to prevent damage to the equipment from debris passing through the system.



The system is highly efficient in treating high loads of organic material and can be designed to remove nutrients such as nitrogen and phosphorus as well. Good operational control is necessary and the excess sludge must be disposed of.



The activated sludge process can be modified to increase its capacity for greenhouse gas emission reduction by controlling the aeration period to suit the amount of influent and save energy. However, sufficient oxygen concentration must be ensured to avoid anaerobic conditions that would generate methane.

CONCLUSIONS

A good example of the activated sludge process in Thailand is the Din Daeng wastewater treatment plant in Bangkok. The plant fully treats wastewater from influent to effluent. The assessment of greenhouse gas emissions was conducted directly from the treatment system and indirectly from the electricity consumption for aeration and water and sludge pumping. Activated sludge is an aerobic process with sufficient oxygen to avoid methane generation. As a result, this system produces lower direct greenhouse gas emissions compared with other systems. However, the indirect greenhouse gas emission from energy consumption is higher than the baselines of stabilisation ponds or septic tanks. The activated sludge process of the Din Daeng wastewater treatment plant can reduce greenhouse gas emissions by 52.24% and 75.57% compared with the baselines of stabilisation ponds and septic tanks, respectively.

The activated sludge process is a wastewater treatment system that requires a small area, making it suitable for urban areas, and is highly efficient in treating high organic load domestic wastewater. However, the system requires electricity for aeration and water and sludge pumping, so the operating cost is higher than natural treatment systems. The system must be monitored closely and maintained the equipment regularly by skilled operators.

In summary, the operating system must be designed and chosen to be appropriate to the amount and characteristics of the wastewater to treat as well as to ensure consistent equipment operation and maintenance. Greenhouse gas emissions can be reduced through energy-saving measures but anaerobic conditions must be strictly avoided to prevent methane generation.

CONTACT INFORMATION OF THE STUDY AREA ORGANISATION

Project location:

Din Daeng wastewater treatment plant, Mit Maitri Rd., Din Daeng, Bangkok 10400

Address: Water Control Systems Office, 3rd floor

Drainage and Sewerage Department Building, 123 Mit Maitri

Rd., Din Daeng, Bangkok 10400

Telephone: 022485037, 022485057





Office of Natural Resource and Environment Policy and Planning. (Online). Information on project management monitoring and evaluation under the Integrated Waste and Environment Plan. http://waste.onep.go.th/wwt.php (Cited date 30 June 2021)

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APPENDIX

THE EQUATIONS FOR CALCULATING GOOD PRACTICES AND TECHNOLOGIES FOR CLIMATE-FRIENDLY DWW MANAGEMENT (PTCMs)

Good practices and technologies for climate-friendly	Equations	Source of equations
Septic Tank	1. CH ₄ Emission • TOW = P x BOD x I x 0.001 x 365 • EF = BO x MCF 2. N ₂ O Emission • TNDOM = P x Protein x FNPR x FNON-CON x FIND-COM	2019 IPCC Guidelines
	Field Sampling: • Gas Concentration (mg/m³) = $\frac{\left(\frac{Cppm}{10^{S}}\right) \left(MW\right) \left(1000 \frac{mg}{g}\right)}{\frac{RT}{P}}$	(Diaz-Valbuena et al., 2011)
Aeration septic Tank	1. GHG flux in Septic Zone • GHG flux (g/cap.day) = $\frac{(m) (V_{f_c}) (A_{comp})(86400 \text{ sec/d})}{(1000 \text{ mg/g}) (SA_{f_c})(capita)}$	Harold et al.,2010
	2. GHG flux in Aeration Zone • GHG flux (g/ m².day) = $\frac{(Average C)}{(Q_{airflow}/Area)}$	(Diaz-Valbuena et al., 2011)
	3. Emission factor calculation • Methane Emission Factor (kgCH ₄ /kgBOD) = (Total CH ₄ Emission) (TOW)	
	• Nitrous Oxide Emission Factor (kgN ₂ O-N/kgN) = $\frac{(Total N_2O Emission)}{(N_j)}$	

Good practices and technologies for climate-friendly	Equations	Source of equations
Aeration septic Tank	Aeration septic Tank GHG estimation using 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories 1. CH ₄ Emission • TOW = P × BOD × I × 0.001 × 365 • EF = BO × MCF 2. N ₂ O Emission • TN _{DOM} = Q × TN _{inf} × 0.001 × 365 • N ₂ O _{PlantsDOM} = EF × TN _{DOM} × (44/28) • N ₂ O _{EFFLUENT,DOM} = N EFFLUENT,DOM × EF _{EFFLUENT} × (44/28)	
	3. Indirect GHG emission • Greenhouse Gas Emission = Electric Consumption x Emission Factor	TGO
Johkasou	1. CH ₄ Emission • TOW = P x BOD x I x 0.001 x 365 • EF = B ₀ x MCF 2. N ₂ O Emission	2019 IPCC Guidelines
	TN _{DOM} = P x Protein x F _{NPR} x F _{NON-CON} x F _{IND-COM} 3. Indirect GHG emission Greenhouse Gas Emission = Electric Consumption x Emission Factor	TGO
Facultative Stabilization Pond	1. CH ₄ Emission • TOW = P x BOD x I x 0.001 x 365 • EF = B0 x MCF 2. N ₂ O Emission • TN _{DOM} = Q x TN _{inf} x 0.001 x 365 • N ₂ O _{PlantsDOM} = EF x TN _{DOM} x (44/28) • N ₂ O _{EFFLUENT,DOM} = N _{EFFLUENT,DOM} x EF _{EFFLUENT} x (44/28)	2019 IPCC Guidelines
Activated Sludge	1. N ₂ O Emission • TN _{DOM} = Q x TN _{inf} x 0.001 x 365 • N ₂ O _{PlantsDOM} = EF x TN _{DOM} x (44/28) • N ₂ O _{EFFLUENT,DOM} = N _{EFFLUENT,DOM} x EF _{EFFLUENT} x (44/28) 2. Indirect GHG emission	
Constructed Wetland	 Greenhouse Gas Emission = Electric Consumption x Emission Factor 1. CH₄ Emission TOW = P x BOD x I x 0.001 x 365 EF = B₀ x MCF 	IDGG 2014
	2. N ₂ O Emission • TN _{DOM} = Q x TN _{inf} x 0.001 x 365 • N ₂ O _{emission} = EF x TN _{DOM} x (44/28) • N ₂ O _{EFFLUENT,DOM} = N x EF x (44/28)	IPCC,2014 (Wetlands)



Α

AR5 or IPCC AR5 (The Fifth Assessment Report) provides a clear and up to date view of the current state of scientific knowledge relevant to climate change. It consists of three Working Group (WG) reports and a Synthesis Report (SYR) which integrates and synthesizes material in the WG reports for policymakers. The SYR has been published in 2014 (EEA, 2022; IPCC, 2014).

В

Baseline is the emission case refer to the production of greenhouse gases that have occurred in the past and which are being produced prior to the introduction of any strategies to reduce emissions. The baseline measurement is determined over a set period, typically one year (Encyclopedia, 2019).

BAU: Business as usual is a base case for emissions projection that would result if future development trends followed those of the past and no changes in policies take place (Silva–Send, 2015).

BE: Baseline Emission is often found in equations for calculating the emission reduction that will occur in CDM projects, the equation is as follows:

Emission reduction (ER) = Baseline emission (BE) - Project emission (PE) - Leakage (L)

C

CDM: Clean Development Mechanism, defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one ton of CO₂, which can be counted towards meeting Kyoto targets (UNCC, 2022).

Climate is the average weather in each area over a longer period of time. A description of a climate includes information on, e.g., the average temperature in different seasons, rainfall, and sunshine. Also, a description of the (chance of) extremes is often included. The classical period used for describing a climate is 30 years, as defined by the World Meteorological Organization (WMO) (Climateurope, 2020).

Climate change is any systematic change in the long-term statistics of climate variables such as temperature, precipitation, pressure, or wind sustained over several decades or longer. Climate change can be due to natural external forcings (changes in solar emission or changes in the earth's orbit, natural internal processes of the climate system) or it can be human induced (Climateurope, 2020).

CO₂eq: Carbon dioxide equivalent is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential (GWP), by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential, for example, Methane has a GWP 28 times that of CO2 equivalent (Eurostat, 2017; EPA, 2021).

D

Е

Emission is something that has been emitted—released or discharged. In general, emissions consist of things like gas, liquid, heat, sound, light, and radiation. Emission can arise from different activities and natural sources such as burning fuel for energy, industrial processes, some farm activities, and deforestation (IPCC, 2019).

Emission factor is a coefficient that allows converting activity data into GHG emissions. It is the average emission rate of a given source, relative to units of activity or process/processes (EPA, 2022).

F

FOD: First Order Decay is the method for estimating CH4 emissions from solid waste disposal sites (SWDS). This method assumes that the degradable organic component (degradable organic carbon, DOC) in waste decays slowly throughout a few decades, during which CH_a and CO₃ are formed (Frey et al., 2006).

G

GHGs: Greenhouse Gases is any gas that has the property of absorbing infrared radiation (net heat energy) emitted from Earth's surface and reradiating it back to Earth's surface, thus contributing to the greenhouse effect. Carbon dioxide, methane, and water vapor are the most important greenhouse gases. (To a lesser extent, surface-level ozone, nitrous oxides, and fluorinated gases also trap infrared radiation.) (Mann, 2021).

Global warming refers to the rise in global temperatures due mainly to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere (GISS, 2022).

Greenhouse effect is a natural process that warms the Earth's surface. When the Sun's energy reaches the Earth's atmosphere, some of it is reflected back to space and some is absorbed and re-radiated by greenhouse gases. The absorbed energy warms the atmosphere and the surface of the Earth. If the concentrations of greenhouse gases are increasing. This is increasing the greenhouse effect, which is contributing to the warming of the Earth (Australian Department of Agriculture, Water and the Environment, 2021; UCAR SciEd, 2022).

Greenhouse Gas Inventory or GHG-I is an accounting of greenhouse gases (GHGs) emitted to or removed from the atmosphere. An inventory will list, by source, the number of pollutants emitted to the atmosphere during a given period (annual emission estimates from a base year to the latest year) (EPA, 2022).

Grid Emission factor refers to a $\rm CO_2$ emission factor ($\rm tCO_2/MWh$) which will be associated with each unit of electricity provided by an electricity system. It is a parameter to determine the baseline emissions for CDM projects in the renewable energy sector (hydro, wind, solar PV, geothermal power, etc.). The grid emission factor of Thailand's transmission system in 2018 was 0.5290 tCO₂/MWh for electricity producers and 0.4872 tCO₂/MWh for electricity users (Takahashi and Louhisuo, 2021).

GWP: Global Warming Potential was developed to allow comparisons of the global warming impacts of different gases. Specifically, it is a measure of how much energy the emissions of 1 ton of a gas will absorb over a given period, relative to the emissions of 1 ton of carbon dioxide (CO_2). The IPCC's The Fifth Assessment Report (AR5) defined the GWP of CO_2 , CH_4 , N_2O , CF_4 , HFC-152a as 1, 28, 265, 6630, 138, respectively.) (EPA, 2021).

н
I
IPCC: Intergovernmental Panel on Climate Change is the UN body for assessing the science related to climate change. It was established by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988 to provide political leaders with periodic scientific assessments concerning climate change, its implications, and risks, as well as to put forward adaptation and mitigation strategies (United Nations, 2021).
J
К
L
М
N
National Greenhouse Gas Inventory is part of the UNFCCC management of GHG emissions. Inventories are used to monitor progress towards reduction targets and to enable countries to access climate finance mechanisms (Wartmann, 2017).
0
Р
Q
R
S
Т
TGO: Thailand Greenhouse Gas Management Organization (Public Organization) was established in 2007 under the Ministry of Natural Resources and Environment, as an autonomous public organization in accordance with Thai law to manage and expedite development and implementation of greenhouse gas reduction projects and support public, private and international organization partnerships to promote implementation of climate action (TGO, 2019).
U
UNFCCC: United Nations Framework Convention on Climate Change sets out the basic legal framework and principles for international climate change cooperation with the aim of stabilizing atmospheric concentrations of greenhouse gases (GHGs) to avoid "dangerous anthropogenic interference with the climate system" (ENB, 2021).
V, W, X, Y, Z



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คำที่ใช้ในรายงานภาษาอังกฤษ	คำแปลภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง	
A				
Activated Sludge (AS)	ระบบตะกอนเร่ง	ระบบตะกอนเร่ง		
Activated Sludge Tanks	ถังเลี้ยงตะกอน	ถังเลี้ยงตะกอน	สำนักงานจัดการคุณภาพน้ำ	
Activity data	ข้อมูลกิจกรรม	ข้อมูลกิจกรรม		
Aerated Grit Channels	ถังดักกรวดทราย	ถังดักกรวดทราย	สำนักงานจัดการคุณภาพน้ำ	
Aerated Lagoon (AL)	บ่อเติมอากาศ	บ่อเติมอากาศ	MRV	
Aeration tank	ถังเติมอากาศ	ถังเติมอากาศ		
Aeration Process	กระบวนการเติมอากาศ	กระบวนการเติมอากาศ		
Aeration Septic Tank	ระบบบำบัดน้ำเสียติดกับที่ แบบเติมอากาศ	ระบบบำบัดน้ำเสียติดกับที่ แบบเติมอากาศ		
Aerobic Bacteria	แบคทีเรียชนิดใช้ออกซิเจน	แบคทีเรียชนิดใช้ออกซิเจน		
Aerobic digestion	การย่อยแบบใช้อากาศหรือใช้ ออกซิเจน	การย่อยแบบใช้อากาศหรือใช้ ออกซิเจน		
Aerobic process	สภาพใช้อากาศ	สภาพใช้อากาศ		
Aerobic Treatment	การบำบัดแบบใช้อากาศ	การบำบัดแบบใช้อากาศ		
Anaerobic Digestion	การย่อยแบบไร้อากาศ	การย่อยแบบไร้อากาศ	MRV	
Anaerobic filter – Contact aeration	กระบวนการบำบัดน้ำเสียแบบ กรอง ไร้อากาศ และการเติมอากาศ สัมผัส	กระบวนการบำบัดน้ำเสียแบบ กรองไร้อากาศ และการเติม อากาศสัมผัส		
Anaerobic process	สภาพไม่ใช้อากาศ	สภาพไม่ใช้อากาศ		
Anaerobic Treatment	การบำบัดแบบไร้อากาศ	การบำบัดแบบไร้อากาศ		
Anaerobic filter – Contact aeration	กระบวนการบำบัดน้ำเสียแบบ กรองไร้อากาศและการเติม อากาศสัมผัส	กระบวนการบำบัดน้ำเสียแบบ กรองไร้อากาศและการเติม อากาศสัมผัส		
Ammonia	ก๊าซแอมโมเนีย	ก๊าซแอมโมเนีย (NH ₃)		

คำที่ใช้ในรายงานภาษาอังกฤษ	คำภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง
The Fifth Assessment Report (AR5)	รายงานฉบับที่ 5 ของคณะ กรรมการระ หว่างรัฐ บาลว่า ด้วย การเปลี่ยนแปลงสภาพ ภูมิอากาศ Intergovern- mental Panel on Climate Change (IPCC)	The Fifth Assessment Report (AR5)	
В			
Baseline Emission (BE)	การปล่อยก๊าซเรือนกระจกใน กรณีฐาน	การปล่อยก๊าซเรือนกระจกใน กรณีฐาน	TGO
Belt Filter Press	เครื่องรีดตะกอน	เครื่องรีดตะกอน	
Biological Oxygen Demand (BOD)	ค่าความสกปรกของน้ำเสีย	ค่าความสกปรกของน้ำเสีย (BOD)	สำนักงานจัดการคุณภาพน้ำ
Biological Activated Sludge process with Nutrients Removal	ระบบบำบัดน้ำเสียแบบตะกอน เร่งทางชีวภาพร่วมกับการ บำบัดสารอาหาร	ระบบบำบัดน้ำเสียแบบตะกอน เร่งทางชีวภาพร่วมกับการ บำบัดสารอาหาร	
Biodegradable	การย่อยสลายทางชีววิทยา	การย่อยสลายทางชีววิทยา	
Blower	เครื่องเป่าลม	Blower	
Business as Usual (BAU)	กรณีฐานที่ใช้ประมาณการ การปล่อยก๊าซเรือนกระจกใน อนาคตในกรณีที่มนุษย์ดำเนิน กิจกรรมตามปรกติโดยไม่มี กิจกรรมการลดก๊าซเรือนกระ จกใดๆ เพิ่มเติมเลย	BAU	TGO
С			
Carbon dioxide (CO2)	ก๊าซคาร์บอนไดออกไซด์	ก๊าซคาร์บอนไดออกไซด์ (CO2)	TGO
Centimeter (cm)	เซนติเมตร	เซนติเมตร	
Centralized Wastewater Treatment System	ระบบบำบัดน้ำเสียแบบรวม ศูนย์	ระบบบำบัดน้ำเสียแบบรวม ศูนย์	
Clarifier Tank	ถังตกตะกอน	ถังตกตะกอน	
Coarse Screens	ตะแกรงหยาบ	ตะแกรงหยาบ	สำนักงานจัดการคุณภาพน้ำ
Contact Aeration	กระบวนการบำบัดน้ำเสียแบบ เติมอากาศสัมผัส	กระบวนการบำบัดน้ำเสียแบบ เติมอากาศสัมผัส	สำนักงานจัดการคุณภาพน้ำ
Constructed Wetland (CW)	พื้นที่ชุ่มน้ำเทียม	พื้นที่ชุ่มน้ำเทียม	โครงการแหลมผักเบี้ย
Constructed Wetlands with Horizontal Subsurface Flow (HSSF)	พื้นที่ชุ่มน้ำเทียมประเภทการ ไหลใต้ผิวดินในแนวนอน	พื้นที่ชุ่มน้ำเทียมประเภทการ ไหลใต้ผิวดินในแนวนอน	

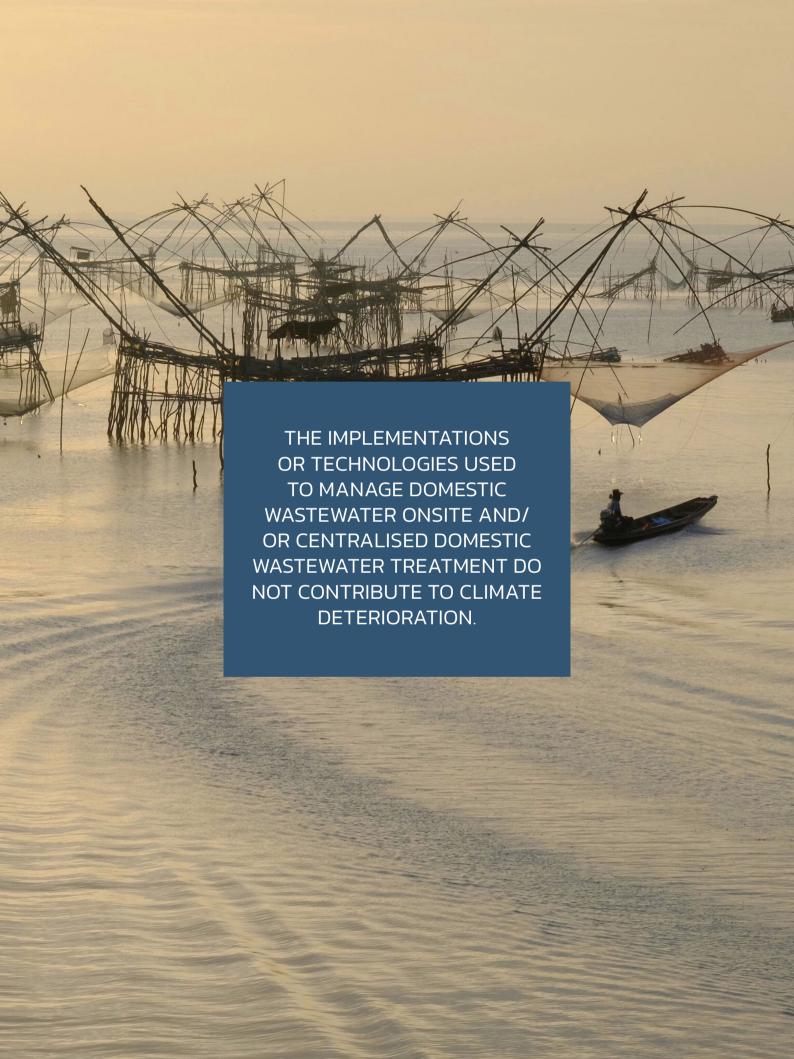
คำที่ใช้ในรายงานภาษาอังกฤษ	คำภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง	
Constructed Wetlands with Subsurface Flow	พื้นที่ชุ่มน้ำเทียมประเภทการ ไหลใต้พื้นผิว	พื้นที่ชุ่มน้ำเทียมประเภทการ ไหลใต้พื้นผิว		
Constructed Wetlands with Surface Flow	พื้นที่ชุ่มน้ำเทียมประเภทการ ไหลตามพื้นผิว	พื้นที่ชุ่มน้ำเทียมประเภทการ ไหลตามพื้นผิว		
Constructed Wetlands with Vertical Subsurface Flow (VSSF)	พื้นที่ชุ่มน้ำเทียมประเภทการ ไหลใต้ผิวดินในแนวดิ่ง	พื้นที่ชุ่มน้ำเทียมประเภทการ ใหลใต้ผิวดินในแนวดิ่ง		
Completely Mixed Activated Sludge (CMAS)	ระบบตะกอนเร่งแบบกวน สมบูรณ์	ระบบตะกอนเร่งแบบกวน สมบูรณ์		
Contact Stabilization Activated Sludge (CSAS)	ระบบตะกอนเร่งแบบปรับ เสถียรสัมผัส	ระบบตะกอนเร่งแบบปรับ เสถียรสัมผัส		
Country specific	ข้อมูลจำเพาะของประเทศ	Country specific	MRV	
Cubic metres per day (m³/d)	ลูกบาศก์เมตรต่อวัน (ลบ.ม./ วัน)	ลบ.ม./วัน		
D				
degree Celsius (°C)	องศาเซลเซียส	°C		
Default	ค่าแนะนำ	Default	MRV	
Diameter	เส้นผ่านศูนย์กลาง	เส้นผ่านศูนย์กลาง		
Diffuse Aerator	เครื่องเติมอากาศชนิดใต้น้ำ	เครื่องเติมอากาศชนิดใต้น้ำ		
Disinfection	การฆ่าเชื้อโรค	การฆ่าเชื้อโรค		
Domestic Wastewater	น้ำเสียชุมชน	น้ำเสียชุมชน		
Domestic Wastewater Treatment	การบำบัดน้ำเสียชุมชน	การบำบัดน้ำเสียชุมชน	MRV	
E				
Emission factor (EF)	ค่าการปล่อยก๊าซเรือนกระจก	Emission factor (EF)		
Excess Sludge	กากตะกอนส่วนเกิน	กากตะกอนส่วนเกิน		
F				
Facultative Stabilization Pond	บ่อปรับเสถียรแบบกึ่งใช้ อากาศ	บ่อปรับเสถียรแบบกึ่งใช้ อากาศ		
Fiber Glass Reinforced Plastic (FRP)	พลาสติกเสริมแรง	พลาสติกเสริมแรง		
Filtration	การกรอง	การกรอง		

คำที่ใช้ในรายงานภาษาอังกฤษ	คำภาษาไทย		อ้างอิง	
G				
Global Warming Potential (GWP)	ค่าศักยภาพการทำให้เกิด ภาวะโลกร้อน	ค่าศักยภาพการทำให้เกิด ภาวะโลกร้อน		
Greenhouse Gases (GHGs)	ก๊าซเรือนกระจก	ก๊าซเรือนกระจก		
1				
Inlet Pumping Station (IPS)	สถานีสูบน้ำเสีย	สถานีสูบน้ำเสีย	สำนักงานจัดการคุณภาพน้ำ	
2006 IPCC Guidelines for National Greenhouse Gas Inventories: 2006 IPCC Guidelines	คณะกรรมาธิการระหว่าง รัฐบาลว่าด้วยการ เปลี่ยนแปลงสภาพภูมิอากาศ 2549	2006 IPCC Guidelines	MRV	
J				
Japan Environmental Sani- tation Center (JESC)	ศูนย์สุขาภิบาลสิ่งแวดล้อม ของประเทศญี่ปุ่น	ศูนย์สุขาภิบาลสิ่งแวดล้อม ของประเทศญี่ปุ่น (JESC)		
Johkasou	ระบบโจกาโซ	ระบบโจกาโซ		
К				
kgCO ₂ /cap/d	กิโลกรัมคาร์บอนไดออกไซด์ ต่อคนต่อวัน	kgCO₂/คน/วัน	TGO	
Kilowatt (kW)	กิโลวัตต์	กิโลวัตต์		
L				
Lagoon Treatment	ระบบบ่อบำบัดน้ำเสีย	ระบบบ่อบำบัดน้ำเสีย		
Latrine	บ่อซึม	บ่อซึม	สำนักงานจัดการคุณภาพน้ำ	
Length	ความยาว	ความยาว	สำนักงานจัดการคุณภาพน้ำ	
М				
Meter (m)	เมตร	เมตร		
Methane (CH₄)	ก๊าซมีเทน	ก๊าซมีเทน (CH4)		
Methane Conversion Factor (MCF)	ค่าปรับแก้สัดส่วนการปล่อย ก๊าชมีเทน	Methane Conversion Factor (MCF)	MRV	
Middle or Large-Scale Johkasou	ระบบโจกาโซขนาดกลาง (ใหญ่)	ระบบโจกาโซขนาดกลาง (ใหญ่)		
Milligrams per liter (mg/L)	มิลลิกรัมต่อลิตร	มิลลิกรัมต่อลิตร		
Ministry of Natural Resources and Environment (MNRE)	กระทรวงทรัพยากรธรรมชาติ และสิ่งแวดล้อม	กระทรวง ทรัพยากรธรรมชาติและสิ่ง แวดล้อม		

าที่ใช้ในรายงานภาษาอังกฤษ	คำภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง
Mixing	ความปั่นป่วน	ความปั่นป่วน	
N			
Nitrification- Denitrification	ปฏิกิริยาไนตริฟิเคชั่น-ดีใน ตริฟิเคชั่น	ปฏิกิริยาไนตริฟิเคชั่น–ดีไน ตริฟิเคชั่น	
Nitrous oxide (N2O)	ก๊าซไนตรัสออกไซด์	ก๊าซไนตรัสออกไซด์ (N₂O)	TGO
0			
Onsite Wastewater Treatment System	ระบบบำบัดน้ำเสียแบบติด กับที่	ระบบบำบัดน้ำเสียแบบติด กับที่	
Oxidation Ditch (OD)	คลองวนเวียน	คลองวนเวียน	MRV
Р			
Plant and Grass Filtration	พืชและหญ้ากรองน้ำเสีย	พืชและหญ้ากรองน้ำเสีย	สำนักงานจัดการคุณภาพน้ำ
Power of Air pump	กำลังป็มเติมอากาศ	กำลังปั๊มเติมอากาศ	
Pollution Control Department	กรมควบคุมมลพิษ (คพ.)	กรมควบคุมมลพิษ (คพ.)	
Percentage of GHG reduction	ร้อยละการลดก๊าซเรือน กระจก	% GHG reduction	
R			
Rake Screens	ตะแกรงละเอียด	ตะแกรงละเอียด	
Return Sludge	ตะกอนจุลินทรีย์ที่สูบกลับ	ตะกอนจุลินทรีย์ที่สูบกลับ	
Rotating Biological Contactor (RBC)	แผ่นจานหมุนชีวภาพ	แผ่นจานหมุนชีวภาพ	MRV
S			
Secondary Treatment	ระบบบำบัดน้ำเสียชุมชนขั้นที่2	ระบบบำบัดน้ำเสียชุมชนขั้นที่2	
Sedimentation	การตกตะกอน	การตกตะกอน	
Sedimentation tank	ถังตกตะกอนน้ำใส	ถังตกตะกอนน้ำใส	
Septic tank	บ่อเกรอะ	บ่อเกรอะ	MRV
Sequencing Batch Reactor (SBR)	ระบบบำบัดน้ำเสียแบบเอ สบีอาร์	ระบบบำบัดน้ำเสียแบบเอ สบีอาร์	
Sewage Sludge	กากตะกอนระบบบำบัดน้ำเสีย	กากตะกอนระบบบำบัดน้ำเสีย	MRV
Site Specific	ข้อมูลพื้นฐานของระบบ	ข้อมูลพื้นฐานของระบบ	

คำที่ใช้ในรายงานภาษาอังกฤษ	คำภาษาไทย	คำที่ใช้ในรายงานภาษาไทย	อ้างอิง	
Solid separation tank	ถังแยกกาก	ถังแยกกาก		
Small-Scale Johkasou	ระบบโจกาโซขนาดเล็ก	ระบบโจกาโซขนาดเล็ก		
Stabilization Pond (SP)	บ่อปรับเสถียร	บ่อปรับเสถียร	MRV	
т				
Tertiary Treatment	ระบบบำบัดน้ำเสียชุมชนขั้นที่3	ระบบบำบัดน้ำเสียชุมชนขั้นที่3		
Total Nitrogen (TN)	ค่าไนโตรเจนทั้งหมด (TN)	ค่าไนโตรเจนทั้งหมด		
W				
Wastewater flow design	ปริมาณน้ำเสียออกแบบ	ปริมาณน้ำเสียออกแบบ		
Wier	เวียร์	เวียร์		

หมายเหตุ การใช้คำศัพท์ที่พบในอ้างอิงนิยมใช้แบบ "ศัพท์ภาษาไทย (ศัพท์ ภาษาอังกฤษ)" เช่น ค่าการปล่อย (Emission Factor)



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