Greenhouse Gas Emissions from the Municipal Wastewater Sector in Indonesia

Global Methane Initiative Dissemination Seminar
Hotel Patra Bandung and Online on Zoom, March 14, 2024

Agenda

Time Slot JAK (GMT+7:00)	Activity	Speaker
08:30-08:35 AM	Opening and housekeeping	Monica Simarmata, Tetra Tech
08:35-08:55 AM	Welcome Address	Monica Shimamura Wastewater and Biogas Program Manager, United States Environmental Protection Agency (USEPA), Global Methane Initiative (GMI)
08:55-09:15 AM	Keynote Address – Government of Indonesia	
09:15-9:30 AM	Understanding the Institutional Arrangement and Regulatory Framework in Domestic Wastewater Methane Emissions in Indonesia	Dr. Budi Kurniawan, National Research and Innovation Agency
09:30-9:50 AM	Fundamentals of Domestic Wastewater Treatment in Indonesia	Dr. Ahmad Soleh Setiyawan, Bandung Institute of Technology
09:50-10:10 AM	GHG Emissions Inventory in the Domestic Wastewater Sector	Dr. Febrian Hadinata, MRV Team and GHG Methodology Panel of the Ministry of Environment and Forestry
10:10-10:55 AM	Case Study: Measurement Based Pilot to Estimate Methane Emissions	Prof. Dr. Tjandra Setiadi, Bandung Institute of Technology
10:55-11:10 AM	Q&A	Moderator: Pri Januar Gusnawan
11:10-11:30 AM	International Experience in Domestic Wastewater GHG Emissions Inventory	Leodegario Lopez, Wastewater Expert; Tetra Tech
11:30-11:55 AM	Q&A	Moderator: Monica Simarmata, Tetra Tech
11:55 AM-12:00 PM	Concluding Remarks	Monica Simarmata, Tetra Tech

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Understanding the Institutional Arrangement and Regulatory Framework in Municipal Wastewater GHG Emissions in Indonesia

Dr. Budi Kurniawan
Pusat Riset Lingkungan dan Teknologi Bersih
Badan Riset dan Inovasi Nasional (BRIN)

March 14, 2024

Regulations Concerning Greenhouse Gas Emission Inventory

- Law Number 32 of 2OO9 concerning Environmental Protection and Management
- Law Number 16 of 2016 concerning Ratification of the Paris Agreement to the United Nations Framework Convention on Climate Change
- Government Regulation No.22 of 2021 concerning Implementation of Environmental Protection
- Presidential Regulation (PERPRES) Number 98 of 2021 concerning Implementation of the Economic Value of Carbon to Achieve Nationally Determined Contribution Targets and Control of Greenhouse Gas Emissions in National Development
- MOEF Minister Regulation No. 73 of 2017 concerning with Guidelines for Conducting and Reporting the National Greenhouse Gas Inventory

Government Regulation No.22 of 2021 on theImplementation of Environmental Protection

Article 156

(1) Water Quality Maintenance is carried out based on the Water Quality Protection and Management plan.

(2) Water Quality Maintenance is carried out at:

a. First class Water Body

b. Water Bodies located in protected areas;

c. springs;

d. groundwater; and/or

e. closed lake.

(3) Ministers, governors, or regents/mayors in accordance with their authority carry out maintenance of water quality through efforts to:

a. conservation of Water Bodies and their ecosystems;

b. Reserves of water bodies and their ecosystems, and/or

c. Controlling climate change.

(6) Climate change control as referred to in paragraph (3) letter c is carried out through Wastewater management to mitigate the release of greenhouse gas emissions.

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Explanation of Article 156 paragraph (6) pf GR 22/2021

- “Mitigating the release of greenhouse gas emissions" is an effort to suppress or avoid the release of greenhouse gas emissions generated by wastewater.
- Greenhouse gas compounds from waste water come from organic compounds contained in waste water, in the form of carbon dioxide (CO2) and methane (CH4).

Presidential Regulation (PERPRES) Number 98 of 2021 on the Implementation of the Economic Value of Carbon to Achieve Nationally Determined Contribution Targets and Control of Greenhouse Gas Emissions in National Development

The Presidential Decree gives a mandate to the Minister who handles the field of environmental protection and management, in this case the Minister of Environment and Forestry (MoEF) to establish guidelines of GHG inventory, coordinating inventory of GHG and carry out monitoring and evaluation of inventory processes and results of GHG. Until now, the supplementary rules of the Presidential Regulation are being in the process of settlement.

The scope of this Presidential Regulation includes:

a. efforts to achieve NDC targets;

b. management of CEV/NEK;

c. transparency framework;

d. monitoring and evaluation;

e. coaching and funding; and

f. steering committee.

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Presidential Regulation (PERPRES) Number 98 of 2021

Article 12

The results of the implementation of the GHG Emissions inventory are reported annually using the following mechanism:

a. Business Actors to relevant regents/mayors, governors or ministers in accordance with technical approval obtained no later than March;

b. the regent/mayor submits the GHG Emission Inventory results report to the Governor via a web-based application no later than March;

c. the governor submits a report on the results of the GHG Emission Inventory to the Minister via a web-based application no later than June; And

d. The relevant minister submits a report on the results of the GHG Inventory to the Minister via a web-based application no later than June.

Methodology

- The methodology for conducting GHG and MRV inventories refers to the guidelines established by the Intergovernmental Panel on Climate Change (IPCC). Indonesian using IPCC Guidelines for National Greenhouse Gas Inventories – 2006 includes supplements and refinements of the guide.
- It has also been adopted into MOEF Minister Regulation No. 73 of 2017 (based on Presidential Regulation No 71/2011 about GHG Inventory), which regulate the procedures for organizing GHG emission, institutional arrangements, categories emission sources, data acquisition and updating mechanisms, analysis processes and reporting governance.
- The scope of regulation in this Ministerial Regulation includes:

a. guidelines for implementing GHG inventories; and

b. guidelines for GHG inventory reporting

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GHGE Inventory

- The implementation of GHGE inventory is a continuous process to obtain data and information on the level, status, and trend of periodic changes in GHG emissions from various emission sources and sinks.
- GHGE Inventory Implementation and Reporting Guidelines aim to implement and/or coordinate GHG inventories at the national and provincial and district/city levels that are reliable, accurate, consistent, and sustainable, consisting of:

  a. the use of internationally recognized methodologies;

  b. calculating/estimating GHG emissions and removals;

  c. preparation of documents on the level, status, and trend of changes in GHG emissions; and

  d. reporting the level, status, and trend of changes in GHG emissions.

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Guidelines

- Guidelines for conducting and reporting of GHG emission aiming at providing guidance in conducting inventory of GHG in the national, provincial and municipal/city level.
- Guidelines for implementing GHG inventories include: a. general guidelines; and b. technical guidelines
- General guidelines for the implementation of GHG inventory include: a. basic principles of GHG inventory; b. stages of GHG inventory; c. general methodology of GHG emissions/removals calculation; d. analysis of uncertainty and key categories; e. quality control and assurance; f. institutional GHG inventory; and g. National GHG inventory system (SIGN).
- Technical guidelines include: a. technical guidelines for the energy procurement and use sector; b. technical guidelines for the industrial process sector and the use of products; c. technical guidelines for agriculture, forestry and other land use sectors; and d. technical guidelines for the waste management sector

GHG INVENTORY REPORTING GUIDELINES

- GHG inventory reporting shall be carried out by the GHG inventory operator.
- The operator of GHG inventory includes:

  a. Regency/City Local Government;

  b. Provincial Local Government;

  c. Relevant Ministries and/or Non-Ministerial Government Institutions; and

  d. The Ministry that organizes government affairs in the field of environment and forestry as the National Focal Point for Climate Change.

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Reporting Mechanism (Provincial & Local Government Level)

- GHGs at the district/city level report the results of GHGE inventory to operators at the provincial level.
- The organizer of the GHGE inventory at the provincial level shall submit a report to the Minister c.q. Director General as the National Focal Point for Climate Change with a copy to the Minister of Home Affairs c.q. Director General of Regional Development.
- The GHG Inventory implementation report shall be submitted at least 1 (one) time a year.

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Reporting Mechanism (Central Government Level)

- GHG Inventory Organizers at relevant Ministries and/or Non-Ministerial Government Institutions include:

  a. Institutions in charge of sub-sector; and

  b. Sector Coordinator.

- The Institutions in charge of sub-sectors and sector coordinators of Ministries and/or Non-Ministerial Government listed in Annex I which is an integral part of this Ministerial Regulation.
- Ministries and/or Non-Ministerial Government Institutions shall submit a report to the Sector Coordinator.
- The Sector Coordinator shall submit a report on the implementation of the GHG inventory to the Minister c.q. Director General as National Focal Point for Climate Change (herewith DG of Climate Change Control/PPI)
- The GHG Inventory Report shall be submitted at least 1 (one) time a year.
- The report shall carry out a quality control and quality assurance process.
- The report shall be submitted to the Minister at least 1 (one) time a year.

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GHG EMISSIONS IN THE WASTE MANAGEMENT SECTOR

SECTOR COORDINATOR : MINISTRY OF ENVIRONMENT AND FORESTRY (DIRECTORATE OF SOLID WASTE MANAGEMENT)

Note: Due to the change of origination structure of concerned ministries, the directorate in charge is also changed

NO.	EMISSION SUB SECTORS	SUBSECTOR (INSTITUTION IN CHARGE)	
1	Municipal Solid Waste (MSW)	Ministry of Environment & Forestry	Directorate of Solid Waste Management
		Ministry of Public Work & Housing	Directorate of Environmental Sanitation and Settlement Development
2	Domestic wastewater	Ministry of Environment & Forestry	Directorate of Water Pollution Control
		Ministry of Public Work & Housing	Directorate of Environmental Sanitation and Settlement Development; Research Center for Housing & Settlement Development
3	Industrial Solid waste (including medicine/ pharmaceutical waste)	Ministry of Environment & Forestry	Directorate of Hazardous waste Management
		Ministry of Industry	Research Center for Green Industry & Environment; Center for data and information
4	Industrial Wastewater	Ministry of Environment & Forestry	Secretary of DG of Environmental Pollution and Degradation Control; Directorat of Performance Evaluation for Hazardous waste Management
		Ministry of Industry	Research Center for Green Industry & Environment; Center for data and information ; Directorat of Industry of Beverage, Tobacco Product and Fresheners; Directorat Food, Seafood and Fisheries Industry
		Central Bureau of Statistics (BPS)	Directorate of Industrial Statistics

Public information disclosure

- The report contains the following:

  a. procedures and arrangements for the continuous collection and storage of data;

  b. greenhouse gas inventory results containing the level, status, and trend of GHG emission changes; and

  c. improvement plans to be carried out to improve the quality of GHG inventories.

- This institution is closely related to the process of quality assurance and control (Quality Assurance and Quality Control) (QA/QC) GHG inventory which has also been regulated in the Regulation of the Director General of PPI Number P.10 of 2018 on Guidelines for Quality Assurance and Control (QA/QC) of Indonesian Green House Gas Inventory
- The level, status and trend of GHG emissions can be accessed by the public through the National GHG Inventory System (SIGN) officially determined by the GHG Inventory Operator
- Public information disclosure in accordance with the provisions of laws and regulations.

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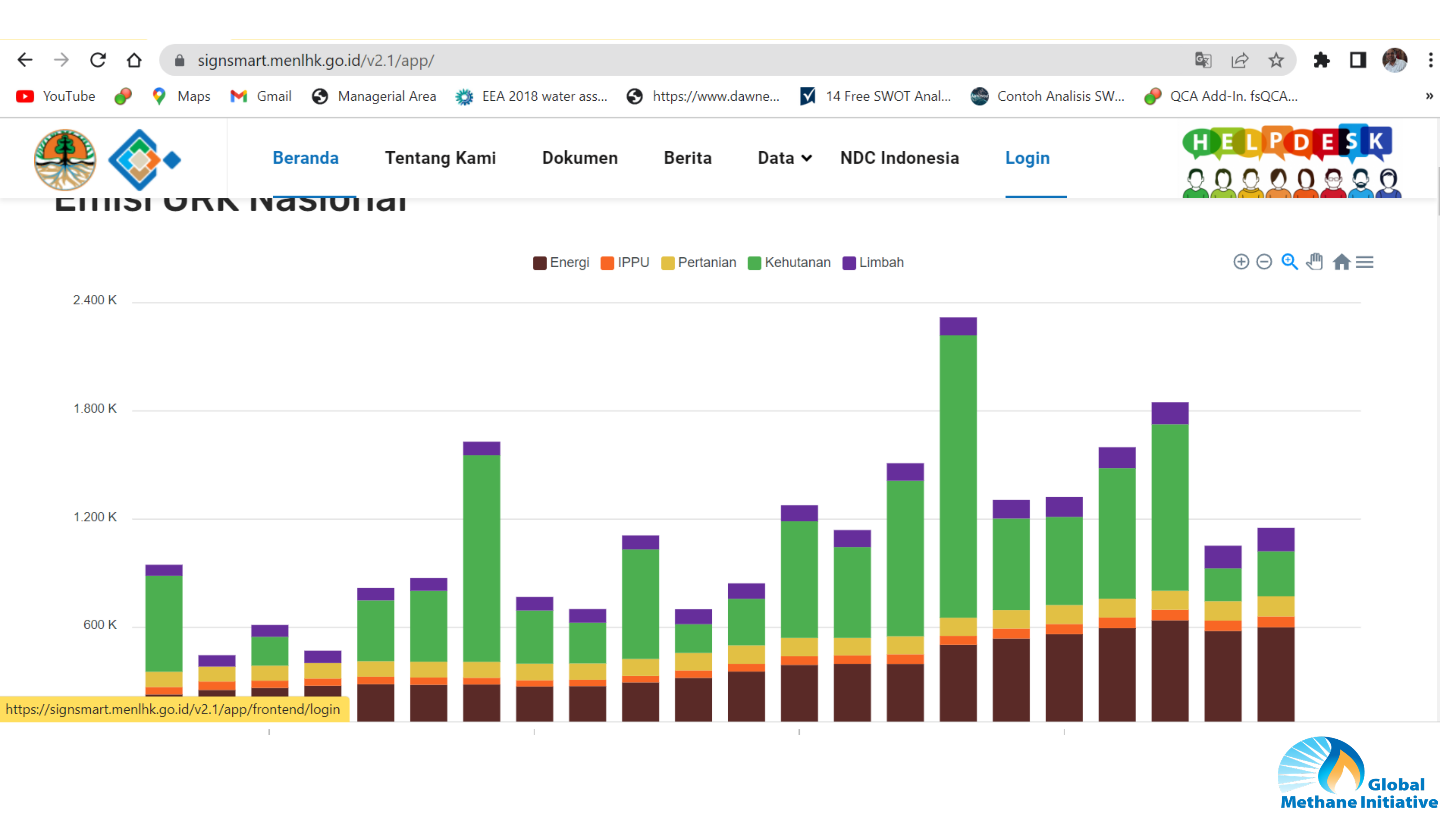
Inventory Report of 2021

- For this reporting period, GHG emission inventory and reduction report still using the previous year's data source (T-1). Settings Institutional and complex data provision needs full attention, so that in the coming years GHGE Inventory reporting can be done in the same year as the data year.
- This is the mandate of the Regulation President 98/2021 and it is a common need that the Inventory report results GHGs are expected to be used to design mitigation and adaptation actions with Faster, Precise and Sustainable

SIGN-SMART

- MOEF prepares a web-based information system / application platform / SIGN-SMART, with a number of features in the form of: input menus, emission graphs and tables, emission calculations, key category analysis (KCA), common Reporting Format (CRF), worksheets and a number of other features. It was also conveyed the reporting timeline in accordance with Presidential Regulation 98 of 2021 and reporting systematics in accordance with Minister of Environment and Forestry 73 of 2017.
- SIGN-SMART: https://signsmart.menlhk.go.id/v2.1/app/, Developed and operated by Directorate of Greenhouse Gas Inventory and Monitoring, Reporting and Verification, DG of Climate Change Control of MOEF
- MOEF has developed Greenhouse Gas Inventory (IGRK) toolkit for waste sector, energy sector and institutional arrangement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Toolkit Limbah_Final-Fix - Excel

Greenhouse Gas Inventory (GHG) toolkit for waste sector, energy sector and institutional arrangement

Waste Disposal Site)

dari Pengelolaan Sampah Landfill/ Penimbunan

SUB KATEGORI	
Katagori pengelolaan kegiatan penimbunan sampah	Nama TPA yang dioperasikan
	Lokasi TPA
	Tipe pengelolaan TPA (open dumping (deep/shallow), controlled /sanitary landfill)
	Tahun dibuka TPA
	Tahun ditutup TPA
	Recovery metan di TPA (jumlah KK pengguna biogas dari TPA)
	Tanah penutup TPA
Composition of waste going to solid waste disposal sites	Food Waste
	Paper/ cardboard
	Nappies
	Garden/park
	Wood
	Textiles
	Rubber and Leather
	Plastics
	Metal
	Glass
	Other

4B Pengolahan Biologi

Sumber Emisi dari Pengelolaan Sampah Secara Biologi

KODE	KATEGORI	SUB KATEGORI	
4 B 1	Pengolahan Biologi Sampah	Estimasi emisi CH_4 dari Pengolahan	a. Komposting
			b. Anaerobic digestion pada fasilitas Biogas

4C Insinerasi atau Open Burning

Sumber Emisi dari Insinerasi dan Pembakaran Terbuka Sampah

KODE	KATEGORI		SUB KATEGORI	
4 C 1	Insinerasi Sampah	Estimasi emisi CO_2, CH_4, N_2O dari Insinerasi dan open burning sampah	Municipal Solid Waste	- Food waste
				- Paper/cardboard
				- Wood
				- Textiles
				- Rubber/Leather
				- Plastic
				- Metal
				- Glass
				- Other
			Hazardous waste	
			Clinical waste	
			Sewage sludge	
			Other (specify)	
		Estimation of CO_2 emissions from incineration of fossil liquid waste	Lubricants	
			Solvents	
			Waste oil	
			Other (specify)	
4C2	Pembakaran terbuka sampah	Estimasi emisi CO_2 CH_4 dan N02 dari Pembakaran Terbuka sampah	Municipal Solid Waste	- Food waste
				- Paper/cardboard
				- Wood
				- Textiles
				- Rubber/Leather
				- Plastic
				- Metal
				- Glass
				- Other
			Other (specify)	

4D Pengolahan dan Pembuangan Limbah

Sumber Emisi dari Wastewater Treatment and Discharge (Domestic dan Industri)

KODE	KATEGORI		SUB KATEGORI	
4 D 1	Pengolahan Air Limbah Domestik	Estimasi emisi CO_2, CH_4, N_2O dari pengolahan ari limbah domestik	Jenis pengolahan	**Untreated System**
				- Sea, river and lake discharge
				- Stagnant sewer
				- Flowing sewer (open or closed)
				Treated System
				- centralized, aerobic treatment plant
				- centralized, aerobic treatment plant (not well managed)
				- Anaerobic digester for sludge
				- Anaerobic shallow lagoon
				- Anaerobic deep lagoon
				- Septic system
				- Latrine (*dry climate, ground water table lower than latrine, small family 3-5 persons*)
				- Latrine (dry climate, ground water table lower than latrine, communal)
				Latrine (wet climate/flush water use, ground water table higher than latrine)
				- Latrine (regular sediment removal for fertilizer)
			Income group	Tinggal di pedesaan
				dan Tinggal di perkotaan
4D2	Pengolahan Air Limbah Industri	Total Organic Degradable Material in wastewater for each industry sector	Jenis Industri	Alcohol Refining
				Beer & Malt
				Coffee
				Dairy Product
				Fish Processing
				Meat Poultry
				Organic Chemicals
				Petroleum Refineries
				Plastic Resin
				Pulp & Paper (Combined)
				Soap & Detergents
				Starch Production
				Sugar Refining
				Vegetable Oils (Except CPO)
				Wine & Vinegar
				CPO
				Sugar Can
				Tepung Tapioka
				Tekstil
				Farmasi
				Crumb Rubber
				Minyak Goreng Sawit dan Margarine
				Oleohemical Berbasis Sawit
				Vegetable, Fruit, and Juice
				Produksi Biodiesel

Findings relating to GHGI Policy and Regulation

- Technical regulations as a complement to the Presidential Regulation No.98/2021 must be immediately drafted to adjust some changes in the institution responsible for GHG inventory
- The gap between regulation and implementation are:
  - management of the timing of providing data and information,
  - developing one GHG data and
  - improving the quality of credible and traceable data.
- Recommendation:
  - The calculation methods applied by various government institutions still vary so that effective coordination must be done periodically
  - Improve institutional framework including budgeting, capacity building, mechanisms and procedures in the collection, processing, reporting and validation of data institutionally and technically
  - Data and information for GHGI are integrated in an inventory of environmental data and information, that the district government can provide the necessary data and information for all proposes at once
- Those problem, challenge, and solution are related to the domestic wastewater management as well

Findings relating to Domestic Wastewater Treatment Management

- The coverage, quantity and quality of domestic WWTP are far from adequate
- There is no wastewater quality monitoring program from WWTP provided by the government
- Regulations requiring the treatment and compliance of domestic wastewater quality standards are in place but no monitoring and supervision has been carried out

Prerequisite of Proper GHG Inventory from Domestic Wastewater

Proper GHG emission Inventory Prerequisite :

- There are appropriate number (availability) of Domestic WWTP
- Operational and maintenance of Domestic WWTPs should be done in accordance to the stipulated guidance and standard
- Monitoring of Domestic WWTP effluent should be conducted periodically and done in accordance to the stipulated guidance and standard
- Standardized Methodology

Transparent, accurate, consistent and comparable

Inventory :

- water pollution load from domestic sources
- GHG emission from domestic wastewater

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Institutional Framework in GHGE Inventory from Domestic Wastewater to obtain Faster, Precise and Sustainable Data

- Institution: Coordinator, O/M operator, monitoring of WWTP effluent, inventory:
  - ✓ Environmental Protection Agency (DLH) of city level : conducting inventory of GHG emission and water pollution sources for local level, effluent monitoring for WWTP owned by community
  - ✓ MoPWH, Provincial and City level of Cipta Karya: conducting of construction of domestic WWTP
  - ✓ PDAM, PDPAL, other BUMD etc: Operator for conducting O/M and effluent monitoring of WWTP owned by government
  - ✓ Environmental Protection Agency (DLH) of provincial level: conducting inventory of GHG emission and water pollution sources for provincial level, effluent monitoring for WWTP owned by community and government
  - ✓ Directorate of Water Pollution Control (MoEF): conducting inventory of GHG emission and water pollution sources for national level, effluent monitoring for WWTP owned by community and government (central government)
- Budgeting: Construction, O/M, effluent monitoring, inventory which are coordinated Nationally by BAPPENAS
- Human resources: O/M, effluent monitoring, inventory
- Guidance, standard, capacity building should be prepared and done by: MoEF, MoPWH, MoHA
- National Coordination should be done by Coordinator Ministry related to marine and Investment

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Institutions	Environmental Protection Agency (DLH) of city level	Environmental Protection Agency (DLH) of provincial level	MoEF			MoPWH	MoHA	PDAM, PDPAL, other BUMD (Local State Owned Enterprises) etc
Institutions Function			Dit. WPC (PPA)	Dit. WM (PS)	Dit. Inventory and MRV			
Inventory of GHG emission and water pollution sources for local level, effluent monitoring for WWTP owned by community	√				National Coordinator for GHG emission inventory			
Inventory of GHG emission and water pollution sources for provincial level, effluent monitoring for WWTP owned by community and government		√			National Coordinator for GHG emission inventory			
Inventory of GHG emission and water pollution sources for national level, effluent monitoring for WWTP owned by community and government (central government)			√	Coordinator of Waste Sector	National Coordinator for GHG emission inventory			
Construction of domestic WWTP			√			√		
O/M and effluent monitoring of WWTP owned by government							√	√
Guidance, standard, capacity building			√				√	

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Thank you for your kind attention.

For more resources and information on events visit https://www.globalmethane.org/ or scan the QR code:

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Fundamentals of Municipal Wastewater Management in Indonesia

Dr. Ahmad Soleh Setiyawan
Institut Teknologi Bandung

March 14, 2024

OUTLINE

01 WASTEWATER MANAGEMENT IN INDONESIA

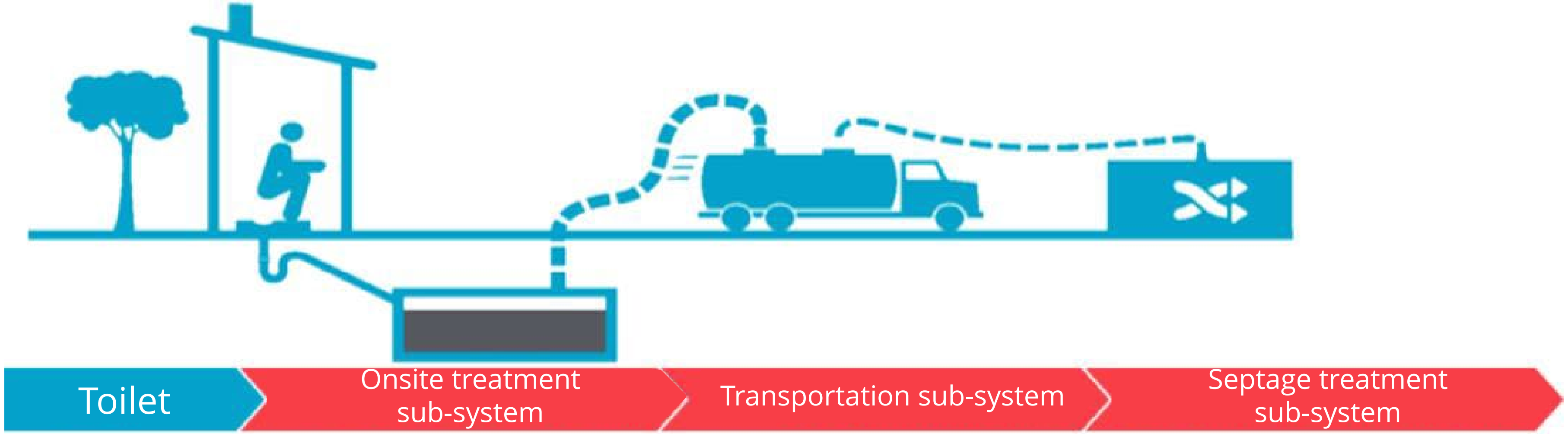
02 NATIONAL ACHIEVEMENTS AND TARGETS

03 TYPE OF TECHNOLOGY

04 GHG EMISSIONS FROM DOMESTIC WASTEWATER

01 WASTEWATER MANAGEMENT IN INDONESIA

Decentralized Systems / On-Site System

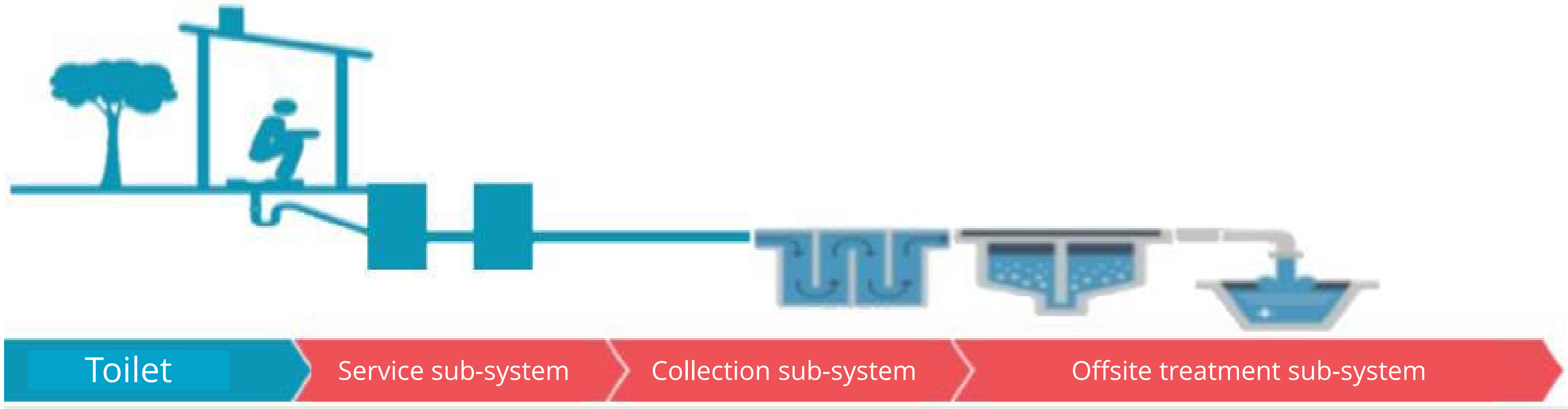


Wastewater disposal system where wastewater is discharged then treated at or near the point of waste generation. A system in which there is no urban riol system or for small environments where yards are still available.

The sludge from treatment technology (fecal sludge) will have to be emptied periodically and treated further. Based on the Regulation of the Indonesian Minister of Public Works Regulation Number 4/PRT/M/2017, the onsite treatment sub-system is divided based on processing capacity:

1. Individual scale: intended for 1 households.
2. Communal scale: intended for 2 to 10 households and / or buildings; and / or MCK

Centralized System / Off-Site Systems



Wastewater treatment systems from all service areas are collected through collection pipes , then conveyed through the city sewers to the wastewater treatment plant (WWTP) and / or with a specific dilution intercepting sewer), which if the stream meets the quality standard, can be discarded directly to the receiving water body.

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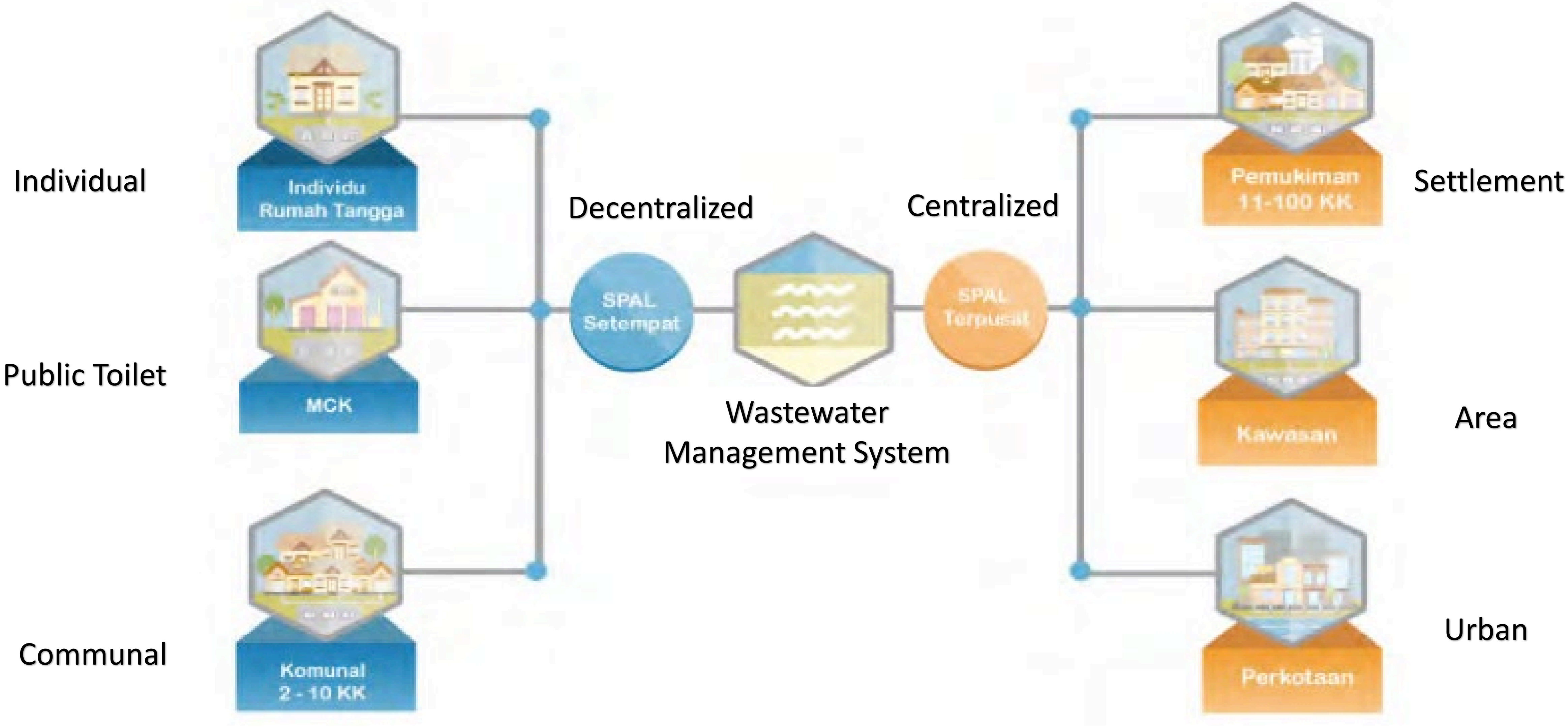

Figure 1. Domestic Wastewater Management System

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REGULATION

OF DOMESTIC WASTEWATER

National Plan of Long Term 2005-2025

National Plan of Medium Term 2020-2024

Government Regulation No. 22/2021

Implementation of Environmental Protection and Management.

Ministry of Public Works Regulation No. 4/2017

Implementation of Domestic Wastewater Management Systems

Ministry and Forestry Regulation No. 68/2016

Effluent Standard of Domestic WWTP

Table 1. National Quality Standards of Domestic Wastewater Effluent

Parameter	Unit	Maximum Level
pH	-	6-9
BOD	mg/L	30
COD	mg/L	100
TSS	mg/L	30
Oils and Grease	mg/L	5
Ammonia	mg/L	10
Total Coliform	MPN/100mL	3.000
Debit	L/person/day	100

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02 NATIONAL ACHIEVEMENTS AND TARGETS

JMP SANITATION

INDONESIA 2020-2023

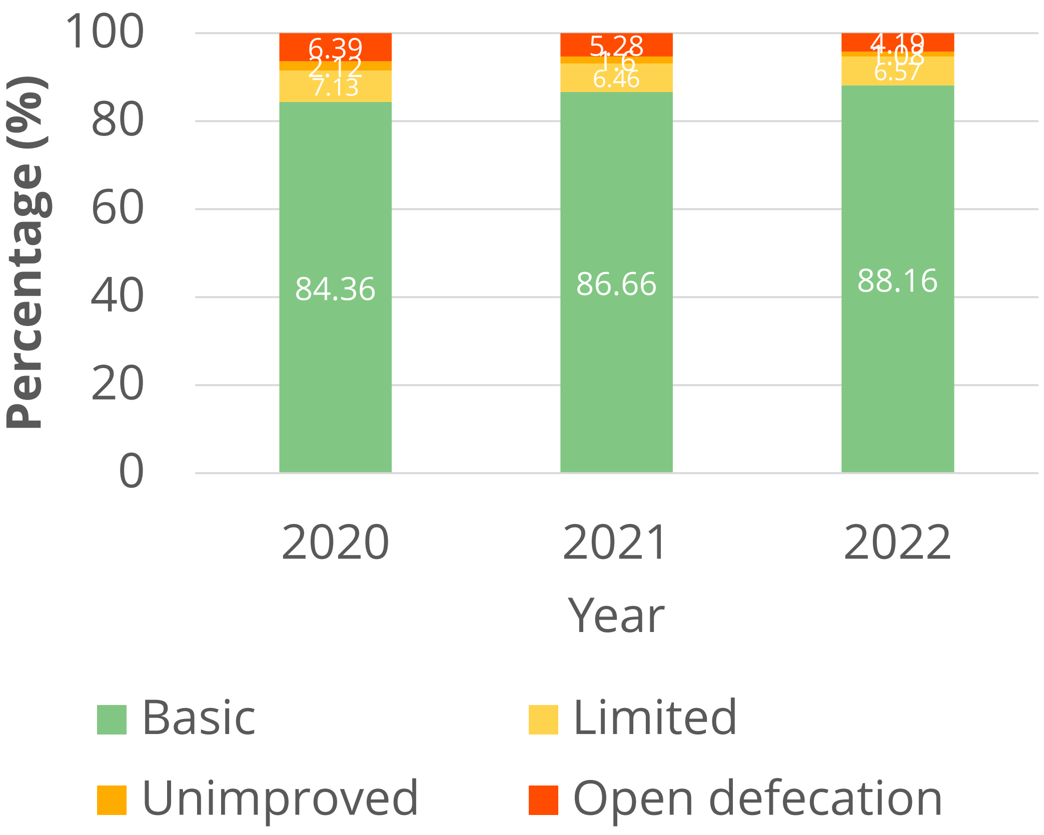

FIGURE 2. JMP SANITAION ANALYSE BY SERVICE LEVEL

Source: WHO UNICEF, 2022

Safely managed	A basic sanitation facility which is not shared with other households and where excreta are safely disposed in situ or treated off-site
Basic	Use of improved facilities which are not shared with other households.
Limited	Use of improved facilities shared between two or more households
Unimproved	Use of pit latrines without a slab or platform, hanging latrines or bucket latrines.
Open defecation	Disposal of human feces in fields, bushes, open bodies of water, beaches and other open spaces or with solid waste.

Improved sanitation facilities are those designed to hygienically separate excreta from human contact, and include: flush/pour flush to piped sewer system septic tank or pit latrines, VIP latrines, composting toilet or pit latrines with slabs.

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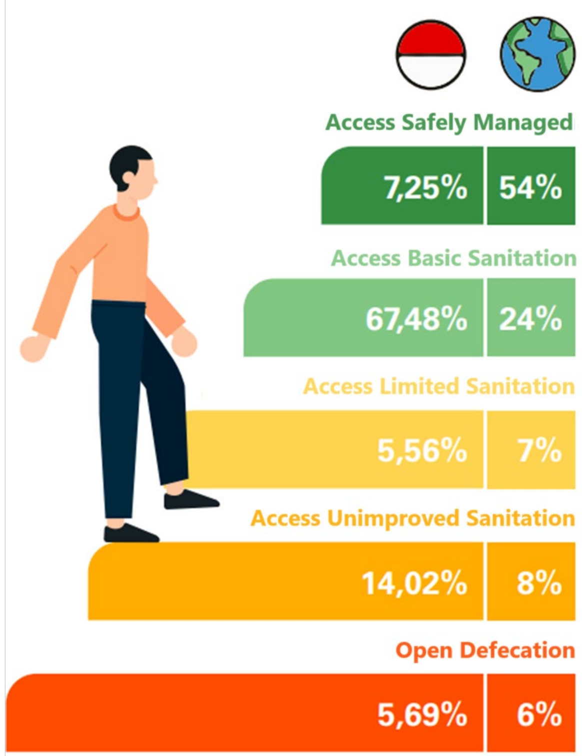
NATIONAL ACHIEVEMENTS AND TARGETS

2020 — **2024** — **2030**

Overview of sanitation access achievements 2020



- The highest provinces are DI Yogyakarta, Bali, and Provinces DKI Jakarta.
- While the lowest province is Papua Province.

Source: Kementerian Kesehatan RI. 2023

Targets RPJMN

Included 20% access safely managed and
0% open defecation.

Targets SDGs

6.2. Achieve access to adequate and equitable sanitation and hygiene for all and **end open defecation**

6.3. Improve water quality by **halving the proportion of untreated wastewater** and substantially increasing recycling and safe reuse globally

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03 TYPES OF TECHNOLOGY

Types of Decentralized Treatment (Part 1)

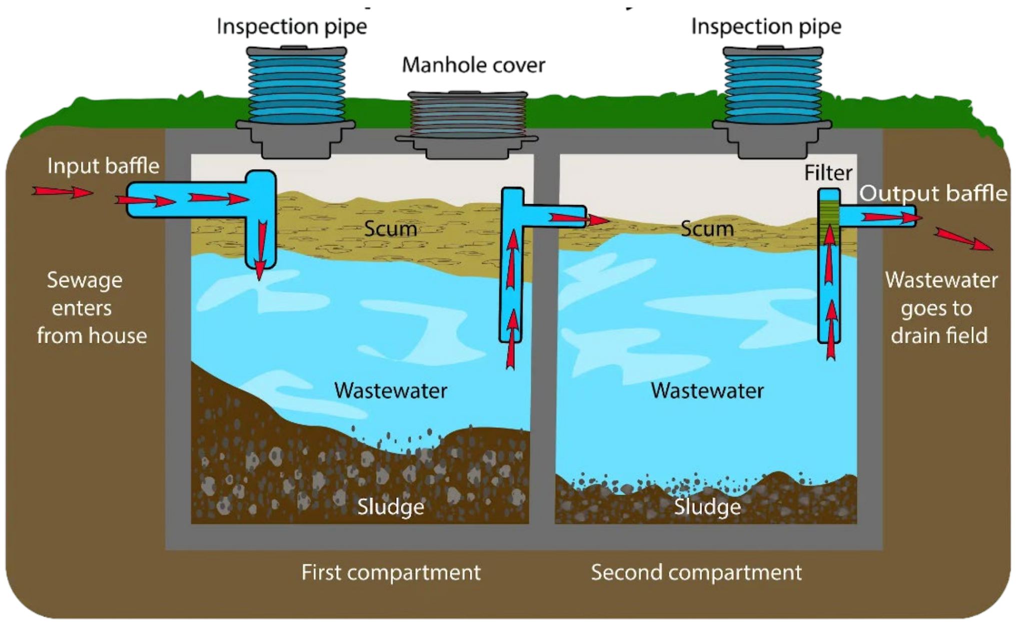

Figure 3. Septic Tank

This type of treatment is usually used for individual scale treatment.

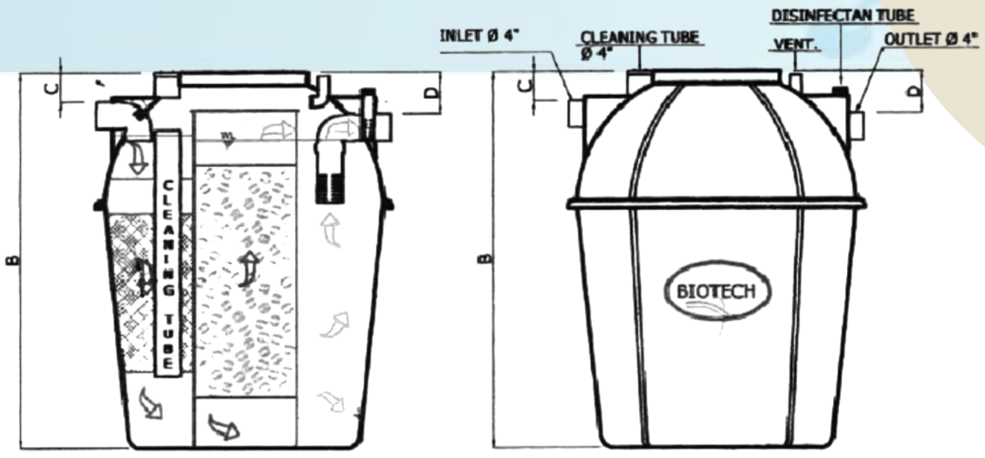

Figure 4. Filter Anaerobik (Bio Filter)

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Types of Decentralized Treatment (Part 2)

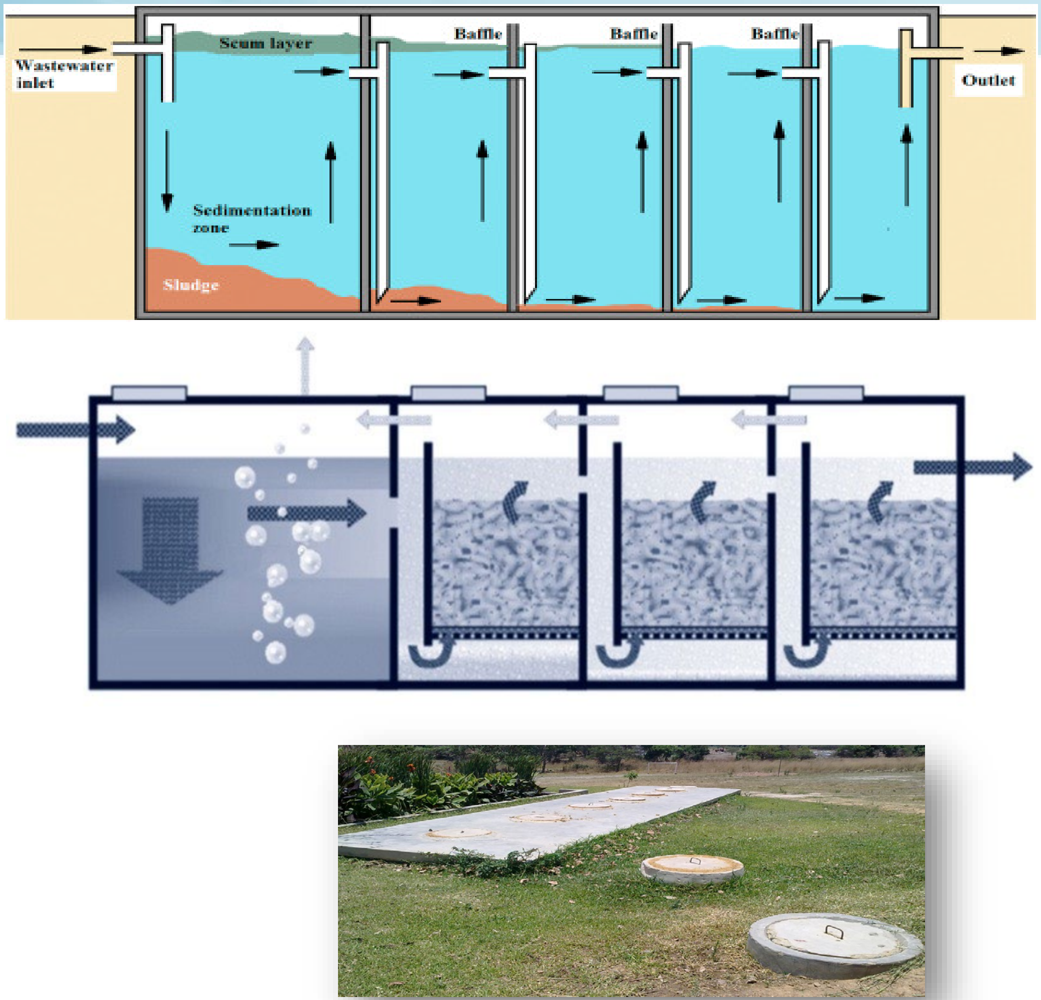

Figure 5. Anaerobic Baffled Reactor (ABR) and Anaerobic Up-flow Filter (AUF)

Figure 6. Constructed Wetland

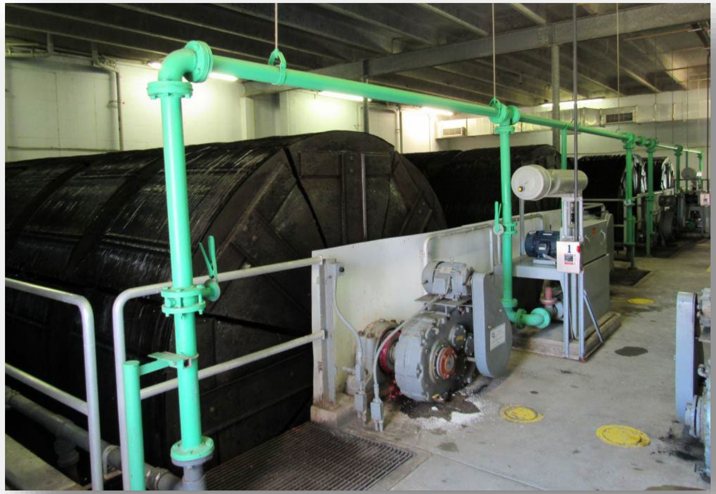

Figure 7. Rotating Biological Contactor (RBC)

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Types of Centralized Treatment (Part 1)

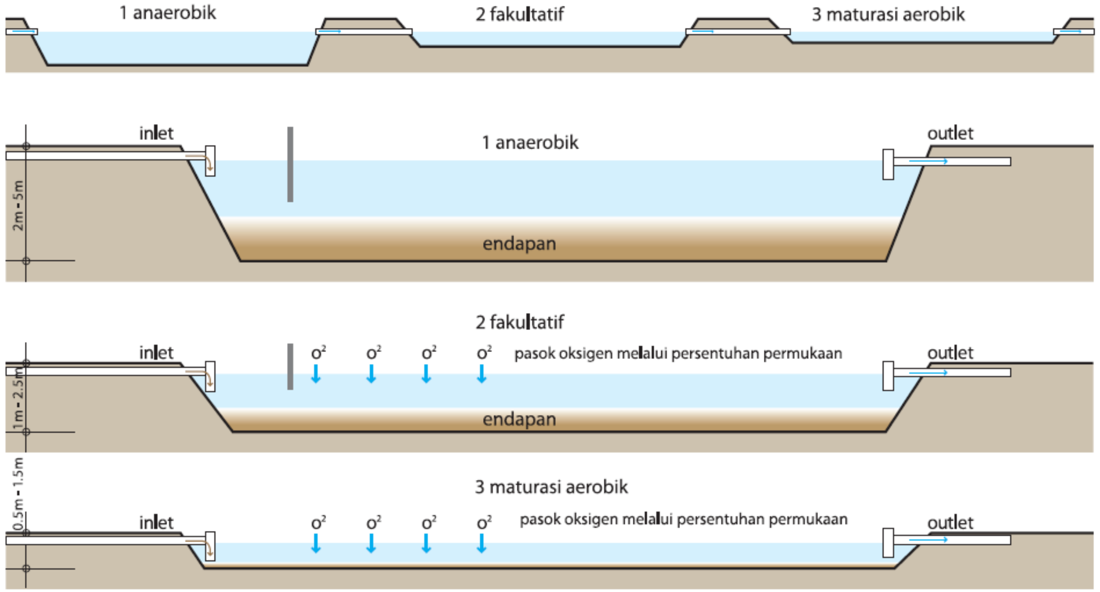

Figure 8. Stabilization Pond

Stabilization Ponds are artificial earthen ponds consisting of a series of anaerobic, facultative, and maturation ponds.

Figure 9. Activated Sludge

A series of reactor tanks (aeration and clarifier) that use aerobic microorganisms to decompose organic substances in wastewater.

Types of Centralized Treatment (Part 2)

Figure 10. Aerated Pond

Figure 11. MBBR

Figure 12. Oxidation Ditch

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FIGURE 13. Location pf Bojongsoang Wastewater Treatment Installation

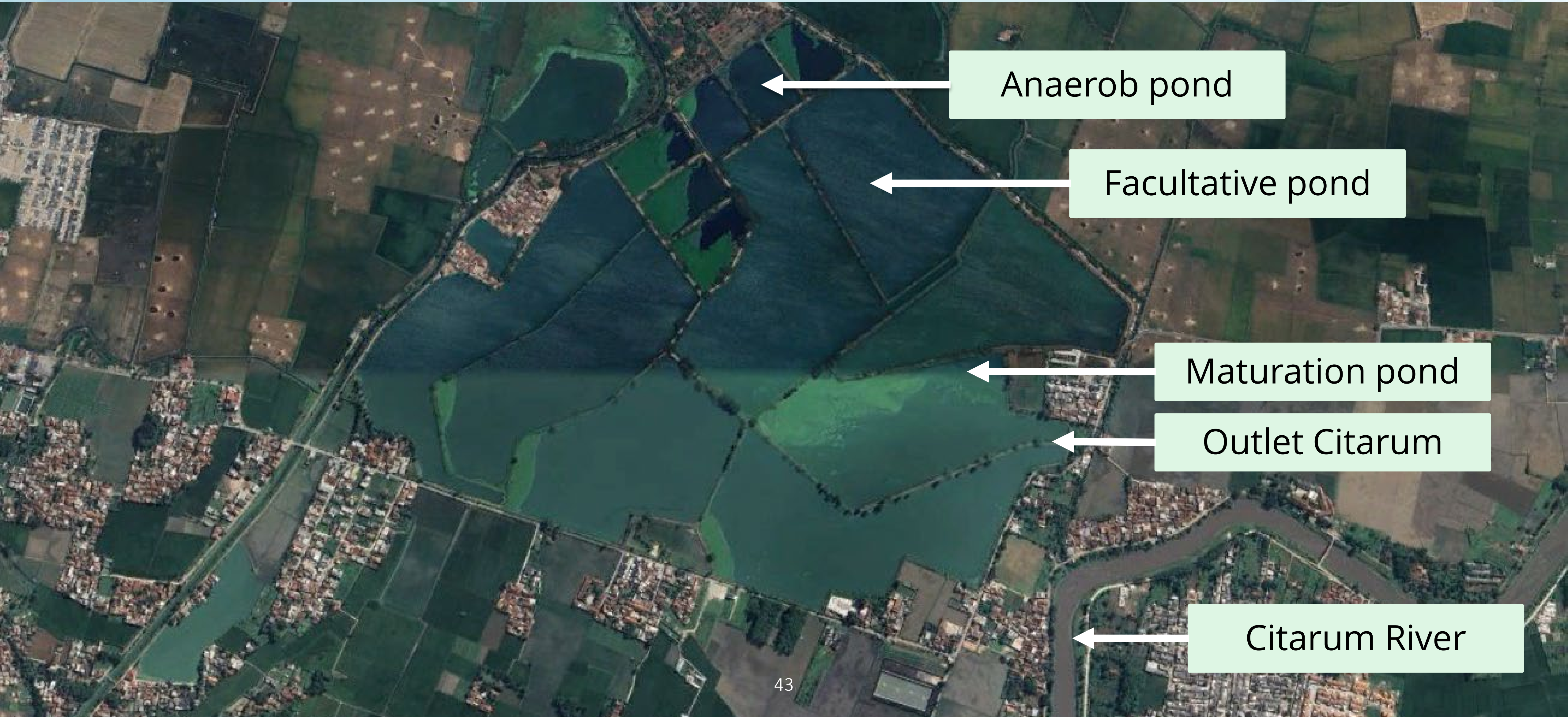
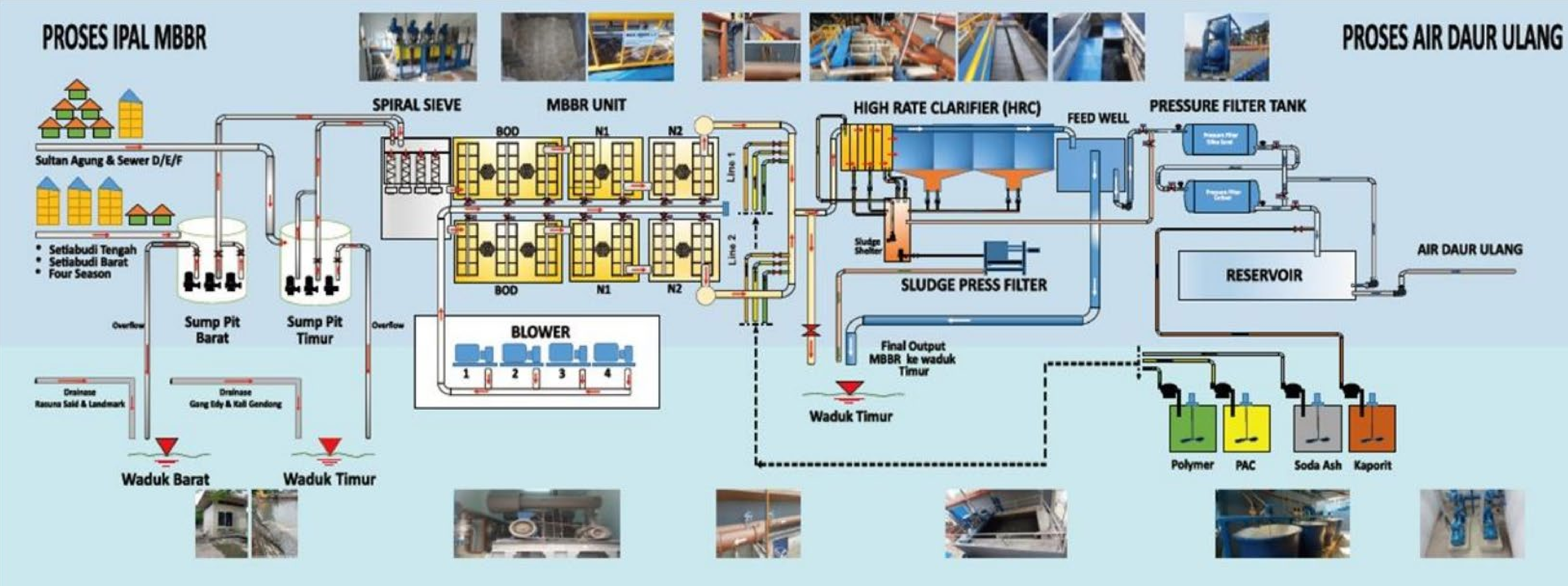


FIGURE 14. Setiabudi WWTP Processing Scheme



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04 GHG EMISSIONS FROM DOMESTIC WASTEWATER

IMPORTANT

GHG EMISSIONS FROM DOMESTIC WASTEWATER

1. Concern on global warming there is further mindfulness about emissions of greenhouse gases (GHGs) worldwide.
2. Both public and private sector organisations are increasingly being needed to report on, manage and (where possible) reduce their GHGs.
3. WWTP appear can emit gases that are harmful to the climate, such as nitrous oxide (N_2O), carbon dioxide (CO_2), and methane (CH_4) during the biological wastewater treatment processes and CO_2 is also emitted during the production of the energy required for the plant operation.
4. The wastewater treatment sector is classified as one of the larger minor sources of greenhouse gas emissions (U.S. EPA, 1997).

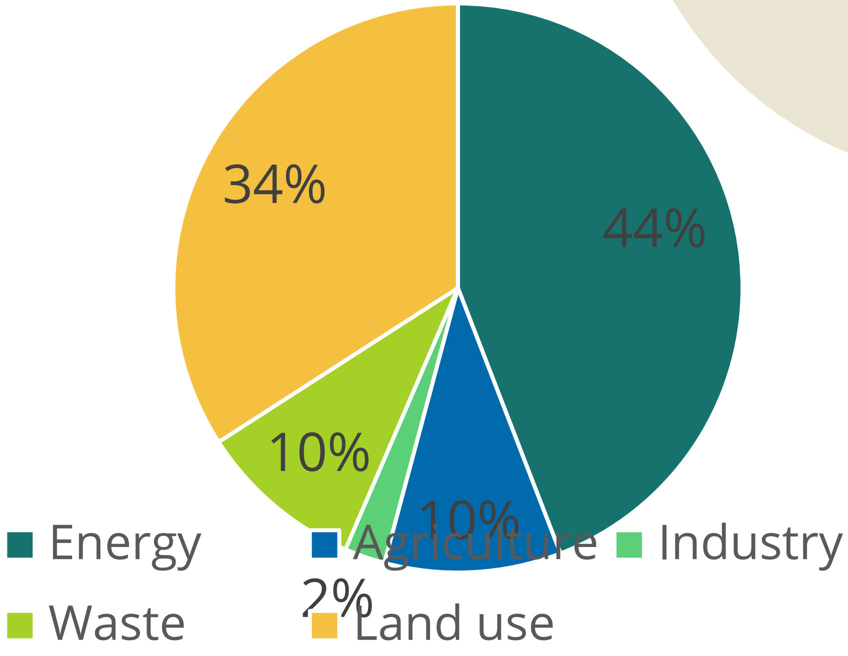

Figure 15. GHG Emissions in Indonesia

Source : Climate Watch, 2020

Indonesia produces GHG emissions of around 1.48 Gt CO_2eq. This figure is equivalent to 3.1% of global GHG emissions, the total volume of which reaches 47.5 Gt CO_2 eq.

IMPORTANT

GHG EMISSIONS FROM DOMESTIC WASTEWATER

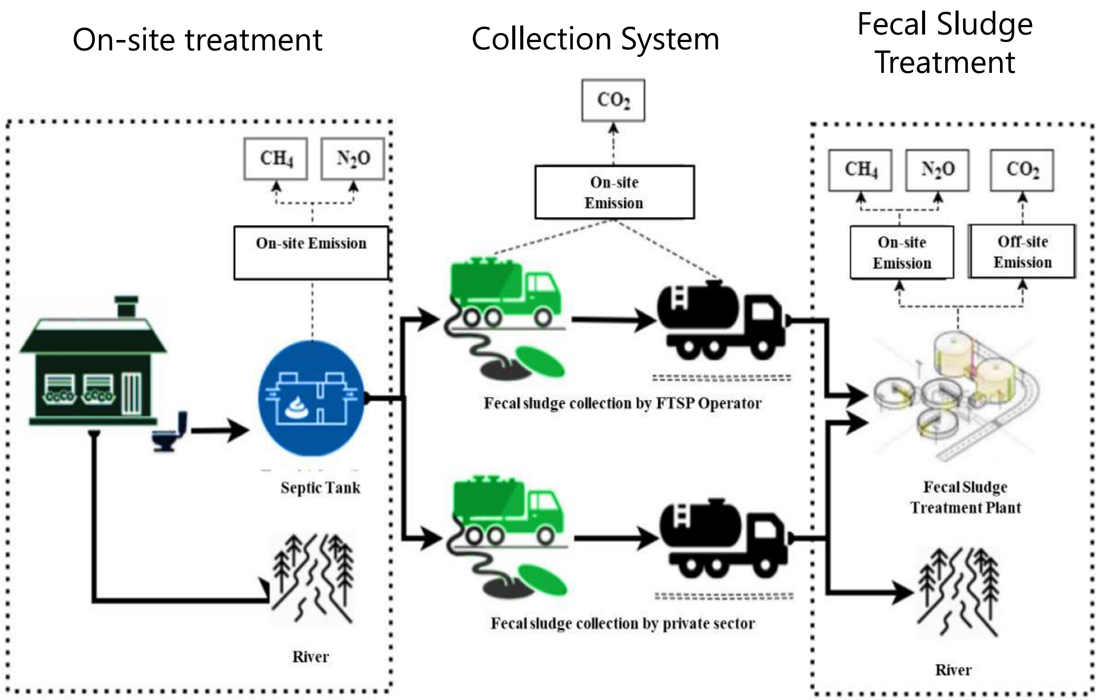

Figure 16. The boundary of GHG emissions from wastewater management

Source : Pratama et al., 2021

GHG EMISSIONS

- Indonesia's wastewater management system is generally an on-site system, where people mostly use septic tanks equipped with an infiltration area.
- GHGs are emitted from a WWTP through three main mechanisms:
  1. Direct; biological processes (emissions of CO_2 from microbial respiration, N_2O from nitrification and denitrification, and CH_4 from anaerobic digestion).
  2. Indirect internal; consumption of imported electrical or thermal energy.
  3. Indirect external; sources not directly controlled within the WWTP (e.g., third-party biosolids hauling, production of chemical sand their transportation to the plant, etc.)

IMPORTANT

GHG EMISSIONS FROM DOMESTIC WASTEWATER

BACKGROUND

- N_2O : is an intermediate of biological processes such as heterotrophic denitrification and nitrification. Its production occurs mainly in the activated sludge units (90%) while the remaining 10% comes from the grit and sludge storage tanks.
- CO_2: its production is attributed to two main factors: biological treatment process and electricity consumption. In the main stream of the WWTP the organic carbon of wastewater is either incorporated into biomass or oxidized to CO_2. In the sludge line, it is converted mainly to CO_2 and CH_4 during anaerobic digestion and, finally, methane is oxidized to CO_2 during biogas combustion.

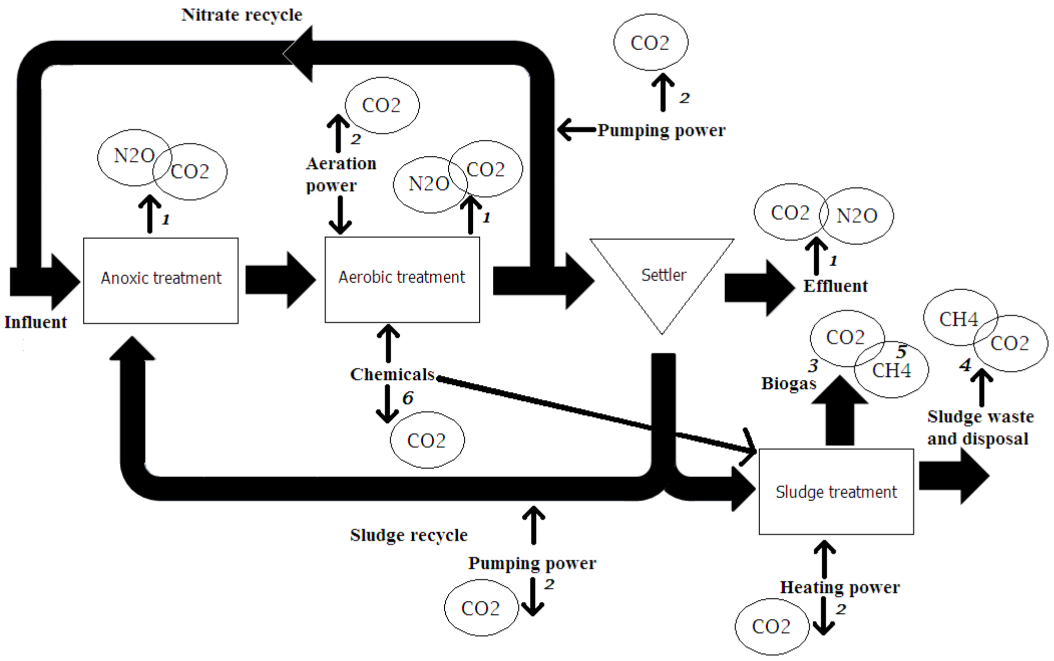

Figure 17. GHG Emissions of a Wastewater Treatment Plant

Source : Snip, 2010

- CH_4 : The main sources of methane detected were; the primary sludge thickener, the centrifuge, the exhaust gas of the cogeneration plant, the buffer tank for the digested sludge, and the storage tank for the dewatered sludge. These units contribute to around 72% of methane emissions of the WWTP.

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Thank you for your kind attention.

For more resources and information on events visit https://www.globalmethane.org/ or scan the QR code:

Global Methane Initiative

References

Ahmad, D. A., and Kristanto, G. A. (2021): Estimation of household greenhouse gas emissions from different activities in Bintang Alam, Karawang Regency, Indonesia, IOP Conference Series: Earth and Environmental Science, 724(1), 012062. https://doi.org/10.1088/1755-1315/724/1/012062

Kristanto, G. A., Pratama, M. A., and Rahmawati, D. F. (2020): Estimation of greenhouse gas emissions from solid waste management and wastewater treatment in the Nizam Zachman Fishery Port, Jakarta, Indonesia, IOP Conference Series: Earth and Environmental Science, 423(1), 012039. https://doi.org/10.1088/1755-1315/423/1/012039

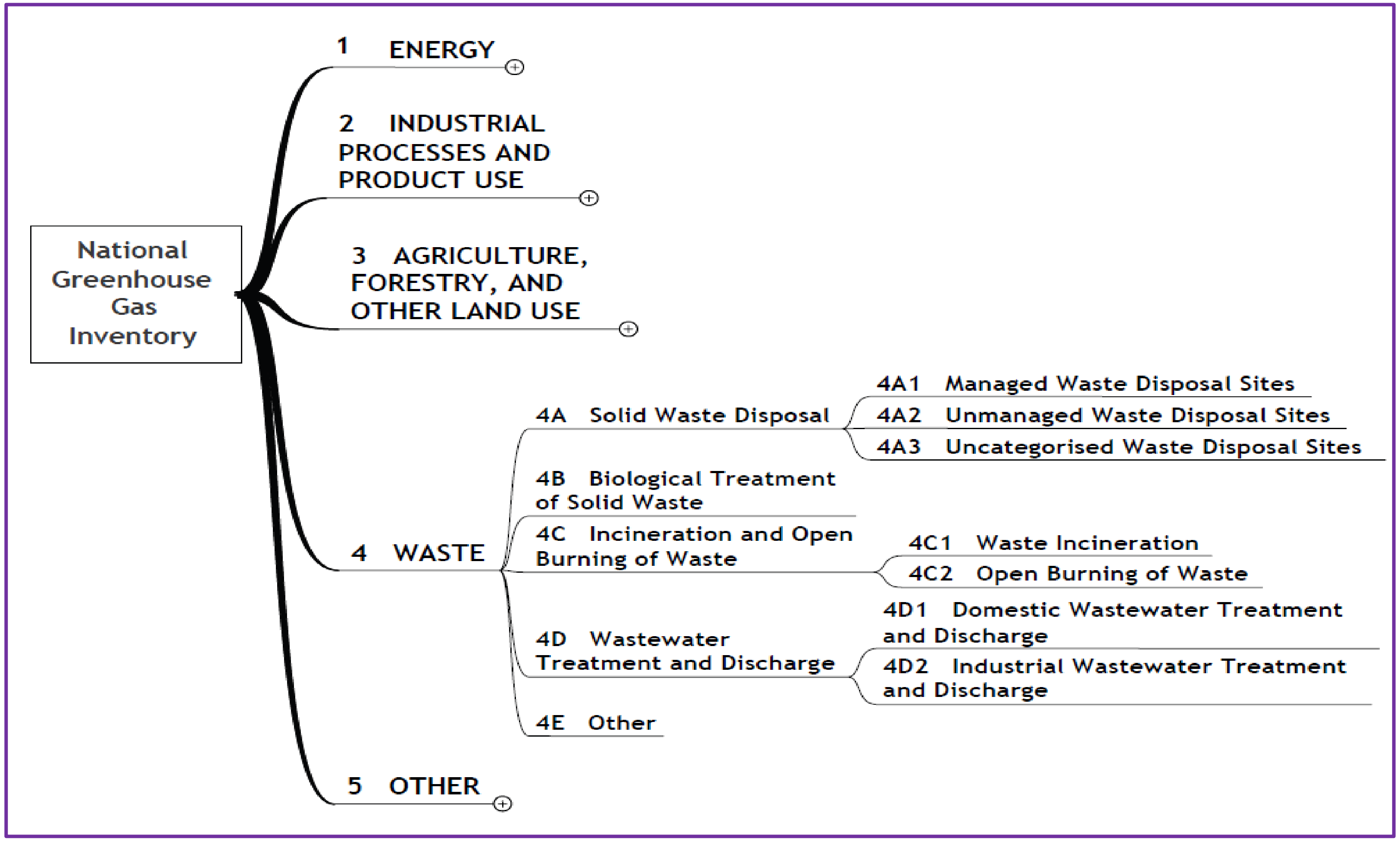
Pratama, M. A., Amrina, U., and Kristanto, G. A. (2021): Estimation of greenhouse gases from sewage from on-site sewage management system, IOP Conference Series: Earth and Environmental Science, 724(1), 012031. https://doi.org/10.1088/1755-1315/724/1/012031

GHG Emissions Inventory in the Municipal Wastewater Sector

Dr. Febrian Hadinata
MRV Team and GHG Methodology Panel of the Ministry of Environment and Forestry

March 14, 2024

1. Structure of Emissions Categories within the Waste Sector



source: 20006 IPCC GL, Vol. 5, Ch. 1, page 1.4

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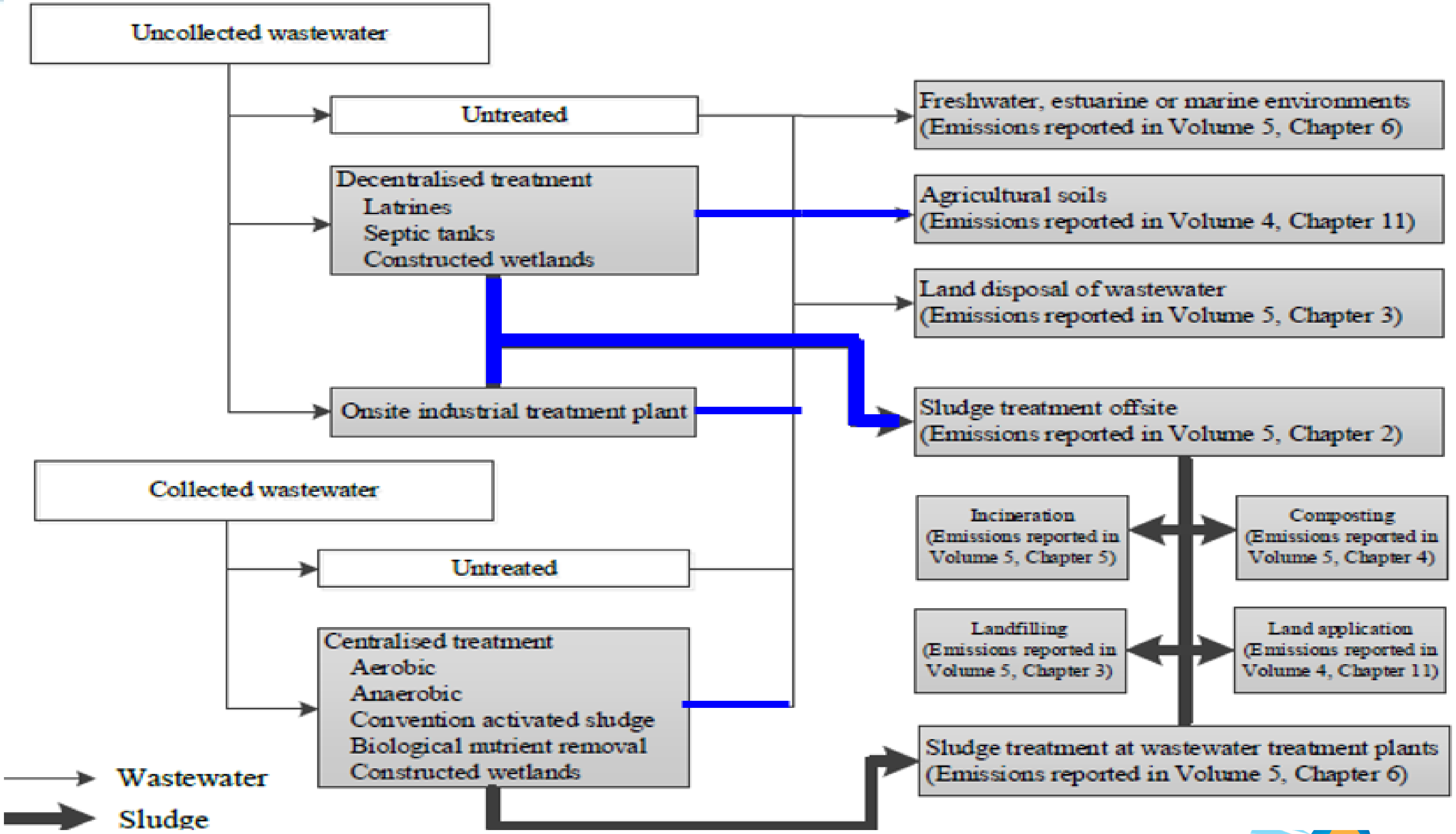
Wastewater treatment and disposal pathways in IPCC Guideline

Note: Blue ink is a new processing/disposal pathway in Refinement 2019



Source: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 5, Ch. 6, page 6.8

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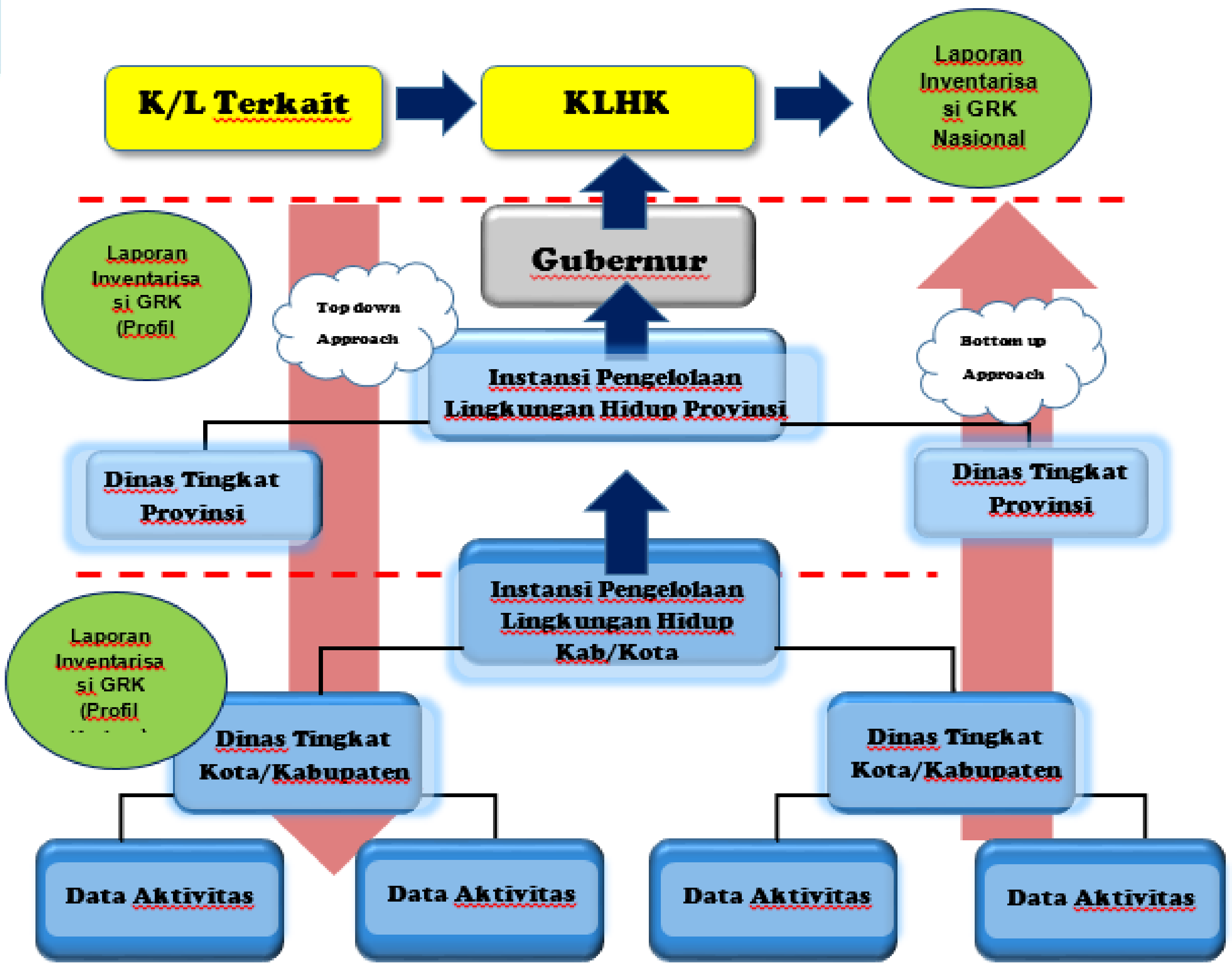
Institutional Arrangements of National GHG Inventory

Coordinator for Waste Sector: Directorate of Waste Handling, MoEF.

Domestic Wastewater Sub-Sector:

- Directorate of Water Pollution Control, MoEF;
- Directorate of Environmental Sanitation and Settlement Development, Ministry of Public Works & Public Housing;
- Center for Housing and Settlement Research and Development, Ministry of Public Works & Public Housing.

Source:
Regulation of The President of The Republic of Indonesia Number 16 of 2018;
Regulation of MoEF Number P.73/MENLHK/SETJEN/KUM.1/12/2017



GHG Inventory Data Flow and Reporting

Source: 2021 GHG Inventory Report, accessed from https://www.ditjenppi.org/indonesia/document on 08/03/2024

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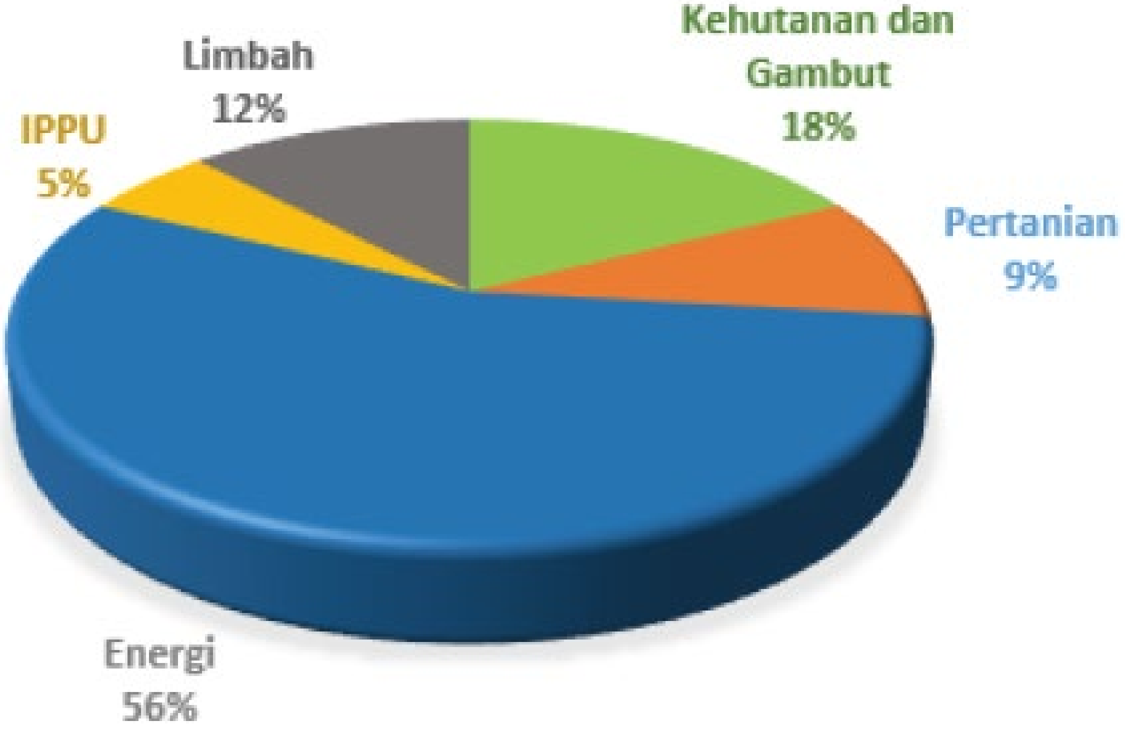
GHG Emissions in Indonesia (2020)



Waste sector (= 126.797 Gg CO2e) contributed 12% to Indonesia's Total Emissions in 2020 (= 1.050.413 Gg CO2e)

Domestic wastewater is one of the key emissions in 2020

NO.	Code	Category	Total GHG Emissions (Gg CO2e)	Absolut Emission (Gg CO2e)	Level /Range (%)	Cumulatif (%)
1	Other	Peat Decomposition	397.422,84	397.423	22,96%	22,96%
2	3B1a.	Forest Remaining Forest	-335.018,10	335.018	19,36%	42,32%
3	1.A.1.a	Main activity electricity and heat production	279.334	279.334	16,14%	58,46%
4	1.A.3	Transport	135.217	135.217	7,81%	66,27%
5	1.A.2	Manufacturing industries and construction	105.641	105.641	6,10%	72,37%
6	4D 2	Industrial Wastewater Treatment and Discharge	57.675	57.675	3,33%	75,70%
7	3B6b.	Non-Otherland to Otherland	52.942,87	52.943	3,06%	78,76%
8	3B2b.	Non-Cropland to Cropland	51.608,25	51.608	2,98%	81,75%
9	4A 2	Unmanaged Solid Waste Disposal	39.183	39.183	2,26%	84,01%
10	2.A.1	Cement	29.083	29.083	1,68%	85,69%
11	3.C4	Direct N2O Manure Management	26.845,84	26.846	1,55%	87,24%
12	1.A.4.b	Residential	26.543	26.543	1,53%	88,77%
13	3.C7	Rice Cultivation	24.863,76	24.864	1,44%	90,21%
14	4D 1	Domestic Wastewater	24.443	24.443	1,41%	91,62%
15	Other:	Peat Fire	18.460,42	18.460	1,07%	92,69%
16	3.A1	Enteric Fermentation	18.174,00	18.174	1,05%	93,74%
17	1.B.2	Fugitive from Oil/Natural Gas	15.883	15.883	0,92%	94,66%
18	1.A.1.b	Petroleum Refining	13.683	13.683	0,79%	95,45%

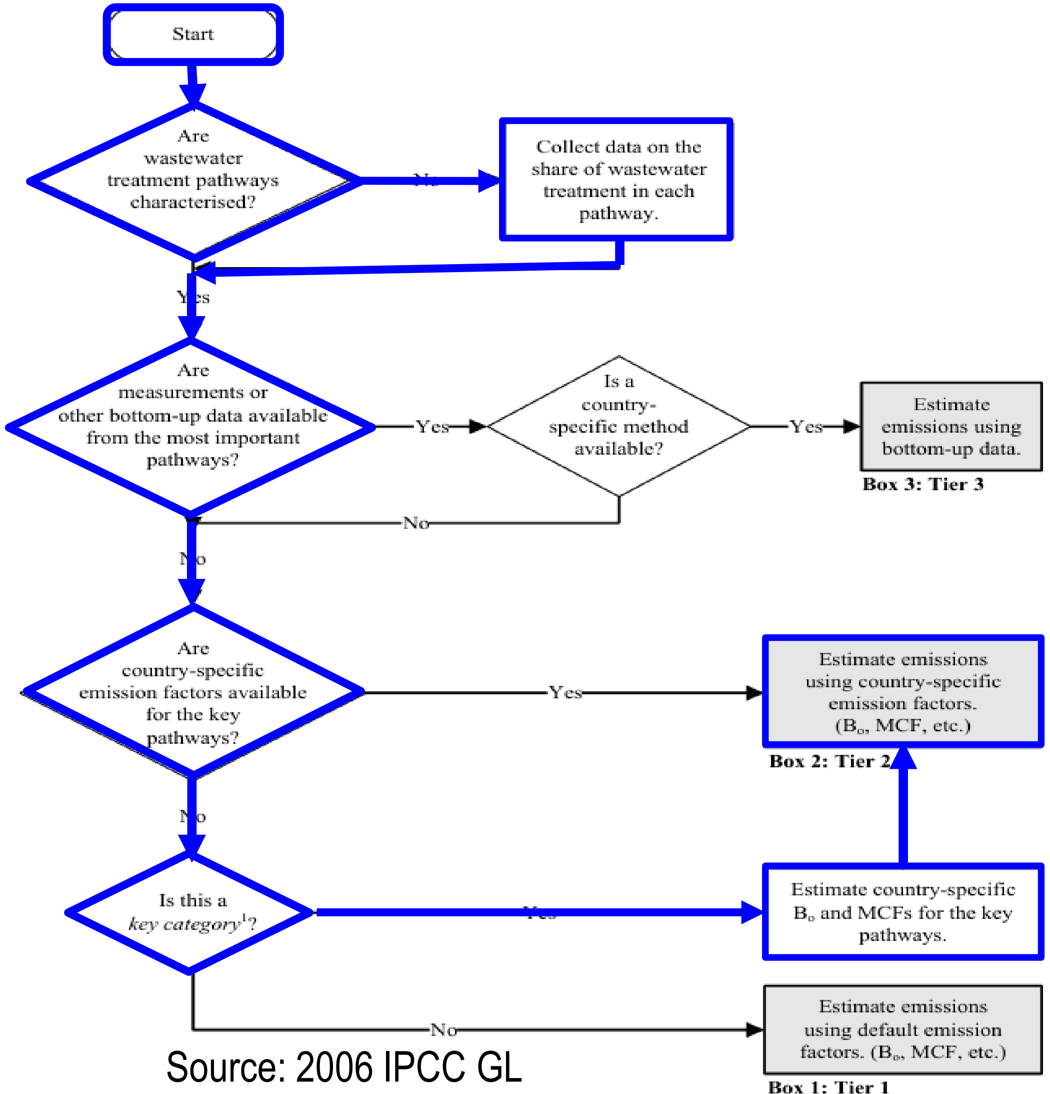
Source: 2021 GHG Inventory Report, accessed from https://www.ditjenppi.org/indonesia/document on 08/03/2024

Global Methane Initiative

Methodology for Calculating GHG Inventory for the Domestic Wastewater Sub-Sector

- Currently, referring to the method in the 2006 IPCC Guidelines (**Tier I**);
- The application of the methodology is stipulated in the Regulation of MoEF Number P.73/MenLHK/Setjen/Kum.1/12/2017 on Guidelines for Organizing and Reporting of Greenhouse Gas Inventories;
- The Global Warming Potential (GWP) value follows the GWP value for the 100-year horizon in the Second Assessment Report (2nd AR of IPCC).

Due to Domestic Wastewater is one of the key emissions, it is best to use Tier II.



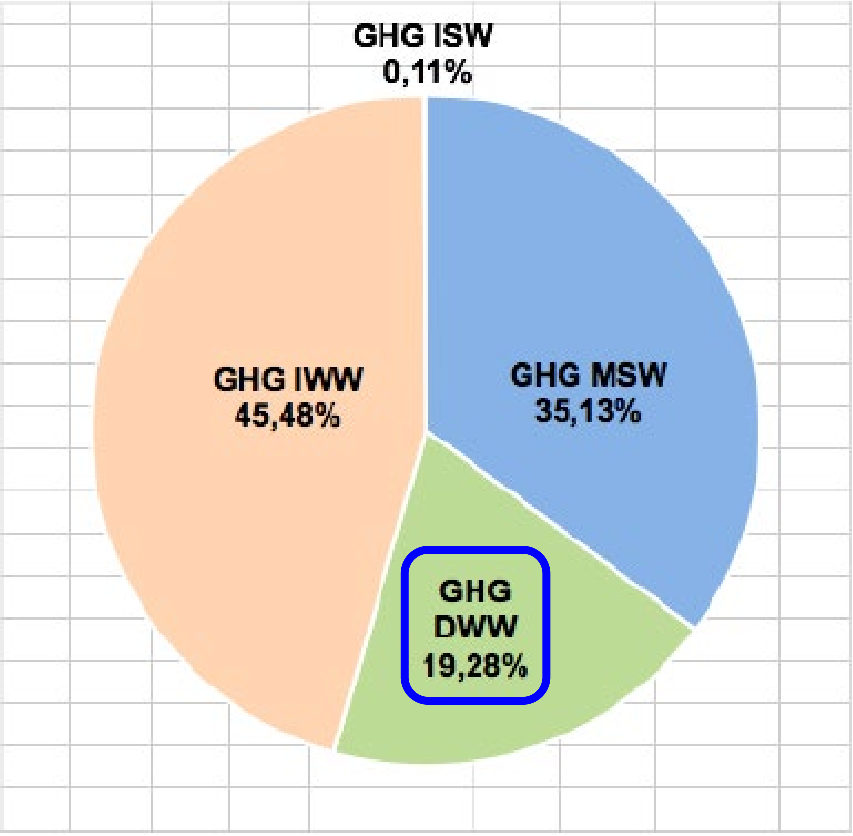
Source: 2006 IPCC GL

Global Methane Initiative

Contribution of the Domestic Wastewater Sub-Sector to Total Waste Sector Emissions in 2020

GHG Source and Sink Categories			CO2*	CH4	N2O	TOTAL
			(Ggram CO2-e)			
Total Waste			**3.056**	**120.092**	**3.648**	**126.797**
A.	**Solid waste disposal**					
	1.	Manage waste disposal sites				
	1.1	Managed domestic waste disposal sites				
	1.2	Manage Industrial waste disposal		22,14		**22,14**
	2.	Unmanage domestic waste disposal sites		39.183		**39.183**
	3.	Uncategorised waste disposal sites				
B.	**Biological treatment od solid waste**					
	1.	Composting of domestic solid waste		0,057	2,10	**2,16**
	2.	Composting of industrial solid waste		0,90	0,80	**1,71**
	3.	Anaerobic digestion at biogas facilities				
C.	**Incineration and open burning of waste**					
	1.	Waste incineration				
	2.	Open burning of domestic solid waste	3.055	1.943	351	**5.349**
D.	**Wastewater treatment and dischrage**					
	1.	Domestic wastewater		21.149	3.294	**24.443**
	2.	Industrial wastewater		57.675		**57.675**
	3.	Other (as specified in Table 5 D)				
E.	**Other (please specify)**					
	1.	Industrial solid waste handling	1,14	119,74		**120,88**

*CO2 emission from waste sector is derived from fossil content (C2) and as CO2 equivalent emitted from pre-treatment of biomass fuel (E1)



Source: 2021 GHG Inventory Report, accessed from https://www.ditjenppi.org/indonesia/document on 08/03/2024

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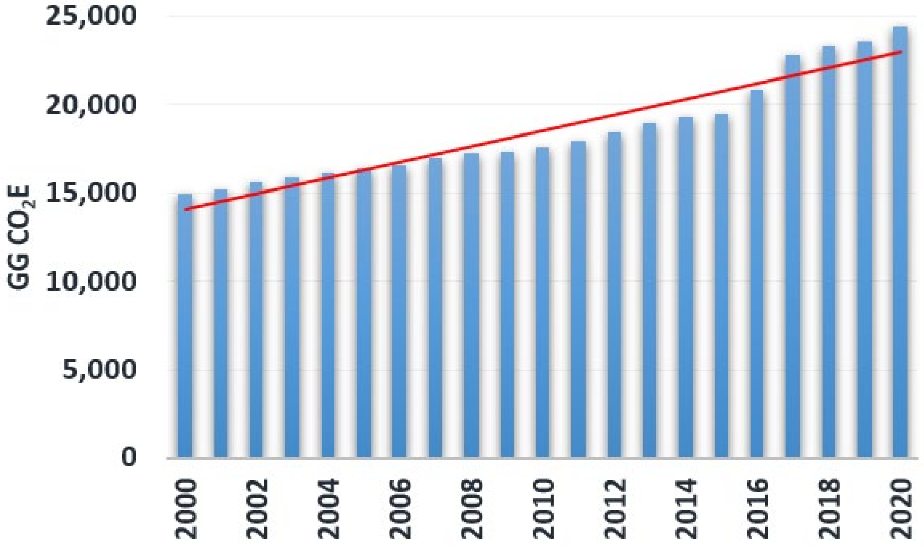
Trends in GHG emissions in the Domestic Wastewater Sub-sector in 2010 - 2020



Verified GHG emission reduction in the Domestic Wastewater Sub-sector in 2020

Mitigation Action	Baseline emissions (tonnes of CO_2e)	Verified emissions reductions (tonnes of CO2e)	Note
Use of Integrated WWTP	24,500,283 (Scenario with Activity data on the 1st BUR)	71,160	Emission reduction is the difference between the emission level in the baseline scenario and the emission level in current conditions
Use of Biodigester		42	
Use of Fecal Sludge Treatment Plants		2,778	
Use of WWTP (from Statistics)		56,367	
Total		**130,348**	

Source: 2021 GHG Inventory Report, accessed from https://www.ditjenppi.org/indonesia/document on 08/03/2024

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2. GHG Emission Reporting via the SIGN SMART Platform

SIGN SMART

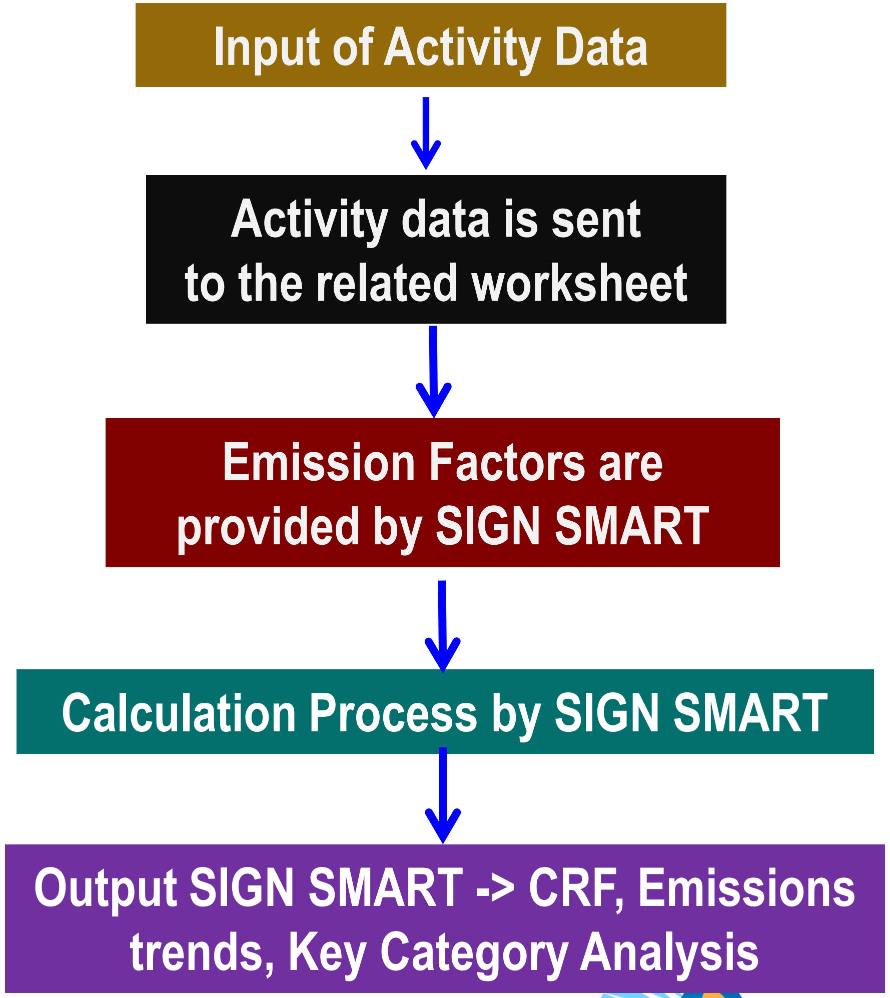
Sistem **I**nventarisasi **G**as Rumah Kaca **N**asional-

***S**ederhana, **M**udah, **A**kurat, **R**ingkas, dan **T**ransparan*

In English:

National Greenhouse Gas Inventory System - Simple, Easy, Accurate, Concise and Transparent

Access at http://signsmart.menlhk.go.id/v2.1/



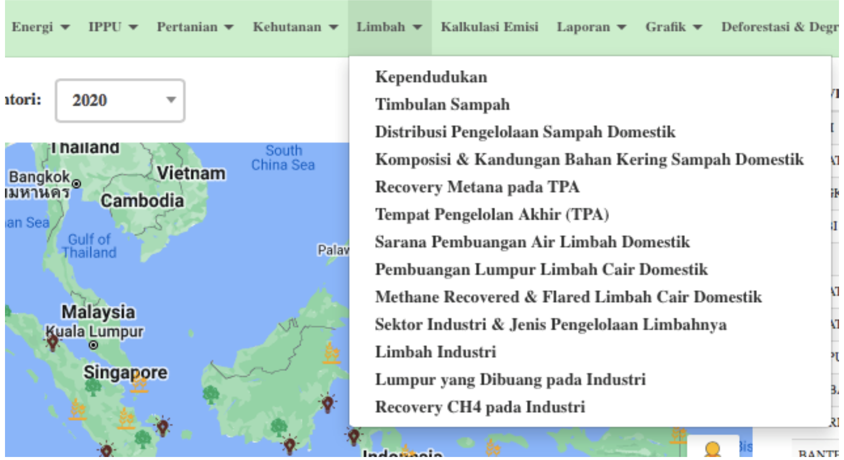
SMART SIGN WORKFLOW

Global Methane Initiative

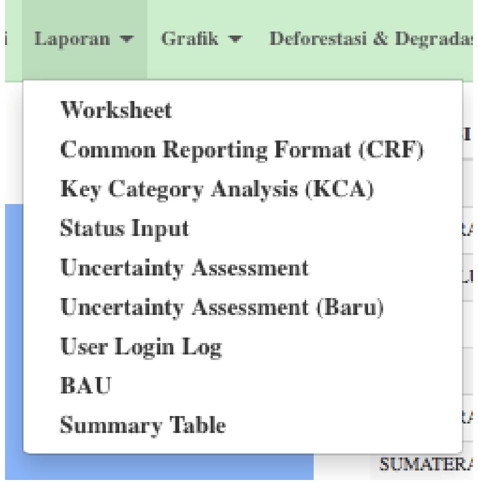
Using the SIGN-SMART Platform

MENU IN SIGN-SMART PLATFORM

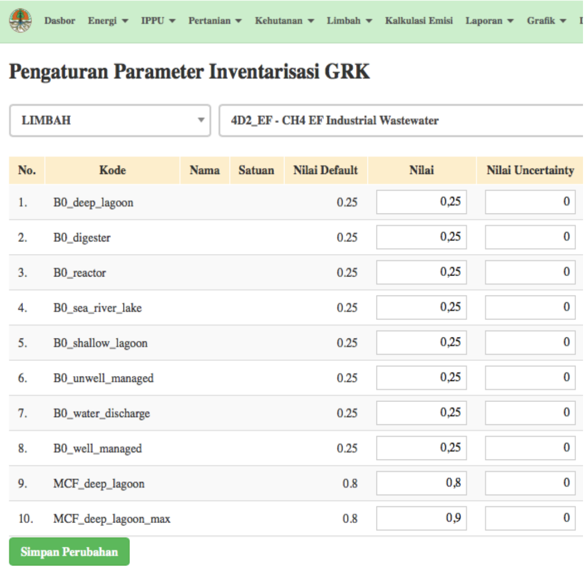
DATA INPUT



OUTPUT

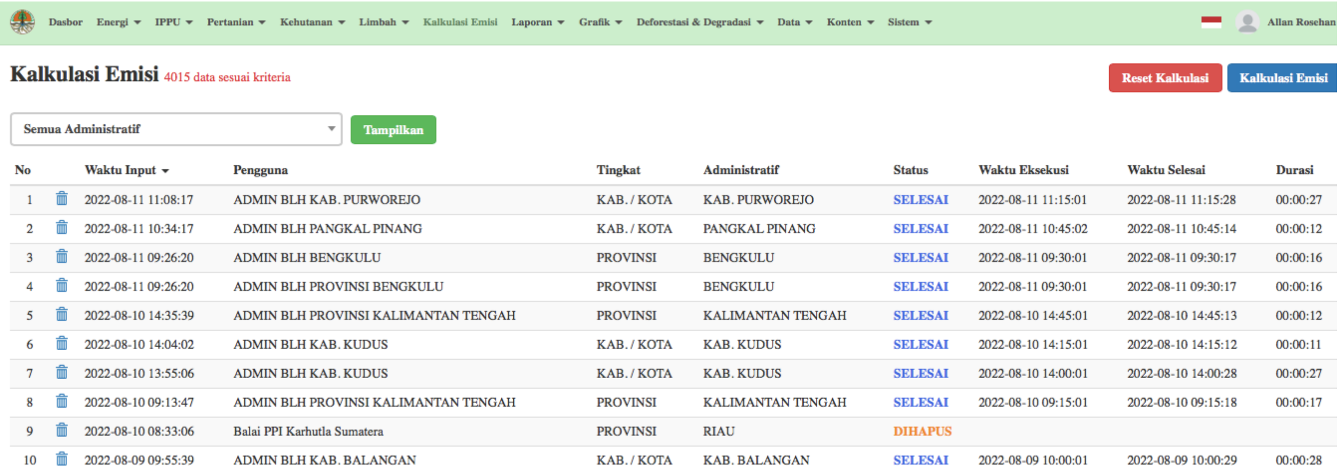


OPTION MENU FOR UPDATING PARAMETER



No.	Kode	Nama	Satuan	Nilai Default	Nilai	Nilai Uncertainty
1.	B0_deep_lagoon			0.25	0,25	0
2.	B0_digester			0.25	0,25	0
3.	B0_reactor			0.25	0,25	0
4.	B0_sea_river_lake			0.25	0,25	0
5.	B0_shallow_lagoon			0.25	0,25	0
6.	B0_unwell_managed			0.25	0,25	0
7.	B0_water_discharge			0.25	0,25	0
8.	B0_well_managed			0.25	0,25	0
9.	MCF_deep_lagoon			0.8	0,8	0
10.	MCF_deep_lagoon_max			0.8	0,9	0

CALCULATION OF EMISSION



No	Waktu Input	Pengguna	Tingkat	Administratif	Status	Waktu Eksekusi	Waktu Selesai	Durasi
1	2022-08-11 11:08:17	ADMIN BLH KAB. PURWOREJO	KAB. / KOTA	KAB. PURWOREJO	SELESAI	2022-08-11 11:15:01	2022-08-11 11:15:28	00:00:27
2	2022-08-11 10:34:17	ADMIN BLH PANGKAL PINANG	KAB. / KOTA	PANGKAL PINANG	SELESAI	2022-08-11 10:45:02	2022-08-11 10:45:14	00:00:12
3	2022-08-11 09:26:20	ADMIN BLH BENGKULU	PROVINSI	BENGKULU	SELESAI	2022-08-11 09:30:01	2022-08-11 09:30:17	00:00:16
4	2022-08-11 09:26:20	ADMIN BLH PROVINSI BENGKULU	PROVINSI	BENGKULU	SELESAI	2022-08-11 09:30:01	2022-08-11 09:30:17	00:00:16
5	2022-08-10 14:35:39	ADMIN BLH PROVINSI KALIMANTAN TENGAH	PROVINSI	KALIMANTAN TENGAH	SELESAI	2022-08-10 14:45:01	2022-08-10 14:45:13	00:00:12
6	2022-08-10 14:04:02	ADMIN BLH KAB. KUDUS	KAB. / KOTA	KAB. KUDUS	SELESAI	2022-08-10 14:15:01	2022-08-10 14:15:12	00:00:11
7	2022-08-10 13:55:06	ADMIN BLH KAB. KUDUS	KAB. / KOTA	KAB. KUDUS	SELESAI	2022-08-10 14:00:01	2022-08-10 14:00:28	00:00:27
8	2022-08-10 09:13:47	ADMIN BLH PROVINSI KALIMANTAN TENGAH	PROVINSI	KALIMANTAN TENGAH	SELESAI	2022-08-10 09:15:01	2022-08-10 09:15:18	00:00:17
9	2022-08-10 08:33:06	Balai PPI Karhutla Sumatera	PROVINSI	RIAU	DIHAPUS			
10	2022-08-09 09:55:39	ADMIN BLH KAB. BALANGAN	KAB. / KOTA	KAB. BALANGAN	SELESAI	2022-08-09 10:00:01	2022-08-09 10:00:29	00:00:28

SIGN SMART

sumber: Allan Rosehan Y., S.P., M.P. (2023)

Global Methane Initiative

Inputs for the domestic wastewater sub-sector in SIGN-SMART

- Population
- The proportion of the population living in villages and cities
- Protein consumption per capita
- Domestic Wastewater Treatment and Disposal Fraction

Dasbor | Energi | IPPU | Pertanian | Kehutanan | Limbah | Kalkulasi Emisi | Laporan | Deforestasi & Degradasi | Grafik | Data | Konten | Sistem | Allan Rosehan

Tahun Inventori: 2020

CATATAN: Emisi yang ditampilkan di dashboard di-update setiap malam (tidak real-time). Jika Anda melakukan kalkulasi hari ini, maka akan muncul di dashboard keesokan harinya.

PROVINSI	ENERGI	IPPU	PERTANIAN	KEHUTANAN	LIMBAH
ACEH	0,00	0,00	1.227.386,68	94.509.290,81	0,00
SUMATERA UTARA	493.031.890,07	394.359,03	6.142.027,45	6.416.856,59	4.816.301,53
BENGKULU	956.946,62	0,00	713.496,33	-2.933.717,45	716.246,69
JAMBI	1.285.582,77	0,00	1.492.319,11	0,00	0,00
RIAU	20.570.988,13	115,35	2.224.020,72	154.585.811,60	6.510.703,62
SUMATERA BARAT	1.763.410,60	0,00	2.413.081,26	-513.411,27	78.131,76
SUMATERA SELATAN	30.611.813,81	1.057.548,65	3.137.783,49	59.860.803,33	3.032.061,89
LAMPUNG	0,00	0,00	2.718.482,00	-877.906,40	1.246.140,05
KEP. BANGKA BELITUNG	2.758.479,40	0,00	460.504,24	-537.644,70	479.639,07
KEP. RIAU	0,00	0,00	37.382,70	0,00	0,00
BANTEN	0,00	0,00	1.009.865,44	-2.770.990,26	1.752.476,88
JAWA BARAT	24.965.964,35	13.284.419,89	18.694.874,41	11.611.593,96	22.288.154,30
DKI JAKARTA	9.244.746,89	0,00	3.169,55	0,00	1.279,94
JAWA TENGAH	70.359.771,37	4.560.793,98	21.467.705,64	0,00	2.171.631,07
JAWA TIMUR	5.742.418,12	0,00	16.085.796,02	1.315.876.828,71	0,00
DI YOGYAKARTA	2.719.793,76	0,00	1.331.252,42	3.695.251,11	431.896,28
BALI	7.538.636,37	0,00	1.612.140,17	0,00	212.945,44
NUSA TENGGARA BARAT	4.220.076,73	0,00	3.564.483,20	-227.673,68	0,00
NUSA TENGGARA TIMUR	1.440.170,62	0,00	3.345.061,19	0,00	0,00

sumber: Allan Rosehan Y., S.P., M.P. (2023)

Population

Total Population data must be consistent. Data source:
- Central Bureau of Statistics
- Population and Civil Registry Agency

The proportion of the population living in villages and cities
Example of data source:
Population projections for districts/cities in West Java province 2010 – 2020

PROTEIN CONSUMPTION
Example of data source:
▪Provincial Level: Calorie and protein consumption of the Indonesian population and Provinces (Central Bureau of Statistics)
▪District/city level: People's Welfare Statistics Book (Central Bureau of Statistics)

Kependudukan Prov. SUMATERA SELATAN

PROVINSI | SUMATERA SELATAN | Tampilkan | Ekspor Excel | Data Historis

No.	Tahun	Aksi	Meta	QC	QA	Jumlah Penduduk (jiwa)	Tinggal di Pedesaan (%)	Tinggal di Perkotaan (%)	Konsumsi Protein Per Kapita (kg / org / tahun)
1.	2022								
2.	2021					8.550.849	73,55	26,45	63,62
3.	2020					8.467.432	73,79	26,21	58,85
4.	2019					8.470.729	73,78	26,22	59,90
5.	2018					8.370.320	73,78	26,22	59,34
6.	2017					8.266.983	73,78	26,22	63,12
7.	2016					8.160.901	73,78	26,22	
8.	2015					8.052.315	73,78	26,22	
9.	2014					7.941.495	73,79	26,21	
10.	2013					7.828.740	73,79	26,21	

source: Allan Rosehan Y., S.P., M.P. (2023)

Example: Data On The Fraction Of The Population Living In Villages And Cities

https://sensus.bps.go.id/topik/tabular/sp2022/187/1/0

BERANDA | LAYANAN DATA | METADATA | MEDIA | PRODUK STATISTIK | Cari Informasi.. | ID | Pilih Sensus Lain

Tabel Grafik Peta

Wilayah : INDONESIA

JSON

Jumlah Penduduk menurut Wilayah, Daerah Perkotaan/Perdesaan, dan Jenis Kelamin, INDONESIA, Tahun 2022

Nama Provinsi	Perkotaan			Perdesaan			Total		
	Laki-laki	Perempuan	Total	Laki-laki	Perempuan	Total	Laki-laki	Perempuan	Total
19. KEPULAUAN BANGKA BELITUNG	435.958	425.681	861.639	331.624	301.358	632.982	767.582	727.039	1.494.621
21. KEPULAUAN RIAU	961.344	936.294	1.897.638	150.808	131.374	282.182	1.112.152	1.067.668	2.179.820
31. DKI JAKARTA	5.375.869	5.304.082	10.679.951	-	-	-	5.375.869	5.304.082	10.679.951
32. JAWA BARAT	19.431.090	18.834.986	38.266.077	5.636.136	5.503.596	11.139.731	25.067.226	24.338.582	49.405.808
33. JAWA TENGAH	9.588.991	9.554.625	19.143.617	9.025.877	8.862.917	17.888.793	18.614.868	18.417.542	37.032.410
34. DI YOGYAKARTA	1.377.361	1.371.728	2.749.089	484.724	528.057	1.012.781	1.862.085	1.899.785	3.761.870
35. JAWA TIMUR	11.333.300	11.268.595	22.601.895	9.192.456	9.355.623	18.548.079	20.525.756	20.624.218	41.149.974
36. BANTEN	4.503.237	4.370.677	8.873.914	1.737.804	1.640.267	3.378.071	6.241.041	6.010.944	12.251.985

Source: https://sensus.bps.go.id/

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Example of Protein Consumption Data At Province Level

Tabel / *Table* **A.4.3**

Rata-rata Konsumsi Kalori dan Protein per Kapita Sehari di Daerah Perkotaan dan Perdesaan menurut Provinsi, Maret 2021

Average Daily Consumption of Calorie and Protein per Capita in Urban Area and Rural Area by Province, March 2021

Provinsi / *Province*	Kalori (Kkal) / *Calorie (Kcal)*			Protein (Gram) / *Protein (Grams)*		
	Makanan Dimasak di Rumah/ *Home Cooked Foods*	Makanan dan Minuman Jadi/ *Prepared food and beverage*	Jumlah/ *Total*	Makanan Dimasak di Rumah/ *Home Cooked Foods*	Makanan dan Minuman Jadi/ *Prepared food and beverage*	Jumlah/ *Total*
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Aceh	1 671,96	499,17	2 171,13	50,14	12,88	63,02
Sumatera Utara	1 753,63	395,60	2 149,23	51,46	11,80	63,26
Sumatera Barat	1 649,81	485,48	2 135,30	44,28	14,10	58,39
Riau	1 714,60	364,93	2 079,53	47,98	10,06	58,04
Jambi	1 745,67	394,87	2 140,54	48,52	11,48	60,01
Sumatera Selatan	1 799,37	432,74	2 232,11	50,60	13,01	63,62
Bengkulu	1 768,27	356,32	2 124,59	48,58	10,33	58,90
Lampung	1 746,74	350,47	2 097,21	47,80	9,85	57,65
Kep. Bangka Belitung	1 669,37	442,15	2 111,52	51,34	13,30	64,63
Kepulauan Riau	1 679,71	469,62	2 149,34	52,39	17,91	70,31
DKI Jakarta	1 617,87	605,45	2 223,32	50,29	20,22	70,51
Jawa Barat	1 657,37	556,61	2 213,98	47,43	17,37	64,79
Jawa Tengah	1 556,90	515,38	2 072,28	42,69	16,60	59,28

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Protein Consumption in West Java Province = 64.79 Gram/person/day

= 64.79 Gram/org/hari * 365 * 0.001 = 23.65 kg/person/yr

Example of Protein Consumption Data At District/City Level

Tabel 7.3 Rata-Rata Konsumsi Protein per Kapita Sehari menurut Kelompok Komoditas Makanan dan Kelompok Pengeluaran (Gram), 2023

Kelompok Komoditas Makanan		Kelompok Pengeluaran			Total Konsumsi Protein
		40 Persen Terbawah	40 Persen Tengah	20 Persen Teratas	
(1)		(2)	(3)	(4)	(5)
1.	Padi-padian	15,39	17,74	16,99	16,65
2.	Umbi-umbian	,19	,37	,45	,31
3.	Ikan/Udang/ Cumi/Kerang	3,78	7,21	9,47	6,29
4.	Daging	5,21	9,65	11,08	8,16
5.	Telur dan Susu	3,49	5,08	6,51	4,73
6.	Sayur-sayuran	1,15	1,72	1,90	1,53
7.	Kacang-kacangan	5,66	7,26	7,95	6,76
8.	Buah-buahan	,30	,67	1,01	,59
9.	Minyak dan Kelapa	,04	,10	,10	,08
10.	Bahan Minuman	,49	,79	,67	,65
11.	Bumbu-bumbuan	,22	,37	,49	,33
12.	Bahan MakananLainnya	1,40	1,62	1,47	1,50
13.	Makanan dan Minuman Jadi	11,12	16,02	21,66	15,19
14.	Rokok dan Tembakau	-	-	-	-
Rata-Rata Konsumsi Kota Bandung		**48,45**	**68,59**	**79,76**	**62,77**

Sumber: Badan Pusat Statistik, Survei Sosial Ekonomi Nasional (Susenas) Maret

https://bandungkota.bps.go.id

Protein Consumption in Bandung City 2023 = 62.77 gram/person/day

= 62.77 g/person/day * 365 days * 0.001 kg/g= 22.91 kg/person/yr

Degree of utilization of treatment or discharge pathway

Tabel 6.10 **Persentase Rumah Tangga[1] menurut Kabupaten/Kota dan Tempat Pembuangan Akhir Tinja, 2023**
Table *Percentage of Households[1] by Regency/Municipality and Septage Disposal, 2023*

	Kabupaten/Kota *Regency/Municipality*	Tangki Septik *Septic Tank*	IPAL *Sewage System*	Kolam/Sawah/Sungai/ Danau/Laut *Pond/Rice Field/ River/Lake/Sea*	Lubang Tanah *Land Hole*	Pantai/Tanah Lapang/ Kebun, Lainnya *Beach/Open Field/Yard, Others*	Jumlah *Total*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
01.	Kab. Bogor	72,05	1,36	17,70	8,18	0,72	100,00
02.	Kab. Sukabumi	34,49	1,04	13,05	50,87	0,55	100,00
03.	Kab. Cianjur	55,63	0,35	21,99	21,93	0,10	100,00
04.	Kab. Bandung	68,82	0,26	18,85	11,60	0,47	100,00
05.	Kab. Garut	51,86	1,35	31,28	15,51	0,00	100,00
06.	Kab. Tasikmalaya	56,38	1,22	36,42	5,84	0,13	100,00
07.	Kab. Ciamis	59,51	0,05	15,59	24,69	0,15	100,00
08.	Kab. Kuningan	79,04	0,00	8,30	12,43	0,23	100,00
09.	Kab. Cirebon	94,10	0,02	4,53	1,35	0,00	100,00
10.	Kab. Majalengka	86,54	0,09	12,03	0,90	0,45	100,00
11.	Kab. Sumedang	62,99	0,70	3,73	32,58	0,00	100,00
12.	Kab. Indramayu	99,12	0,05	0,71	0,00	0,12	100,00
13.	Kab. Subang	90,64	0,05	4,85	4,34	0,10	100,00
14.	Kab. Purwakarta	58,88	0,45	2,67	37,99	0,00	100,00
15.	Kab. Karawang	92,10	0,94	5,41	1,22	0,32	100,00
16.	Kab. Bekasi	91,86	2,83	4,50	0,75	0,06	100,00
17.	Kab. Bandung Barat	46,72	0,86	5,26	47,09	0,06	100,00
18.	Kab. Pangandaran	87,60	0,28	7,06	4,96	0,10	100,00
19.	Kota Bogor	71,08	4,52	23,59	0,00	0,81	100,00
20.	Kota Sukabumi	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21.	Kota Bandung	41,03	16,32	41,30	1,11	0,23	100,00
22.	Kota Cirebon	86,23	8,48	4,92	0,28	0,09	100,00
23.	Kota Bekasi	99,25	0,57	0,16	0,00	0,02	100,00
24.	Kota Depok	97,91	0,00	1,50	0,23	0,36	100,00
25.	Kota Cimahi	73,37	3,40	23,05	0,00	0,17	100,00
26.	Kota Tasikmalaya	60,52	0,00	35,85	3,36	0,27	100,00
27.	Kota Banjar	90,74	1,57	7,66	0,03	0,00	100,00
	Jawa Barat	**72,82**	**1,74**	**13,99**	**11,20**	**0,26**	**100,00**

Catatan/*Note* : [1]Rumah tangga yang memiliki fasilitas tempat buang air besar dengan penggunaan sendiri atau bersama/ [1]*Households using toilet facility by their own or shared with certain household*

Sumber/*Source* : Badan Pusat Statistik, Survei Sosial Ekonomi Nasional (Susenas) Maret/*BPS-Statistics Indonesia, The March National Socio-Economic Survey (Susenas)*

https://jabar.bps.go.id

SIGN SMART Input Connection with IPCC Worksheet (2006) for Domestic Wastewater Treatment and Disposal

Sector	Waste
Category	Domestic Wastewater Treatment and Discharge
Category Code	4D1
Sheet	1 of 3 Estimation of Organically Degradable Material in Domestic Wastewater

STEP 1

Year	Region or City	A Population (P) cap	B Degradable organic component (BOD) (kg BOD/cap.yr) [1]	C Correction factor for industrial BOD discharged in sewers (I) [2]	D Total Organically degradable material in wastewater (TOW) (kg BOD/yr) D = A x B x C
2000			14,6	1	0
2001			14,6	1	0
2002			14,6	1	0
2003			14,6	1	0
2004			14,6	1	0
2005			14,6	1	0
2006			14,6	1	0
2007			14,6	1	0
2008			14,6	1	0
2009			14,6	1	0
2010		238.518.800	14,6	1	3.482.374.480
2011		241.990.700	14,6	1	3.533.064.220
2012		245.425.200	14,6	1	3.583.207.920

Sector	Waste
Category	Domestic Wastewater Treatment and Discharge
Category Code	4D1
Sheet	3 of 3 Estimation of CH_4 emissions from Domestic Wastewater

STEP 3

Year	Income group	Type of treatment or discharge pathway	A Fraction of population income group (U_i) (fraction)	B Degree of utilization (T_{ij}) (fraction)	C Emission Factor (EF_j) (kg CH_4/kg BOD) Sheet 2 of 3	D Organically degradable material in wastewater (TOW) (kg BOD/yr) Sheet 1 of 3	E Sludge removed (S) (kg BOD/yr)	F Methane recovered and flared (R) (kg CH_4/yr)	G Net methane emissions (CH_4) (kg CH_4/yr) G = [(A x B x C) x (D -E)] - F	H Net methane emissions (CH_4) (Gg CH_4/yr)
2021	Rural	Septic tank	42,7%	72,1%	0,30	3.998.644.350	-		368.738.035,314	368,74
		Non Septic tank		27,9%	0,06				28.589.336,606	28,59
		Centralized		0,0%	0,18				0,000	-
		Biodiegester +CH4 Rec		0,0%	0,48		0	0	0,000	-
	Urban	Septic tank	57,3%	83,9%	0,30		570.897		576.745.800,649	576,75
		Non Septic tank		10,0%	0,06				13.759.641,598	13,76
		Centralized		5,7%	0,18				23.379.222,928	23,38
		Biodiegester +CH4 Rec		0,5%	0,48		2151958,24	1077504	3.054.255,821	3,05
								Total	1.014.266.292,915	**1.014,266**

Sector	Waste
Category	Domestic Wastewater Treatment and Discharge
Category Code	4D1
Sheet	1 of 2 Estimation of nitrogen in effluent

Year	units	A Population (P) (people)	B Per capita protein consumption (Protein) (kg/person/ year)	C Fraction of nitrogen in protein (F_{NPR}) kg N/kg protein)	D Fraction of non-consumption protein ($F_{NON-CON}$) (-)	E Fraction of industrial and commercial co-discharged protein ($F_{IND-COM}$) (-)	F Nitrogen removed with sludge (default is zero) (N_{SLUDGE}) (kg)	H Total nitrogen in effluent ($N_{EFFLUENT}$) kg N/year) H = (A x B x C x D x E) – F
2000				0,16	1,1	1,25	0	0
2001				0,16	1,1	1,25	0	0
2002				0,16	1,1	1,25	0	0
2003				0,16	1,1	1,25	0	0
2004				0,16	1,1	1,25	0	0
2005				0,16	1,1	1,25	0	0
2006				0,16	1,1	1,25	0	0
2007				0,16	1,1	1,25	0	0
2008				0,16	1,1	1,25	0	0
2009				0,16	1,1	1,25	0	0
2010		238.518.800	20,08	0,16	1,1	1,25	0	1.053.609.811
2011		241.990.700	20,53	0,16	1,1	1,25	0	1.093.041.743

Category Code	4D1
Sheet	2 of 2 Estimation of emission factor and emissions of indirect N_2O from Wastewater

	A Nitrogen in effluent ($N_{EFFLUENT}$) (kg N/year)	B Emission factor (kg N_2O-N/kg N)	C Conversion factor of kg N_2O-N into kg N_2O 44/28	D Emissions from Wastewater plants (default = zero) (kg N_2O-N/year)	E Total N_2O emissions (kg N_2O-N/year) E= A x B x C – D	F Total N_2O emissions (Gg N_2O-N/year)
2000	0,000	0,005	1,571	0,000	0,000	**0,00**
2001	0,000	0,005	1,571	0,000	0,000	**0,00**
2002	0,000	0,005	1,571	0,000	0,000	**0,00**
2003	0,000	0,005	1,571	0,000	0,000	**0,00**
2004	0,000	0,005	1,571	0,000	0,000	**0,00**
2005	0,000	0,005	1,571	0,000	0,000	**0,00**
2006	0,000	0,005	1,571	0,000	0,000	**0,00**
2007	0,000	0,005	1,571	0,000	0,000	**0,00**
2008	0,000	0,005	1,571	0,000	0,000	**0,00**
2009	0,000	0,005	1,571	0,000	0,000	**0,00**
2010	1.053.609.810,796	0,005	1,571	0,000	8.278.362,799	**8,28**
2011	1.093.041.743,063	0,005	1,571	0,000	8.588.185,124	**8,59**

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3. Estimation of CH4 Emission Levels at Maleer WWTP

CH_4 Emissions From Domestic Wastewater (Refinement 2019):

Emisi CH_4 = [((TOW – S) * EF) – R]

- CH_4 Emissions = CH4 emissions from treatment/discharge pathway or system, kg CH_4/yr;
- **TOW** = organics in wastewater of treatment/discharge pathway or system, kg BOD/yr;
- **Sludge Removal, S =** organic component removed from wastewater (in the form of sludge) from treatment/discharge, kg BOD/tahun. For wastewater discharged into aquatic environments, there is no sludge removal (**S** = 0) and no CH4 (**R** = 0);
- **EF = emission factor for treatment/discharge pathway or system, kg CH_4/kg BOD**.
- **R = amount of CH4 recovered or flared from treatment/discharge pathway or system**, default value = 0;

TOW = P * BOD * 0,001 * 365

TOW	=	total organics in wastewater in inventory year, kg BOD/yr;
P	=	**population (person)**;
BOD	=	**country-specific per capita BOD5 in inventory year, g/person/day** (default for Asia, Timur Tengah, Amerika Latin = 40 g BOD/person/day);
0,001	=	conversion from grams BOD to kg BOD.

Sludge Removal in WWTP (S)

The 2019 Refinement to 2006 IPCC GL:

- **AEROBIC TREATMENT PLANTS:**

Organic components removed as sludge from aerobic treatment plants are a function of the sludge produced from wastewater processing (S_{mass}) and sludge factors (K_{rem}), namely: $\mathbf{S_{aerobic} = S_{mass} * K_{rem} * 1000}$.

S_{aerob} = organic component removed from wastewater (in the form of sludge) in aerobic treatment plants, kg BOD/yr;
S_{mass} = **amount of raw sludge removed from wastewater treatment as dry mass, tonnes/year;**
K_{rem} = **sludge factor, kg BOD/kg sludge;**
1000 = conversion factor for tonnes to kilograms.

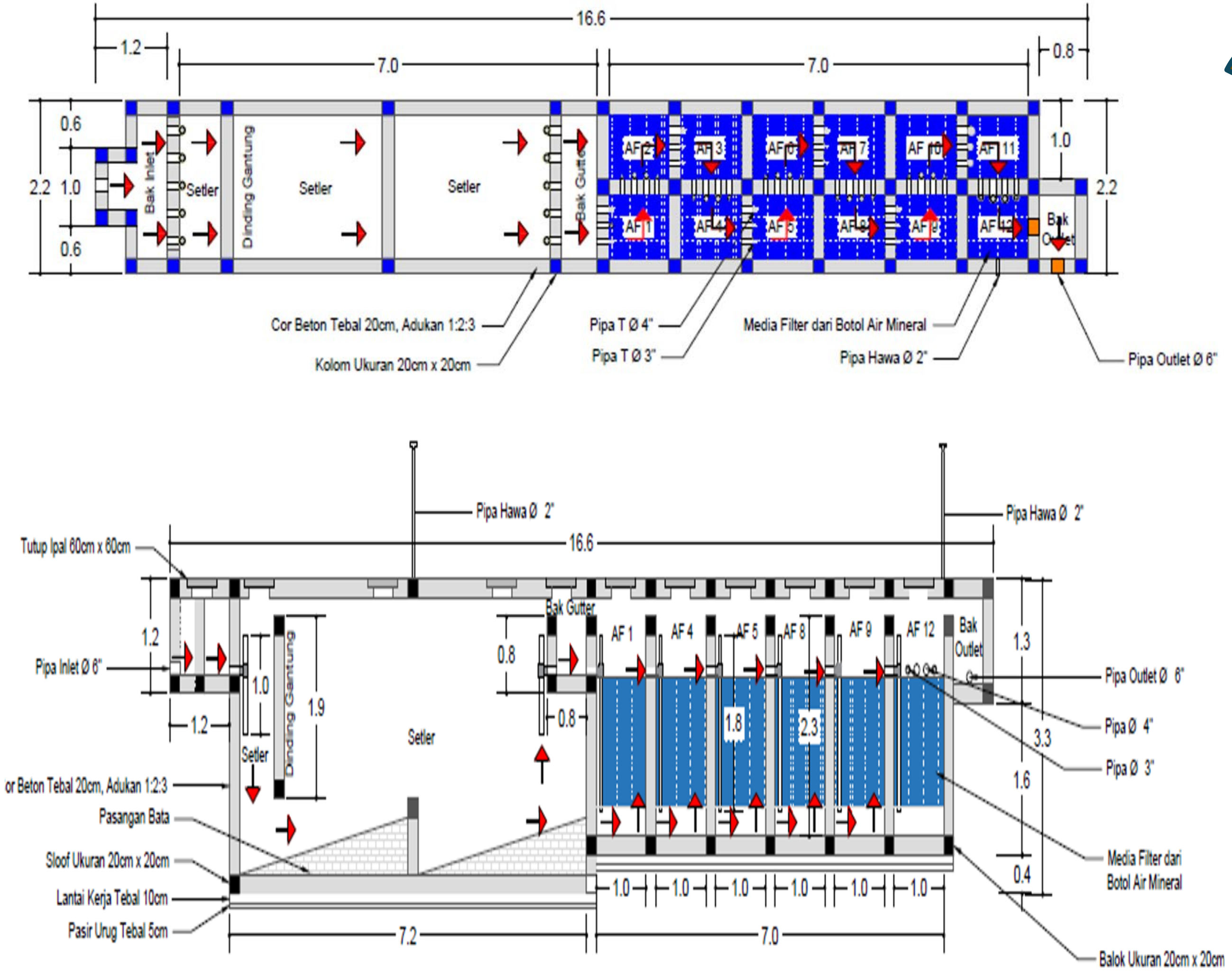
- **SEPTIC TANK:**

For septic systems, emissions depend on the fraction of population who manage septic tanks according to sludge removal instructions (F). Default value F = 0.5 (50% of the population complies with septic tank sludge removal instructions). Organic components removed as sludge are: $\mathbf{S_{septic} = TOW_{septic} * F * 0,5}$

S_{septic} = organic component removed from wastewater (in the form of sludge) in septic systems, kg BOD/yr;
TOW_{septic} = total organics in wastewater in septic systems inventory year, kg BOD/yr -> **TOWseptic = P*BOD*0,001*365** * **degree of septic tank utilization;**
F = **fraction of the population managing their septic tank in compliance with the sludge removal instructions of their septic system;**
0,5 = fraction of organics in wastewater removed in sludge when septic tank is managed in accordance with sludge removal instructions.

Note: Default value for sludge removal (IPCC 2006) = 0 (zero), see 2006 IPCC GL, Vol. 5, Ch. 6, page 6.9.

Identification type of of Maleer's WWTP



Anaerobic reactor with default values (IPCC, 2006, Ref 2019), as follows:

- **BOD_5 = 40 gram/person/day (Asia, Middle East, Latin America);**
- **Maximum methane-producing capacity = 0.6 kg CH4/kg BOD or 0.25 kg CH4/kg COD**
- **Methane Correction Factor, MCF = 0.8;**
- **EF = 0.48 kg CH_4/kg BOD or 0.20 kg CH_4/kg COD**
- **TOW_{REM} = 0.85 -> biological treatment plants;**

What default values can be updated from sampling results?

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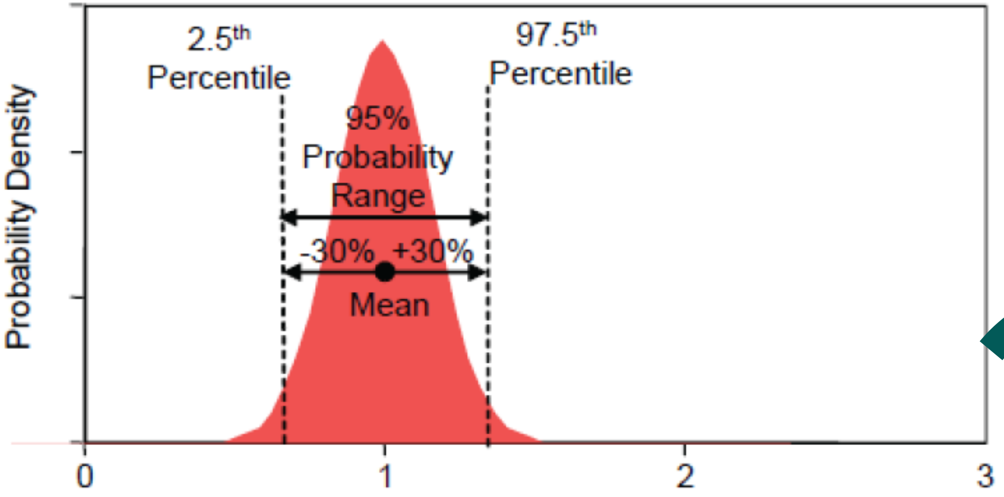
No.	Date	Time	COD (mg/liter)		% removal
			Inlet	Outlet	
1	28/01/2024	08:00	42.49	18.21	57.14%
2	28/01/2024	08:00	36.42	21.24	41.67%
3	28/01/2024	12:00	42.49	18.21	57.14%
4	28/01/2024	12:00	36.42	21.24	41.67%
5	28/01/2024	15:00	33.38	18.21	45.45%
6	28/01/2024	15:00	45.52	15.17	66.67%
7	29/01/2024	08:00	39.45	15.17	61.54%
8	29/01/2024	08:00	30.35	15.17	50.00%
9	29/01/2024	12:00	30.35	18.21	40.00%
10	29/01/2024	12:00	33.38	18.21	45.45%
11	29/01/2024	15:00	30.35	18.21	40.00%
12	29/01/2024	15:00	33.38	15.17	54.55%
13	30/01/2024	08:00	51.59	36.42	29.41%
14	30/01/2024	08:00	33.38	36.42	-9.09%
15	30/01/2024	12:00	36.42	12.14	66.67%
16	30/01/2024	12:00	36.42	15.17	58.33%
17	30/01/2024	15:00	39.45	18.21	53.85%
18	30/01/2024	15:00	54.62	15.17	72.22%
19	02/02/2024	08:00	60.69	9.10	85.00%
20	02/02/2024	08:00	54.62	12.14	77.78%
21	02/02/2024	12:00	39.45	18.21	53.85%
22	02/02/2024	12:00	36.42	18.21	50.00%
23	02/02/2024	15:00	42.49	12.14	71.43%
24	02/02/2024	15:00	36.42	18.21	50.00%
25	04/02/2024	08:00	54.62	15.17	72.22%
26	04/02/2024	08:00	45.52	15.17	66.67%
27	04/02/2024	12:00	57.66	18.21	68.42%
28	04/02/2024	12:00	45.52	24.28	46.67%
29	04/02/2024	15:00	42.49	21.24	50.00%
30	04/02/2024	15:00	51.59	21.24	58.82%
31	05/02/2024	08:00	33.38	18.21	45.45%
32	05/02/2024	08:00	39.45	15.17	61.54%
33	05/02/2024	12:00	30.35	18.21	40.00%
34	05/02/2024	12:00	39.45	21.24	46.15%
35	05/02/2024	15:00	33.38	18.21	45.45%
36	05/02/2024	15:00	45.52	18.21	60.00%
	Average		**40.97**	**18.29**	**53.39%**
	Standar deviation		**8.41**	**5.40**	**16.33%**
	Lower limit		**24.48**	**7.70**	**21.39%**
	Upper limit		**57.46**	**28.88**	**85.39%**

Analysis of sampling results of COD and % COD Removal

Location: Maleer 1 Village, Batununggal District RT 04 RW 12



Updated parameters:

- COD_{inlet} (mg/l): 40.97 ± 16.49, with range: 24.48 to 57.46;
- COD_{outlet} (mg/l): 18.29 ± 10.59, with range: 7.70 to 28.88;
- % COD removal (%): 53.39 ± 32.00, with range 21.39 to 85.39.

After sampling, local value of COD and % removal are obtained.

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CH4 Emission Levels at Maleer WWTP

CH_4 Emission Level at WWTP, if using sampling data:

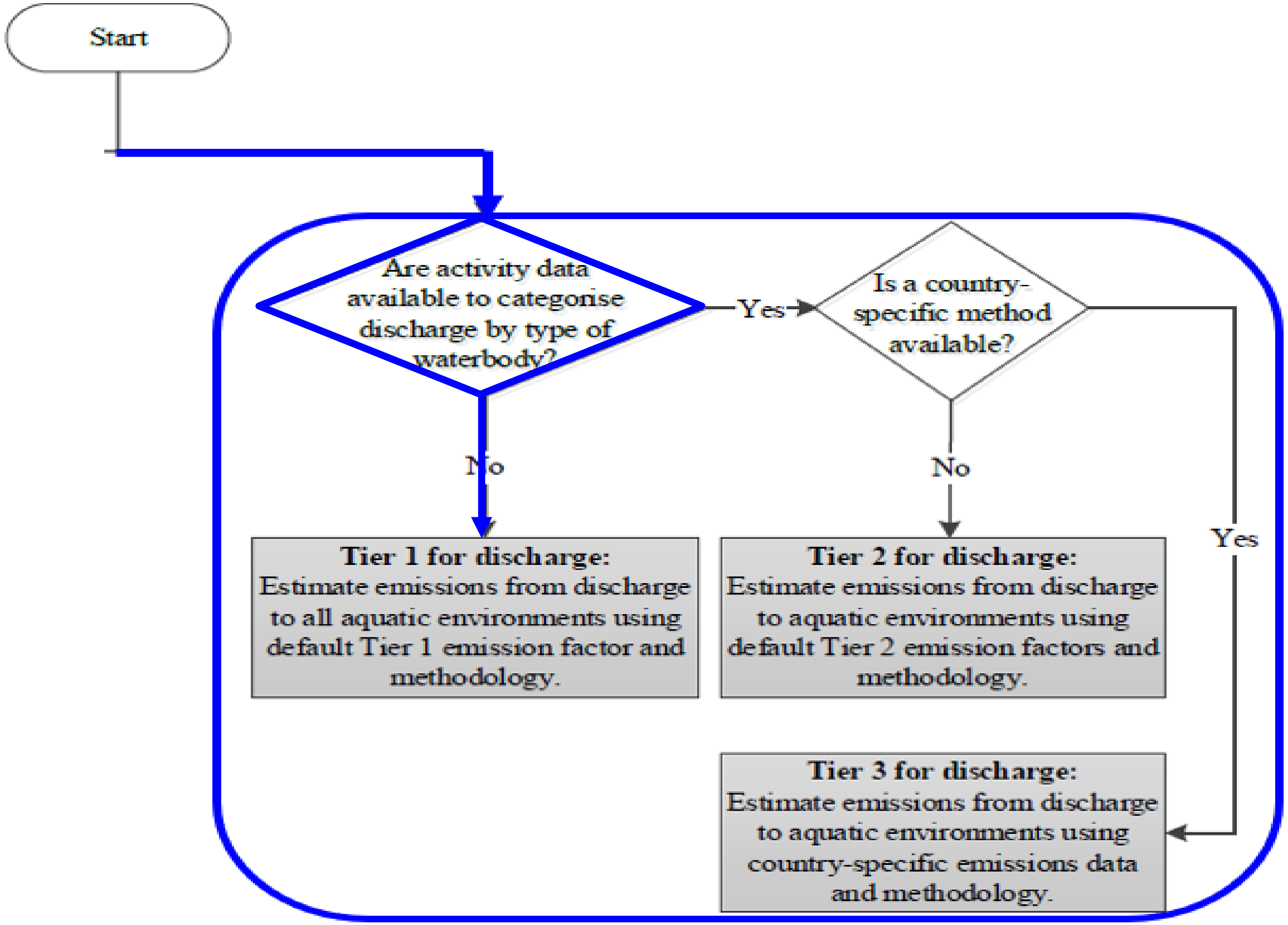
- Maleer IPAL users = 239 persons; Wastewater flowrate = 146.61 litre/person/day, COD = 40.97 mg/litre;
- COD load = 146.61 litre/person/day * 40.97 mg/litre *0.001 g/mg = 6.01 g/person/day;
- Organics in wastewater of treatment (TOW) = 239 person * 6.01 g COD/person/day * 0.001 kg/g * 365 days/yr = 523.96 kg COD/yr;
- Organic component removed from wastewater (in the form of sludge), S = **0** kg COD/yr (Default IPCC);
- Emission factor of anaerobic reaktor = 0.2 kg CH_4/kg COD (Default IPCC);
- Recovered/flared CH_4 in WWTP = 0 kg CH_4/yr;
- CH_4 emission at Maleer WWTP = [(523.96 – **0**) kg COD/yr * 0.2 kg CH_4/kg COD] – 0 kg CH_4/yr = **104.79 kg CH_4/yr.**

CH_4 Emission Level at WWTP, if using default values of 2006 IPCC:

- Maleer IPAL users = 239 persons;
- BOD load = 40 g BOD/person/day;
- Organics in wastewater of treatment (TOW) = 239 person * 40 g BOD/person/day * 0,001 kg/g * 365 days/yr = 3,489.40 kg BOD/yr;
- Organic component removed from wastewater (in the form of sludge), S = **0** kg BOD/yr;
- Emission factor of anaerobic reaktor = 0.48 kg CH_4/kg BOD;
- Recovered/flared CH_4 in WWTP = 0 kg CH_4/yr;
- CH_4 emission at Maleer WWTP = [(3,489.40 – **0**) kg BOD/yr * 0.48 kg CH_4/kg BOD] – 0 kg CH_4/yr = **1,674.91 kg CH_4/yr.**

4. CH4 Emission Levels from WWTP's effluent Discharge

Tier selection is related to CH_4 estimates from wastewater discharge (effluent and/or discharge without treatment)



Source: vectorstock.com

CH4 Emission Levels from Maleer WWTP's Effluent Discharge

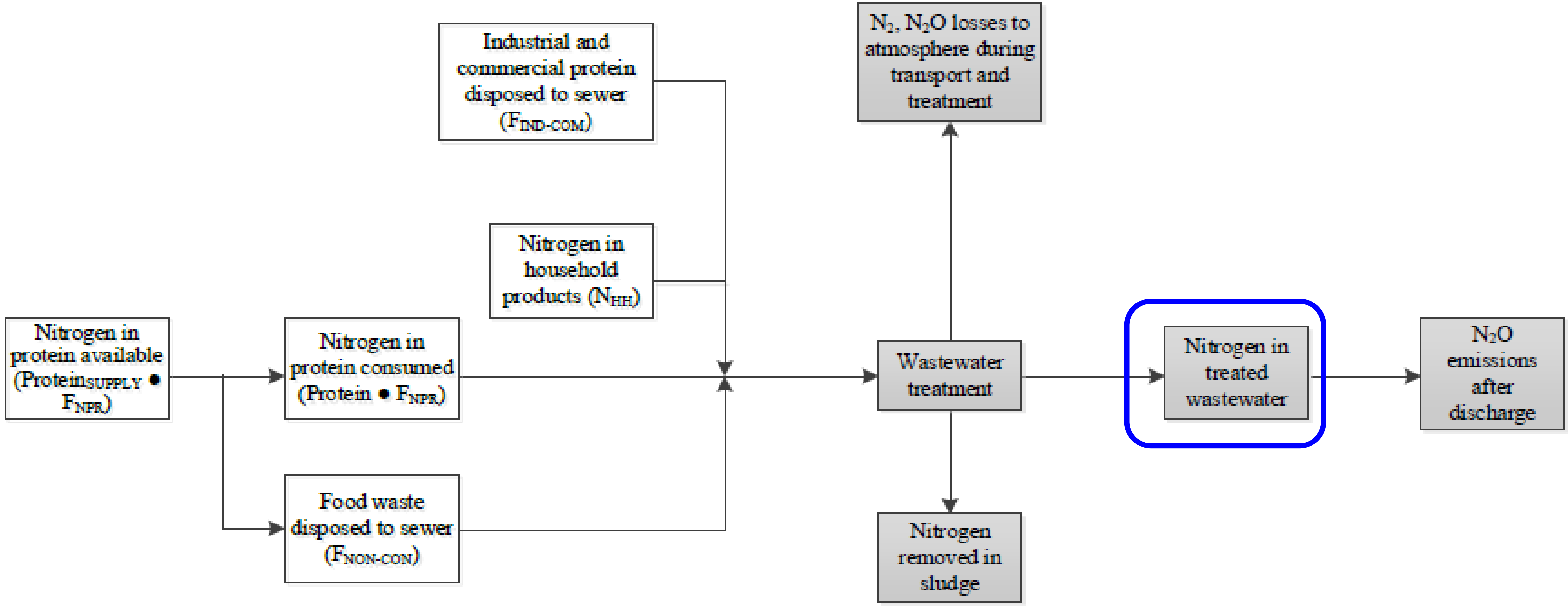
CH_4 Emission Level of Maleer WWTP effluent discharge, if using sampling data:

- Maleer IPAL users = 239 persons; Wastewater flowrate = 146.61 litre/person/day, COD = 40.97 mg/litre;
- COD load = 146.61 litre/person/day * 40.97 mg/litre * 0.001 g/mg = 6.01 g/person/day;
- Organics in wastewater of treatment (TOW) = 239 persons * 6.01 g COD/person/day * 0.001 kg/g * 365 days/yr = 523.96 kg COD/yr;
- % of COD removal (TOW_{REM}) = 53,39% = 0.5339;
- Total organics in treated wastewater effluent discharged, $TOW_{EFFtreat}$ = 523.96 kg COD/yr * (1 – 0.5339) = 244.21 kg COD/yr;
- Emission factors for discharge to the aquatic environment = 0.028 kg CH_4/kg COD;
- CH_4 emissions from the discharge pathways = 244.21 kg COD/tahun * 0.028 kg CH_4/kg COD = **6.84 kg CH_4/yr.**

CH_4 Emission Level of Maleer WWTP effluent discharge, if using default value of IPCC:

- Maleer IPAL users = 239 persons;
- BOD load = 40 g BOD/person/day;
- Organics in wastewater of treatment (TOW) = 239 persons * 40 g BOD/person/day * 0,001 kg/g * 365 day/yr = 3,489.40 kg BOD/yr;
- % of COD removal (TOW_{REM}) = 85% = 0.85 (default of Refinement 2019 for biological treatment);
- Total organics in treated wastewater effluent discharged, $TOW_{EFFtreat}$ = 3,489.40 kg BOD/yr * (1–0.85) = 523.41 kg BOD/yr;
- Emission factors for discharge to the aquatic environment = 0.068 kg CH_4/kg BOD;
- CH_4 emissions from the discharge pathways = 1,626.33 kg COD/tahun * 0.068 kg CH_4/kg BOD = **35.59 kg CH_4/yr.**

5. N2O Emission Levels at Maleer WWTP



Source: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 5, Ch. 6, page 6.40

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Method of Estimating N2O Emission Levels at Maleer WWTP

N_2O Emission Levels at WWTP (Refinement IPCC, 2019):

$$N_2O\ Plants_{DOM} = TN_{DOM} * EF * 44/28$$

- N_2O Plants$_{DOM}$: N_2O emissions from domestic wastewater treatment plants, kg N_2O/yr.
- TN_{DOM} : Total annual amount of nitrogen in domestic wastewater, kg N/yr.
- EF : Emission factor for treatment/discharge pathway or system, kg N_2O-N / kg N
- 44/28 : the conversion of kg N_2O-N into kg N_2O.

Total annual amount of nitrogen in domestic wastewater, **TN_{DOM}** (Refinement IPCC, 2019):

$$TN_{DOM} = P_{treatment} * Protein * F_{NPR} * N_{HH} * F_{NON-CON} * F_{IND-COM}$$

- TN_{DOM} : Total annual amount of nitrogen in domestic wastewater, kg N/yr.
- $P_{treatment}$: Human population who are served by the treatment pathway, persons/yr.
- Protein : Annual per capita protein consumption, kg protein/person/yr.
- F_{NPR} : Fraction of nitrogen in protein, default = 0.16 kg N/kg protein.
- $F_{NON-CON}$: Factor for nitrogen in non-consumed protein disposed in sewer system, default value for Sout East Asia = 1.02 kg N/kg N.
- $F_{IND-COM}$: Factor for industrial and commercial co-discharged protein into the sewer system (co-discharged), default = 1.25 kg N/kg N for centralized WWTP, and default = 0 kg N/kg N for onsite WWTP and discharged.
- N_{HH} : Additional nitrogen from household products added to the wastewater, default =1.1.

- **N_2O emissions in the Anaerobic Reactor (at Maleer WWTP) are insignificant.**

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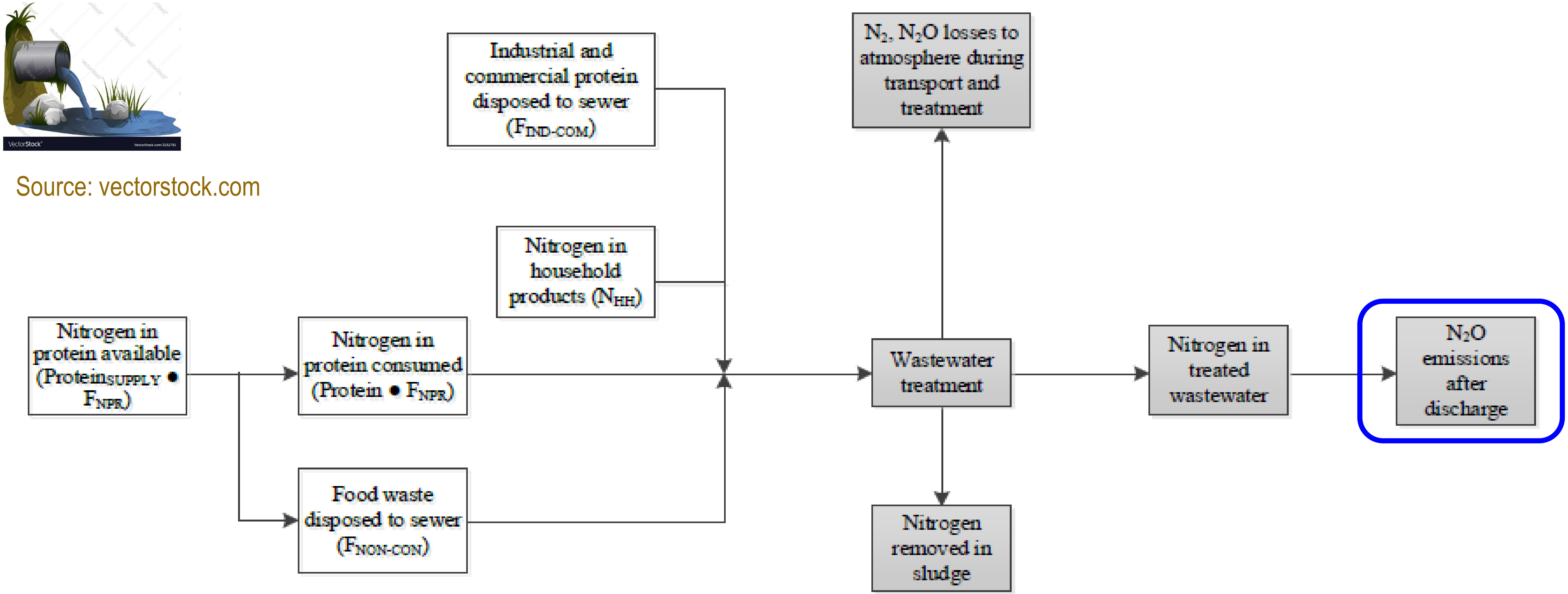
N2O Emission Level due to Maleer WWTP's Effluent Discharge



Source: vectorstock.com

Source: The 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories , Vol. 5, Ch. 6, page 6.40

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N2O Emission Levels from Maleer WWTP's Effluent Discharge

- Maleer IPAL users = 239 persons;
- Protein Consumption in Bandung City = 66.86 g protein/person/day (https://bandungkota.bps.go.id)
  = 66.86 g protein/person/day * 365 days * 0.001 kg/g = 24.40 kg/person/yr
- Fraction of nitrogen in protein, F_{NPR} = 0.16 kg N/kg protein (default IPCC).
- Factor for nitrogen in non-consumed protein disposed in sewer system, $F_{NON\text{-}CON}$ = 1.02 (default IPCC for South East Asia)
- Factor for industrial and commercial co-discharged protein into the sewer system (*co-discharged*), $F_{IND\text{-}COM}$ = 1,00 (justification), default for centralized WWTP = 1.25.
- Additional nitrogen from household products added to the wastewater, N_{HH} = 1.13 (Default IPCC for India).
- Total annual amount of nitrogen in domestic wastewater, TN_{DOM} = 239person * 24.40 kg protein/person/yr * 0.16 * 1.02 * 1.00 * 1.13 = 1,075.61 kg N/yr.
- Fraction of total wastewater nitrogen removed during wastewater treatment, N_{REM} = 0.4. Default of Refinement 2019 for biological treatment.
- Total nitrogen in the wastewater effluent discharged to aquatic environments, $N_{EFFLUENT,\ DOM}$ = 1,075.61 * (1 – 0.4) = 645.37 kg N/yr.
- Emission factor for N_2O emissions from wastewater discharged into aquatic environments, $EF_{EFFLUENT}$ = 0.005 kg N_2O-N/kg N.
- N_2O emissions from WWTP's effluent = 806.71 kg N/tahun * 0.005 kg N_2O-N/kg N * 44/28 = **5.07 kg N_2O/tahun**.

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7. Options of Next Sampling Exercise

- Because Domestic Wastewater is one of the key emissions, it is best to use Tier II -> Development of local methodology and/or emission factor database;
- Updating local emission factor (kg CH4/kg BOD), i.e:

  - Maximum CH_4 production capacity (B_o) for domestic wastewater, kg CH_4/kg BOD;

  - Methane correction factor (MCF).
- Sampling at Communal WWTPs in the dry season -> minimizes dilution effects due to groundwater infiltration and/or surface water runoff in WWTPs and drainage channels;
- Sampling in individual septic tanks (onsite treatment), in the dry and rainy seasons -> CH_4 and N_2O estimates specifically for black water.
- Sampling of untreated grey water.
- Investigation of methane mass balance and emission locations along its path, from septic tanks and/or treatment plants and sludge treatment and disposal.

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Key Takeaways: GHG Inventory for Municipal Wastewater

- Presidential Decree 98 of 2021 explains the importance of accurate calculation data and achieving emission reductions.
- The Indonesian government has mapped the flow of information in its emissions reporting process. Local governments have a role in allocating resources to measure and report their emissions. However, there are obstacles to varying inventory quality.
- The Ministry of Environment and Forestry has the mandate to champion emissions reduction initiatives and the authority to implement changes to improve the management of data collection, measurement-based GHG data collection, with traceable and credible data quality.
- The Directorate of Water Pollution Control (KLHK) has a mandate for wastewater sampling.
- The Indonesian government has developed a web-based information system, the SIGN-SMART platform, for data acquisition, calculation and analysis of GHG emissions up to the City/Regency Government level..
- Law 7/2004 concerning Water Resources and Law 18/2008 concerning Waste Management serve as basic legal instruments for developing technical regulations encouraging sludge management.
- There is no comprehensive data that covers all wastewater treatment infrastructure.
- Even though it is included in one of the key emissions, the estimation of GHG emissions for the Domestic Wastewater Sub-Sector still uses the Tier I method of IPCC (2006).

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Short Term Opportunities for GHG Inventory Improvement

- Conveying the findings to relevant stakeholders, namely: Directorate of GHG & MPV of the Ministry of Environment and Forestry, Directorate of Solid Waste of the Ministry of Environment and Forestry, Directorate of Water Pollution Control of the Ministry of Environment and Forestry; Directorate of Environmental Sanitation and Settlement Development, Ministry of Public Works and Public Housing; Research and Development Center for Housing and Settlements, Ministry of Public Works and Public Housing;
- Conduct studies on onsite and offsite WWTP to fill data gaps and move to Tier II (local emission factors or methodology);
- Develop WWTP data collection guidelines and disseminate them through capacity-building workshops.

Medium Term Opportunities for GHG Inventory Improvement

- **Data Collection and Monitoring**. Invest in a data collection and monitoring system to track GHG emissions from domestic wastewater treatment and disposal, including wastewater quantity and quality, treatment methods, and energy consumption.
- **Technology Improvement.** Consider improving low-emission domestic wastewater treatment technology. For example, anaerobic digestion and biogas recovery can capture methane emissions and convert them into an energy source.
- **Inventory Improvement.** Developing a special GHG inventory for the domestic wastewater sub-sector, including emission calculation methodology towards Tier II, activity data, and local emission factors.
- **Capacity Building.** Invest in capacity building for WWTP managers and regional Environmental Agencies so that they have the knowledge and tools to measure and manage GHG emissions effectively.
- **Research and Innovation.** Support research and innovation to develop new technologies and practices to reduce GHG emissions in the domestic wastewater treatment sub-sector. Establishing collaboration with universities and research institutions.
- **Policies and Regulations**. Implement and enforce policies and regulations that incentivize the reduction of GHG emissions from domestic wastewater treatment.
- **Data Interoperability**. Data Sharing and Collaboration from various stakeholders.
- **Citizen's awareness**. Increase public awareness about reducing GHG emissions from domestic wastewater treatment.
- **Financial Incentives**. Providing financial incentives or subsidies for low-emission domestic wastewater treatment.
- **Benchmarking**. Establish benchmarks and performance indicators for Domestic WWTP..
- **International Support**. Seek support from international organizations and climate finance mechanisms to fund GHG reduction projects in the domestic wastewater sub-sector.

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Thank you for your kind attention.

For more resources and information on events visit https://www.globalmethane.org/ or scan the QR code:

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Case Study: Measurement Based Pilot to Estimate Methane Emissions of Maleer Communal WWTP in Bandung

Prof. Tjandra Setiadi
Bandung Institute of Technology

March 14, 2024

Outline

- Purpose and Scope of the case study
- WWTP Location and General Overview
- Sampling Methodology
- Challenges in Data Collection
- Result Findings
- JICA 2015 Study
- Maleer vs JICA 2015 Studies
- Challenges in measuring GHG from Decentralized WWTPs
- Summary of the Proposed Methodology

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Purpose & Scope of This Case Study

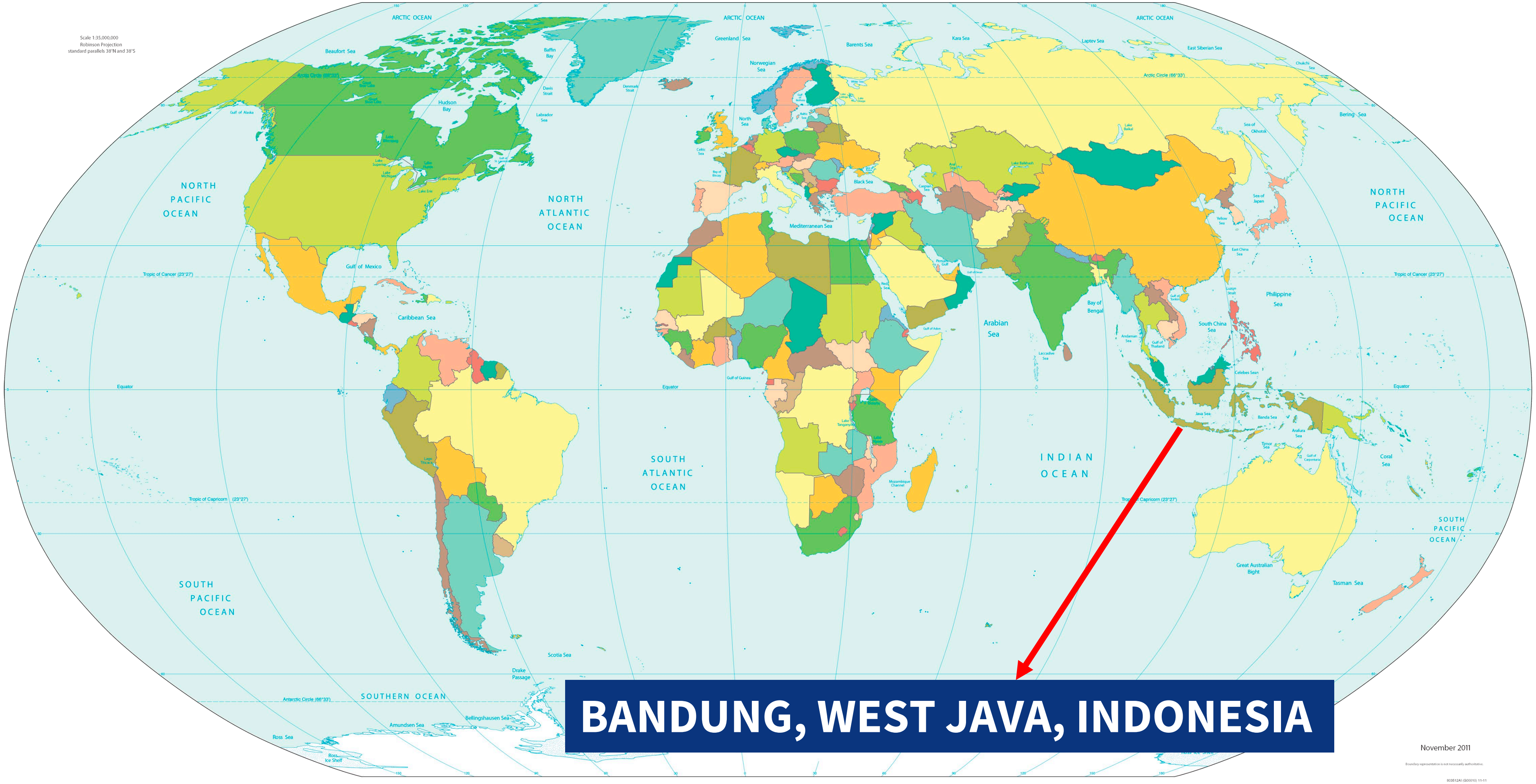
- PURPOSE:

Assess the GHG emissions and the performance of a decentralized wastewater treatment plant (WWTP) located in Maleer 1 Village, Batununggal District, Bandung, Indonesia as a case study.

- SCOPE:

For the case study involves field data collection, including interviews with households connected to the WWTP, water and sludge sample collection and analysis, and flow rate prediction. Gas analysis and measurement will not be conducted due to time constraints

Location of the WWTP



[Source: https://commons.wikimedia.org/wiki/File:1-12_Color_Map_World.png](https://commons.wikimedia.org/wiki/File:1-12_Color_Map_World.png)

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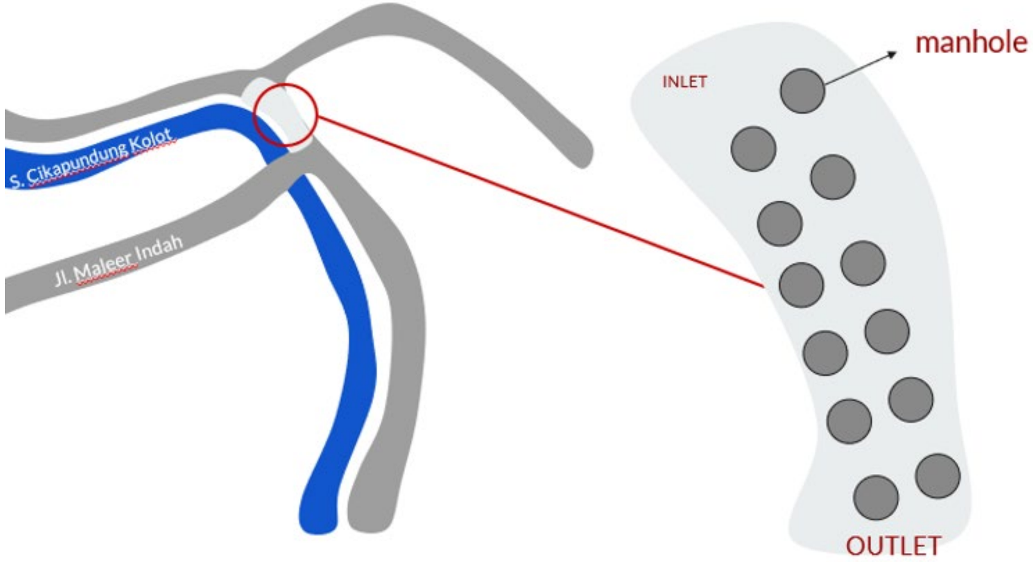
Pilot Location: Maleer WWTP

Communal WWTPs in Indonesia were built in several locations in low-income communities, densely populated, and sanitation-prone environments as **a step to prevent the flow of municipal wastewater** which is **directly discharged into water bodies** (rivers) without any prior processing. The government created a program known as Community Based Sanitation (SANIMAS).

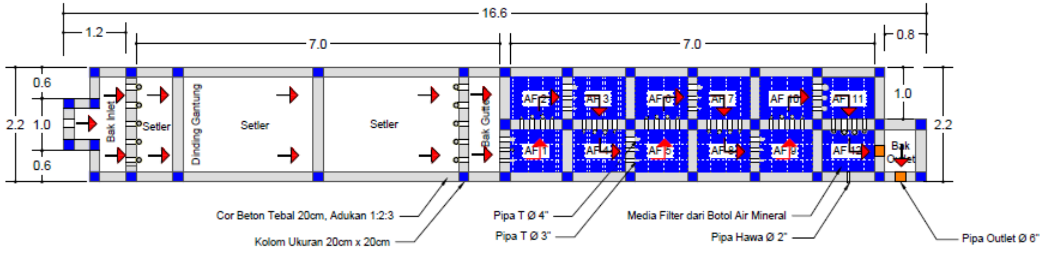
- Maleer Communal Wastewater Treatment Plant (WWTP)
- Kb. Gedang III, Maleer 1 Village, Batununggal District RT 04 RW 12
- Bandung, Indonesia

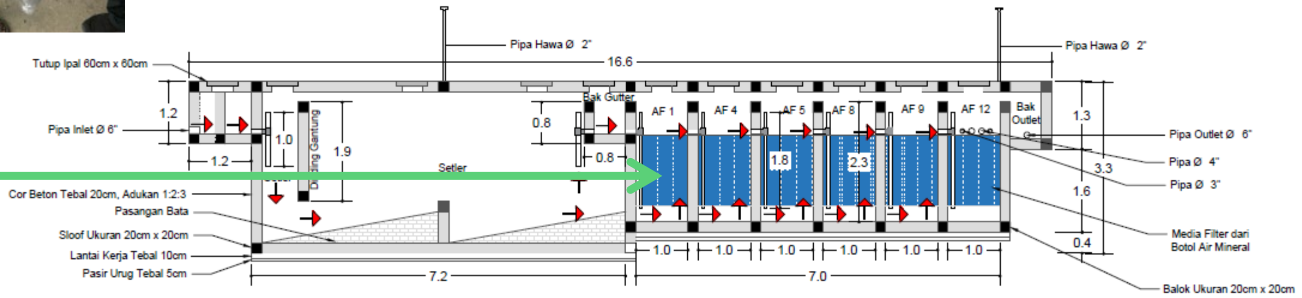


WWTP General Overview

- WWTP type : Anaerobic Upflow Filter (AUF)
- Operating since : January 2019
- Capacity : 28.8 m^3/day
- Dimensions : 16.6 x 2.2 x 3.3 m

Filter Media made from PET bottle plastics





- PET plastic supporting media from used mineral water bottles as a medium for growing biomass on its surface.
- The location is in a densely populated area and is built on riverbanks.

SAMPLING Methodology

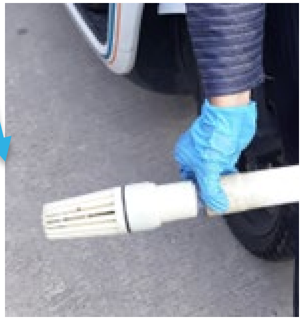
WASTEWATER & SLUDGE

- Prepare tools, materials and label used for sampling

Gas measurement was not carried out, due to time constraints.

Take wastewater samples using a bucket

Put wastewater sample into plastic & glass bottles



Take the sludge sample with DIY Sludge Sampler (pipe and foot valve)

Put sludge samples into plastic bottle

Store the samples in an ice box

No mean to measure Flow-rate

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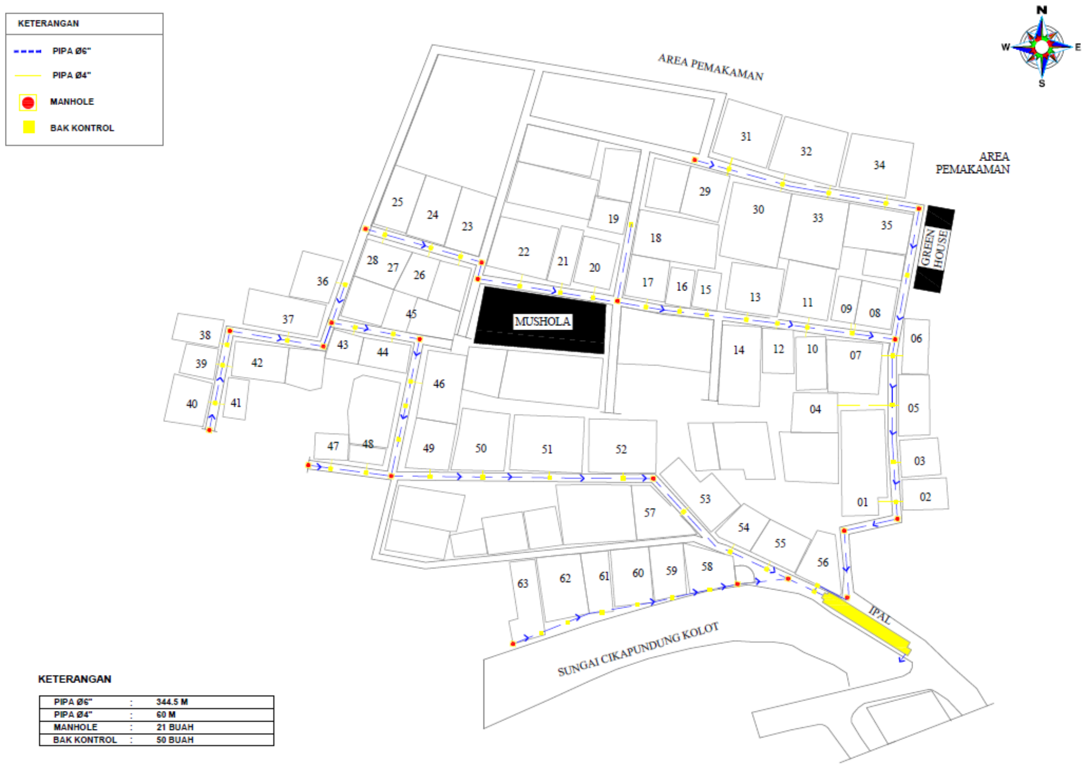
Methodology: Estimating Wastewater Flow Rate

ACTUAL POPULATION & WATER USAGE FLOW RATE

1. Interviews with the Head of the RW (Citizens Association)
2. Survey with sewer shed residents.

Samples were taken based on the L. R. Gay Formula, namely the minimum research sample size for a relatively small population of at least 20% of the sample – house holds (Fauzy A., 2019).



1. **Estimated population data for 2024 using a linear method (interpolation) for 6 years (2018 – 2024).**
2. **Survey amount of water used by the respondents taken from the needs of:**

- Bathing
- Toileting
- Worship (wudu)
- Washing clothes
- Washing dishes
- Drinking, cooking
- Mopping
- Watering plants
- Washing vehicles

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Challenges in data collection (part 1)

- Data collection must be supported by local authorities and the community living nearby.
- Data archiving in several regions in Indonesia is inadequate, making it difficult to obtain complete data.
- The water meter has been removed because there were complaints from residents regarding the costs and the water flow not running smoothly.
- WWTP is underground so it is difficult to access for direct discharge measurement.
- The position of the WWTP on the side of the road is quite narrow so that it sometimes interferes with residents' road activities.

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Challenges in data collection (part 2)

- There are indications of rainwater infiltration in the pipes leading to WWTP so that the concentration of wastewater is diluted during the rainy season.
- Some residents do not know the data and conditions of connections from their homes to the WWTP.
- Other Note:
  - Monitoring of WWTP conditions by the RW is carried out irregularly. Sludge draining is carried out by the RW if it shows signs that it is full, and repairs are carried out if complaints/problems arise.

Findings

Current Population

Estimated population data for 2024 by surveying 20% of the total population of the total of 57 house-holds 179 people).

O (Initial Years)	2018
N (Final Years)	2024
PO (Initial Population)	33
PN (Final Population)	44
T (Time)	6

$$\text{PN} = \frac{44}{33} \times 179 = 239 \text{ people}$$

Wastewater Discharge

Water Usage (L/person/day)	
Average	183
Max	265
Min	107

Because there is no data on hourly flow fluctuations available, it is **assumed that wastewater discharge is an average of 80%** of the average flow of clean water used per person per day.

$$\text{Estimated Wastewater Discharge} = 183 \frac{\frac{\text{L}}{\text{person}}}{\text{day}} \times 80\% \approx 147 \frac{\frac{\text{L}}{\text{person}}}{\text{day}}$$

It was found that the average use of clean water was 183±79 L/person/day.

Findings: Wastewater Concentration

No	Parameters	Unit	Analyzing Method	Inlet Results	Outlet Results
1	pH	-	APHA 4500-H+B	7,06±0,09	7,26±0,03
2	Dissolved Oxygen (DO)	mg/L	APHA 4500-O-G	7,36±0,67	7,67±0,39
3	Temperature	oC	APHA 2550	24,83±0,05	25,03±0,03
4	Electrical Conductance (EC)	µS/cm	APHA 2510	495,00±6,00	324,00±5,00
5	Total Dissolved Solid (TDS)	mg/L	APHA 2540-C	250,00±5,00	164,67±2,67
6	Total Solid (TS)	mg/L	APHA 2540-B	427,33±23,50	284,67±3,67
7	Volatile Solid (VS)	mg/L	APHA 2540-G	150,33±9,00	137,00±5,00
8	Suspended Solid (TSS)	mg/L	APHA 2540-D	11,00±1,75	8,83±6,33
9	Volatile Suspended Solid (VSS)	mg/L	APHA 2540-G	±0,00	9,00±1,00
10	Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210-B	16,60±3,70	9,41±2,48
11	Chemical Oxygen Demand (COD)	mg/L	APHA 5220-B	22,77±4,90	12,99±3,23
12	Total Nitrogen (TN)	mg/L	APHA 4500-Norg-B	24,93±10,50	14,77±0,77
13	Ammonia-Nitrogen (NH3-N)	mg/L	APHA 4500-NH3-F	32,77±2,65	14,77±0,97
14	Nitrate-Nitrogen (NO3-N)	mg/L	APHA 4500-NO3-B	12,63±1,25	2,88±2,69
15	Nitrite-Nitrogen (NO2-N)	mg/L	APHA 4500-NO2-B	4,39±0,75	3,76±0,87
16	Total Phosphate (TP)	mg/L	APHA 4500-P-B-D	0,06±0,00	0,05±0,02
17	Oil and Grease	mg/L	APHA 5520-D	2,60±0,2	1,93±0,33
18	Total Coliform	MPN/100 mL	APHA 9221-B	±24000	±153357
19	Fecal Coliform	MPN/100 mL	APHA 9221-B	±11000	±8017
20	Methylene Blue Active Substance	mg/L	APHA 5540-C	0,08±0,004	0,07±0,02

Findings: Sludge Concentration

No	Parameters	Unit	Analysing Method	Test Results
1	Total Suspended Solid (TSS)	mg/L	APHA 2540-D	94.673±65.420
2	Total Solid (TS)	mg/L	APHA 2540-B	70.377±15.395
3	Volatile Solid (VS)	mg/L	APHA 2540-G	39.260±9.280
4	Volatil Suspended Solid (VSS)	mg/L	APHA 2540-G	39.780±25.880
5	Biochemical Oxygen Demand (BOD)	mg/L	APHA 5210-B	6.317±1.963
6	Chemical Oxygen Demand (COD)	mg/L	APHA 5220-B	17.500±5.000
7	Total Phosphate (TP)	mg/L	APHA 4500-P-B-D	0,59±0,10
8	Total Nitrogen (TN)	mg/L	APHA 4500-Norg-B	1.940±722

Findings: BOD Generation in Several Studies

Parameter	Unit	Value*	Value**	Value***	Value****	This Research
Biochemical Oxygen Demand (BOD)	mg/L	99,03	77,3	291,43	235,11	13,7-21,1
Wastewater Discharge	L/person/day	147				
BOD Generation	gram/person/day	15	11	43	35	2-3
BOD Generation (Default IPCC 2006)	gram/person/day	40				
BOD Generation	kg/person/year	5,3	4,1	15,6	12,6	0,7-1,1
BOD Generation (Default IPCC 2006)	kg/person/year	14,6				

*Pangaribuan, 2023: Sampling conducted thrice during the rainy season;
**Hasby, 2022: Sampling conducted once during the rainy season;
***Iqbal, 2021: Sampling conducted over a 2-day period from March 1, 2021, to March 2, 2021;
****Nur, 2021: Sampling conducted thrice during the dry season.

This research sampling was conducted thrice during the heavy rainy season and the samples tested in daily-composite while the others research tested in a grab sample. It is not known what percentage of rainwater is mixed with wastewater which causes dilution. The result of BOD generation number is 2-3 gram/person/day which the lowest range of generation.

JICA SP3 Study on BOD and TKN (2015)

Results of JICA SP3 Survey on BOD and TKN

	BOD (Kg BOD/cap/yr)	TKN (Kg N/cap/yr)
Average JICA SP3 survey	17.278	1.204
IPCC 2006	14.6	n.a*

**Default N_2O of IPCC2006 for septic system is not available; IPCC2006 only provides default N_2O for centralized treatment*

This survey covered only individual septic tanks. To improve GHG inventory for CH4 and N2O from municipal WWTPs, it is recommended to conduct similar survey in communal WWTPs and other types of communal WWTPs

JICA 2015 Study: Emissions Factor Survey in Septic Tanks

EF Resulted from JIC SP3 Survey

Data Source	CH_4 (kg CH_4/kg BOD)	CO_2 (kg CO_2/kg BOD)	N_2O (kg N_2O/kg N)
Estimated based on Lab-PATI	0.623	2.004	0.00398
Estimated based on Lab-ITB	0.662	4.262	NA
Estimated based on Lab-NIES	0.728	1.881	0.00399
Average (Pati, ITB, NIES)	0.671	2.715	0.004
IPCC2006 Septic System	0.6 x 0.5 = 0.30	n.a	0.005
IPCC2006 Latrine	0.6 x 0.7 = 0.42	n.a	n.a

Notes: Default IPCC2006 based on expert judgment by lead authors and on Doorn et al. (1997), Bo is 0.6 and the MCF for Septic system is 0.5 and for latrine in wet climate with flush water is 0.7

The significant difference of the CH4 EF from the JICA SP3 survey indicates that the septic system in Indonesia is different to the one that is used to develop IPCC2006 guideline. The survey results is closer to default values IPCC2006 for latrine system. It is likely that Indonesian septic system is actually similar to latrine system rather than septic system.

Methane Correction Factor (MCF)

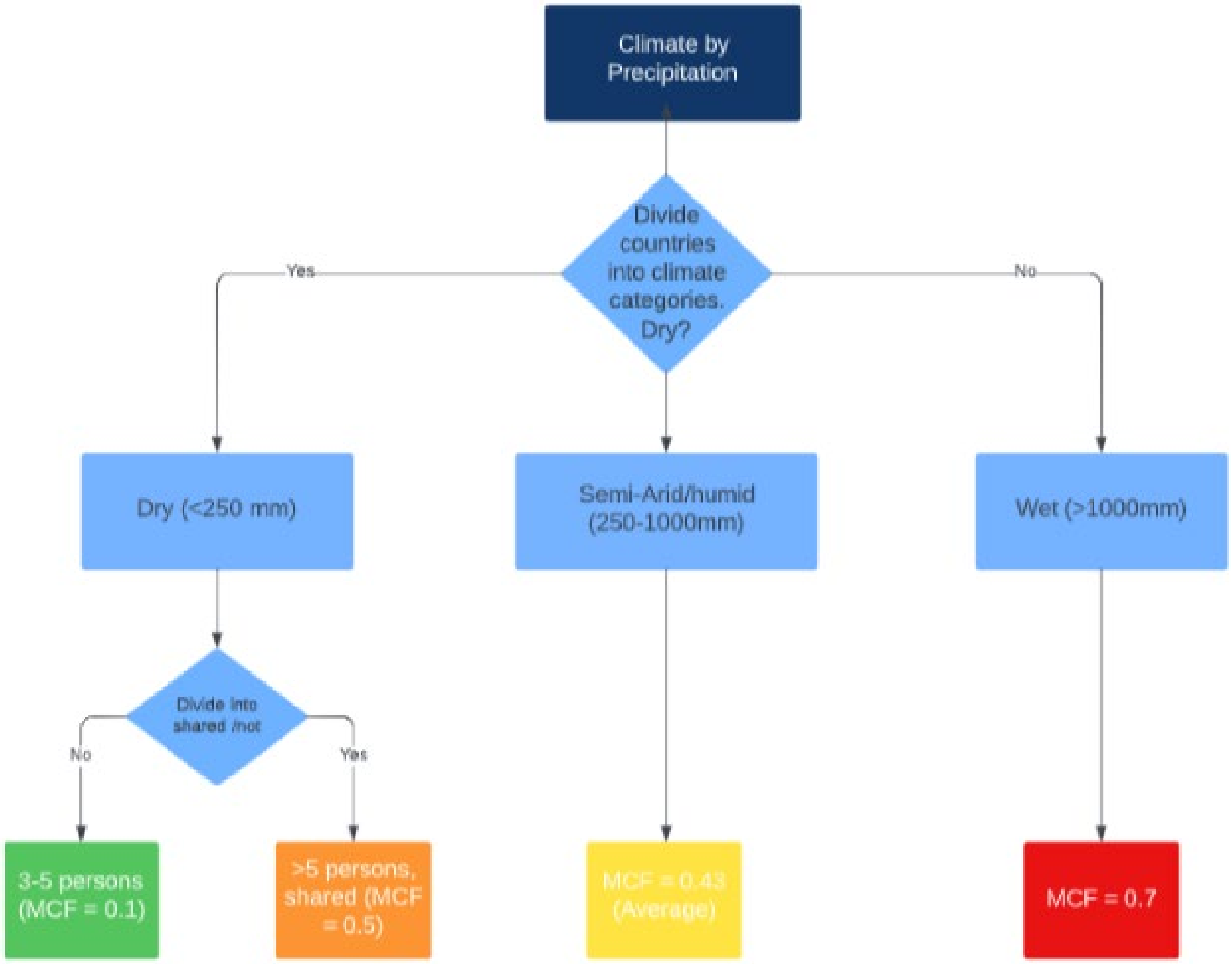


Figure 1: Methane correction factor (MCF) values by climate category and pit latrine utilization

100

This MCF value is based on IPCC guidelines depending on the country's climate and number of people sharing the sewer shed.

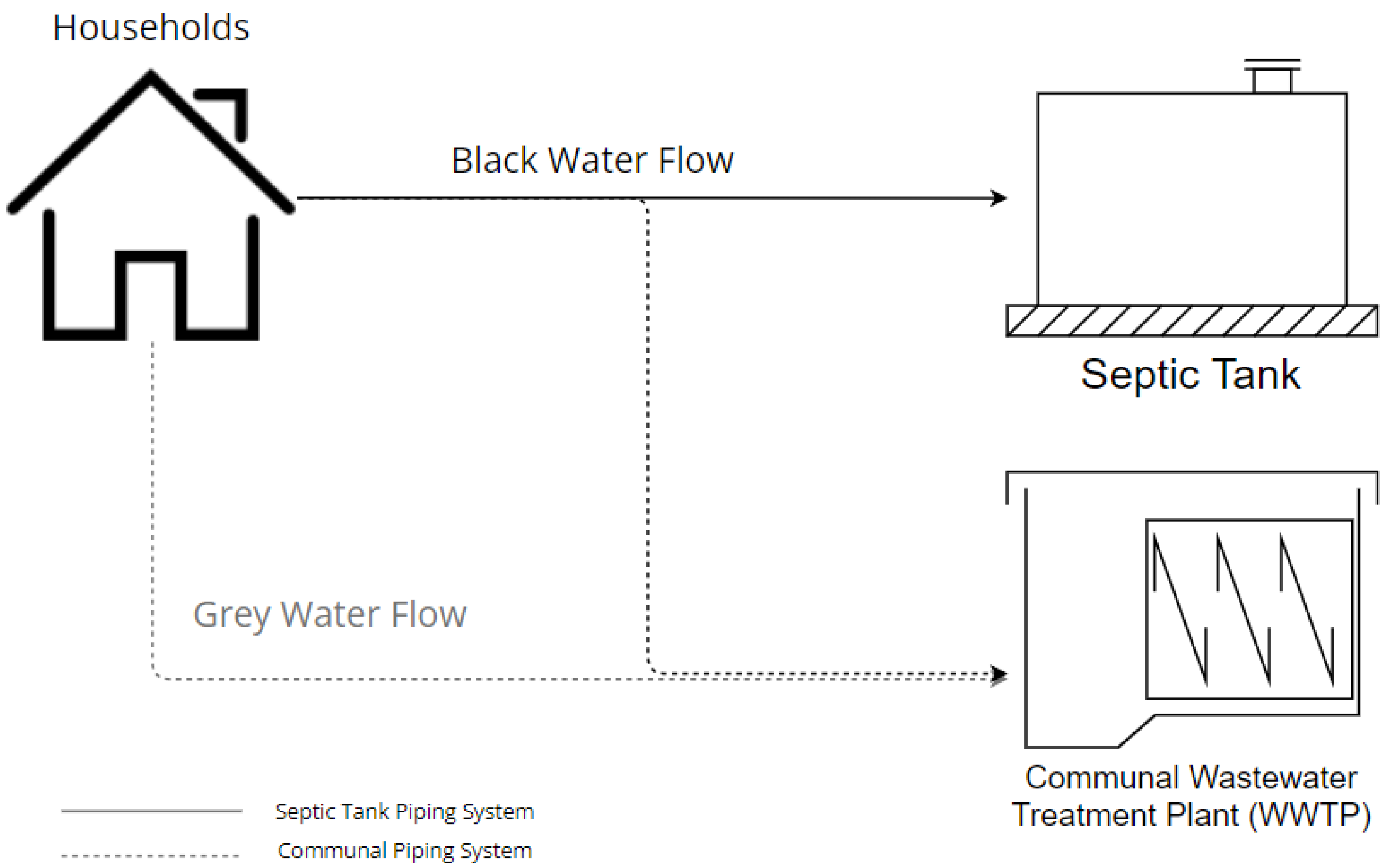
JICA 2015 Study: Gas & Wastewater Sampling

Gas sampling method :

- The open chamber is installed at the sampling point with the tool set as shown.
- The air pump is turned on to draw the gas that has collected in the chamber. With this, the space in the chamber is filled with free air connected from the free air hose (line).
- Gas sampling is carried out in the gas sampling section by opening the valve and capturing the gas using a syringe and transferring the gas into a vial tube to hold the gas sample.
- The vial containing the gas sample is taken to the laboratory for lab testing using a Gas Chromatography device.

2024 GMI Pilot in Maleer vs JICA 2015 Study Results

The wastewater piping system to the Communal WWTP is different from a septic tank. Wastewater (blackwater) usually flows directly from the source to the septic tank, while the communal system collects blackwater and greywater and there are channels that can allow the discharge that flows to the WWTP to be infiltrated with rainwater. Rainwater can make the discharge coming out of housing no longer 147 L/person/day*, but it will be larger because there is a dilution factor by rainwater.



2024 GMI Pilot in Maleer vs JICA 2015 Study Results

		Value*	Value**	Value***	Value****	This Research
2024 GMI Pilot: Maleer WWTP	kgBOD/cap /year	5,313	4,148	15,637	12,615	0,735-1,132
Average JICA SP3 Survey		17,278				
IPCC 2006		14,6				

The values in the blue cells were sampled during **rainy season** and **the yellow cells** sampled during **dry season**. The challenge in sampling during the rainy season: percentage of rainwater flows into the channel is unknown.

Suggestion: Measurements in the Maleer WWTP should be done **during the dry season** to determine the actual generation and Emission Factor (EF).

Challenges in Measuring GHG From Decentralized Wastewater Treatment

Variability in treatment processes

Developing standardized measurement approaches that can accurately capture emissions over different processes.

Complexity of emission sources

These sources interconnect in complex ways within the treatment system making it challenging to isolate and quantify each emission pathways.

Limited access to data

Access to comprehensive emissions data is limited due to resource constraints and logistical challenges.

Spatial and temporal variability

GHG emissions from decentralized wastewater treatment indicates spatial and temporal variability due to factors such as influent composition, hydraulic loading rate, and environmental conditions.

Challenges in Measuring GHG From Decentralized Wastewater Treatment

Analytical techniques and sampling

There is a need for innovative measurement approaches that are specialized to the specific characteristics of decentralized system.

Interference from other sources

These additional sources can interfere and complicate the attribution of emissions to specific wastewater treatment processes.

Modelling uncertainties

Uncertainties in model predictions can arise at various stages, including emission factor estimation, process simulation, and spatial/temporal extrapolation.

Summary of Proposed Future Methodology

For determining population served by Communal WWTPs

1. Use existing data for the most recent year provided by the government/local authority or sample survey and interpolation of estimation from the most recent years (used in this work) or
2. If data is only available from more than 10 years ago, it is recommended to calculate the population growth ratio first and determine a prediction method because the linear method may no longer be accurate or
3. Survey the entire population served by the WWTPs

Summary of Proposed Future Methodology

For determining wastewater flow rate

1. If **there is a water meter**, we can calculate water usage every day and divide it by the number of people in the house, or
2. If the water at **the outlet is flowing and can be measured easily**, we can use calculations using a **flowmeter/current meter** propeller divided by the surface area of the outlet compartments or surface velocity method by calculating the distance and time the object flows.
3. If the water at the **outlet flows out of the pipe**, the discharge can be calculated using the volume divided by the water filling time or the waterfall discharge calculation with a known pipe diameter.
4. **If none of the data above is available**, a survey can be carried out as was carried out in this research.

Summary of Proposed Future Methodology

For Gas and Wastewater Sampling

1. Carry out sampling **in the dry season**: to avoid influence by rainwater discharge.
2. Carry out **gas sampling according to the JICA2015 method** to obtain actual Emission Factor (EF) data from Maleer Communal WWTP.

Thank you for your kind attention.

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International Insights on GHG Inventories

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Content

- IPCC Background
- IPCC to model domestic wastewater discharge
- GHG emission sources
- IPCC use in different countries
- GHG calculation best practices

IPCC background

- IPCC Guidelines for the Wastewater (WW) Sector (controlled discharges)
  - 2006 IPCC guidelines and 2019 Refinement
    - Volume 5: Waste, Chapter 6: Wastewater Treatment and Discharge
  - Volume 1. General guidance for reporting
    - Guidance for reporting and GHG inventories overview
    - Uncertainties
    - Consistency, quality assurance, and quality control
    - Verification of the protocol
  - Top-down approach (based on 3 Tier methodology for EF calculations)
    - Tier 1 : Use of default values with countries with limited data
    - Tier 2 : Use of country-specific EF based on field measurements and activity data
    - Tier 3 : Use of country-specific METHOD. (e.g. based on plant- specific emissions from large WWTPs and advanced methodologies. Asset specific.)
    - Tiers are related to the degree of accuracy in GHG emissions estimate

    EF : Emission Factor

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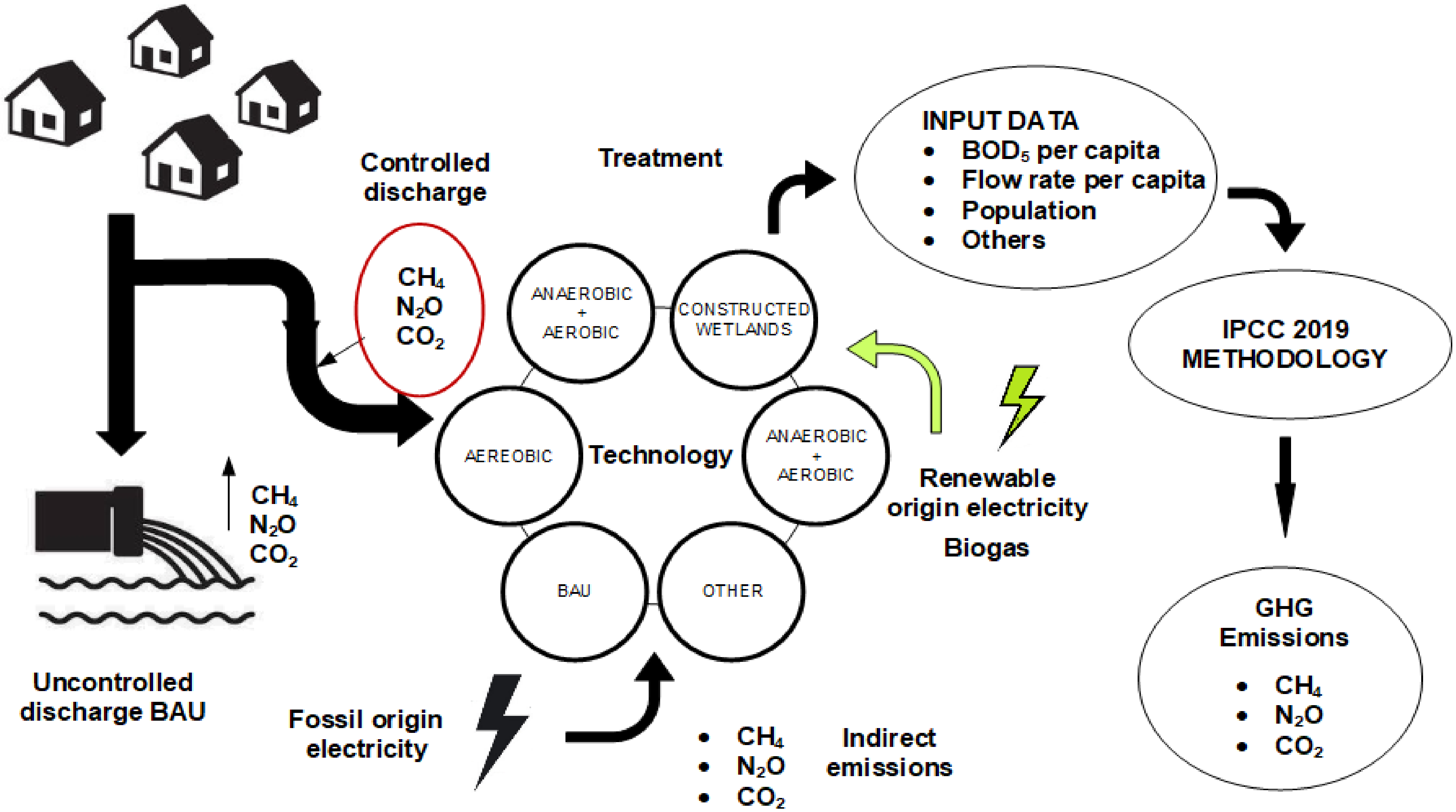
IPCC Modelling Approach



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Emissions Sources

- Direct and Indirect Emissions from Wastewater Treatment
  - Direct emissions of CO_2, N_2O and CH_4 produced from wastewater microorganisms respiration (CO_2 biogenic emissions: net zero)
  - Indirect emissions from fossil fuel-sourced electricity (CO_2, CH_4, and NO_X), transportation of sludge, production, and transportation of chemicals (CO_2 emissions add carbon to the atmosphere)

Emissions Sources

Top-down *versus* Bottom-up Methodologies

- Top down
  - ✓ The EF and activity data derived from secondary sources (e.g. published literature, reports, etc.).
  - ✓ A good practice, when data, methodologies, and resources are not available at the country level to develop a bottom-up approach to full-scale quantification of GHG emissions.

- Bottom-up
  - ✓ In-country EF from national data set developed from a sub-set of facilities
  - ✓ Data specifically EF at individual WWTP level
  - ✓ Specific EF for N_2O and CH_4

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WW GHG Emissions Assessment – Australia

- Australia *(Department of Industry, Science, Energy & Resources, 2021; OPC)*
  - Tier 2 approach for Australia outlined in the National Greenhouse and Energy Reporting (Measurement) Determination 2008 made under sub-section 10(3) of the National Greenhouse and Energy Reporting Act 2007. This legislation provides *four methods* for GHG emissions assessment.
    - Three of the methods relate to different Tier approaches regarding CH_4 calculations. (next slide).
    - A fourth method in GHG emission assessment relates to a Tier 3 approach defined as facility-specific measurement of emissions by continuous or period emissions monitoring – but this is not included as a method for CH4 emissions estimation.

WW GHG Emissions Assessment – Australia

- The Determination provides **three methods** for estimating CH_4 emissions from treatment and emissions from flaring in Part 5.3 Wastewater Handling (Domestic and Commercial).
  - *Method 1 :* Considers COD production per capita and subtracts biogas utilized on-site, flared or exported and provides separate emissions calculations for wastewater and for sludge different types.
  - *Method 2:* Considers an approach aligned with Method 1 but with more specific consideration of a facility. This is based on designation of sub-facility levels based on treatment areas and the use of measured data (e.g. COD or BOD).
  - *Method 3:* Aligns with method 2 but provides for different sampling laboratory certification.

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WW GHG Emissions Assessment - Australia

– Australia (NO_2)
  - In a similar way to CH_4 calculations ***four methods*** are developed for N_2O as described in the National Greenhouse and Energy Reporting (Measurement) Determination 2008 made under sub-section 10(3) of the National Greenhouse and Energy Reporting Act 2007.
    - *Method one:* Is derived from the National Greenhouse Accounts methods and based on national average estimates (default values).
    - *Method two:* Allows for facility-specific values, generally, using industry practices for sampling and Australian or equivalent standards for analysis.
    - *Method three:* While aligned with method 2 is based on Australian or equivalent standards for both sampling and analysis.
    - *Method four:* provides for facility-specific measurement of emissions by continuous or periodic emissions monitoring

WW GHG Emissions Assessment – The United Kingdom

- United Kingdom *(Carbon Accounting Workbook,CAW)*
  - Compulsory to report their GHG emissions to regulator using country-developed EFs and peer-reviewed industry-wide tool for operational carbon assessment
  - Carbon Accounting Workbook (CAW)
  - Sector-level reporting is required by the Economic Regulator for Water Companies in England and Wales (Ofwat) since 2007.
  - Emissions reported in the CAW are in part used for compilation in the UK National Inventory Reporting.
  - Calculation of fugitive CH_4 emissions from sludge storage, thickening and treatment in anaerobic digesters. EFs included for the mass of CH_4 per mass of raw dry solids from sewage sludge
  - Consider leakage from digesters, venting due to ignition failure, and downtime at flare stacks.
  - NOT well aligned with the IPCC methodology and has been recommended for review and revision

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WW GHG Emissions Assessmen – The United Kingdom

- United Kingdom (NO_2)
  - For the national reporting, N_2O emissions from wastewater treatment are not reported, only indirect N_2O from discharge of effluent based on the 2006 IPCC Guidelines is reported.
  - For estimation of N_2O emissions from wastewater treatment, the latest review updated the country-developed EF to its original value of 0.004 kg N_2O-N/kg N load in secondary treatment (originally derived from the simple statistical average of nine studies).
  - Work is underway to develop an approach for industry wide monitoring of N_2O from representative WWTPs to develop country-specific EFs across fixed-film and suspended growth process types.
  - The UK water sector have acknowledged that accurate estimation and mitigation of process emissions is one of the main challenges in their pathway to achieving net zero by 2030.

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WW GHG Emissions Assessment- United States

- United States

- For **CH_4** emissions and **N_2O** the US uses the IPCC **Tier 2 Guidelines** as the basis for their national GHG inventory assessment.
- Domestic Wastewater **CH_4** emissions estimates:
  - Septic Systems (A)
  - Centralized Treatment Aerobic Systems (B)
    - CTSS other than constructed wetlands (B1)
    - Constructed Wetlands Only (B2)
    - CW used as Tertiary Systems (B3)
  - Centralized Anaerobic Systems (C)
  - Anaerobic Sludge Digesters (D)
  - Centralized WWT Effluent (E)

TOTAL DOMESTIC **CH_4 EMISSIONS** FROM WWT & DISCHARGE (kt) = A + B + C + D + E

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WW GHG Emissions Assessment- United States

– United States

Domestic Wastewater CH_4 Emissions from Septic and Centralized Systems (2021, kt, MMT CO_2 Eq. and Percent)

	CH_4 Emissions (kt)	CH_4 Emissions (MMT CO_2 Eq.)	% of Domestic Wastewater CH_4
Septic Systems (A)	223	6.2	45.0
Centrally-Treated Aerobic Systems (B)	74	2.1	14.8
Centrally-Treated Anaerobic Systems (C)	119	3.3	24.1
Anaerobic Sludge Digesters (D)	8	0.2	1.6
Centrally-Treated Wastewater Effluent (E)	72	2.0	14.5
Total	**496**	**13.9**	**100**

EPA Inventory of US Gas Emissions and Sinks, 2022.

WW GHG Emissions Assessment- United States

- United States

- Domestic Wastewater N_2O emissions estimates:
    - Septic Systems (A)
    - Centralized Treatment Aerobic Systems (B)
        - CTSS other than constructed wetlands (B1)
        - Constructed Wetlands Only (B2)
        - CW used as Tertiary Systems (B3)
    - Centralized Anaerobic Systems (C)
    - Anaerobic Sludge Digesters (D)
    - Centralized WWT Effluent (E)

TOTAL DOMESTIC **N_2O EMISSIONS** FROM WWT & DISCHARGE (kt) = A + B + C + D + E

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WW GHG Emissions Assessment- United States

Domestic Wastewater N_2O Emissions from Septic and Centralized Systems (2021, kt, MMT CO_2 Eq. and Percent)

	N_2O Emissions (kt)	N_2O Emissions (MMT CO_2 Eq.)	% of Domestic Wastewater N_2O
Septic Systems	3	0.8	3.8
Centrally-Treated Aerobic Systems	58	15.4	75.5
Centrally-Treated Anaerobic Systems	+	+	+
Centrally-Treated Wastewater Effluent	16	4.2	20.7
Total	**77**	**20.4**	**100**

+ Does not exceed 0.5 kt or 0.05 MMT CO_2 Eq.

Note: Totals may not sum due to independent rounding.

EPA Inventory of US Gas Emissions and Sinks, 2022.

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WW GHG Emissions Assessment- United States

- United States
  - For N_2O in addition to using the 2006 IPCC Guidelines EF of 3.2 g N_2O/person/year (0.00035 kg N_2O-N/kg N load) for WWTPs without intentional denitrification.
  - The United States Environmental Protection Agency (USEPA) have introduced a country-developed EF for WWTPs with intentional nitrification and denitrification due the large number of biological nutrient removal (BNR) WWTPs in the country.
  - Per capita protein intake figures are considered specific to dietary intake in the US whilst the IPCC 2006 estimate of 16 kg N/kg protein is applied.
  - **California,** water companies emitting from 10,000 to 25,000 tCO2e/yr reports to the California Air Resources Board (CARB) and also at a sector-level to The Climate Registry (TCR) voluntary reporting program

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WW GHG Emissions Assessment- United States

CH_4 and N_2O Emissions from Domestic and Industrial Wastewater Treatment ($MMT\ CO_2$ Eq.)

Activity	1990	2005	2017	2018	2019	2020	2021
CH_4	**22.7**	**22.7**	**21.5**	**21.4**	**21.2**	**21.3**	**21.1**
Domestic Treatment	15.1	14.6	12.6	12.3	11.9	12.1	11.9
Domestic Effluent	1.4	1.4	2.0	2.0	2.0	2.0	2.0
Industrial Treatment[a]	5.5	6.1	6.4	6.5	6.6	6.6	6.6
Industrial Effluent[a]	0.7	0.6	0.6	0.6	0.6	0.5	0.5
N_2O	**14.8**	**18.1**	**20.6**	**21.2**	**21.3**	**20.9**	**20.9**
Domestic Treatment	10.5	13.7	15.7	16.2	16.4	16.1	16.2
Domestic Effluent	3.9	3.9	4.4	4.5	4.5	4.3	4.2
Industrial Treatment[b]	0.3	0.4	0.4	0.4	0.5	0.4	0.4
Industrial Effluent[b]	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total	**37.5**	**40.7**	**42.2**	**42.5**	**42.5**	**42.2**	**42.0**

[a] Industrial activity for CH_4 includes the pulp and paper manufacturing, meat and poultry processing, fruit and vegetable processing, starch-based ethanol production, petroleum refining, and breweries industries.

[b] Industrial activity for N_2O includes the pulp and paper manufacturing, meat and poultry processing, starch-based ethanol production, and petroleum refining.

Note: Totals may not sum due to independent rounding.

EPA Inventory of US Gas Emissions and Sinks, 2022

WW GHG Emissions Assessment – Other Countries

- Mexico (Noyola et al. 2016)
  - Model a GHG emissions reduction up to a 34% depending on the technology
  - Anaerobic + aerobic treatments produces -4% vs. only aerobic
  - Biogas valorization into electricity reduces -27% GHG emissions vs. aerobic
  - Scenario to reach the 2030 wastewater emissions mitigation goals:
    - UASB + CAS up to 73% of WWTP should have this configuration by 2030
    - Trickling filter 14%
    - Aerated ponds 12.2%
    - Oxidation ditches 3.4%

IPCC International Best Practice

- Adopt a geographic boundary approach for emissions within the WWTP and outside the facility
  - Follow the GHG Global Protocol for Cities 2014 (Scope 1, 2 and 3)
  - C40 Cities Initiatives, 2020

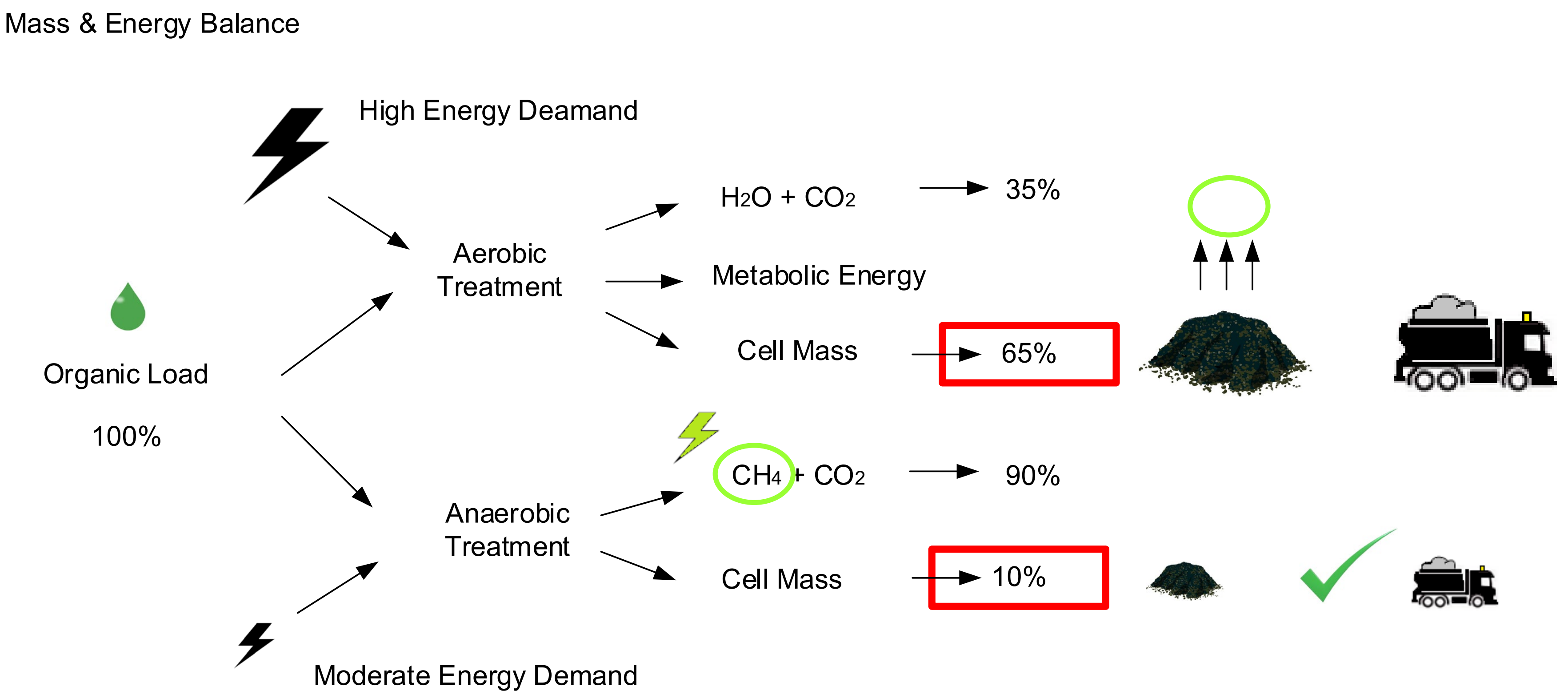
- ISO 14064-1:2018 which provides
  - Categories for understanding and reporting of GHG emissions and removals in the water sector.

- Consider emissions from biosolids recycled to land (out boundary emissions)
  - Categories for understanding and reporting of GHG emissions and removals in the water sector.

- Bottom-up EF calculation
  - Long-term facility monitoring may be used to develop facility-level EF

Overall Recommendations

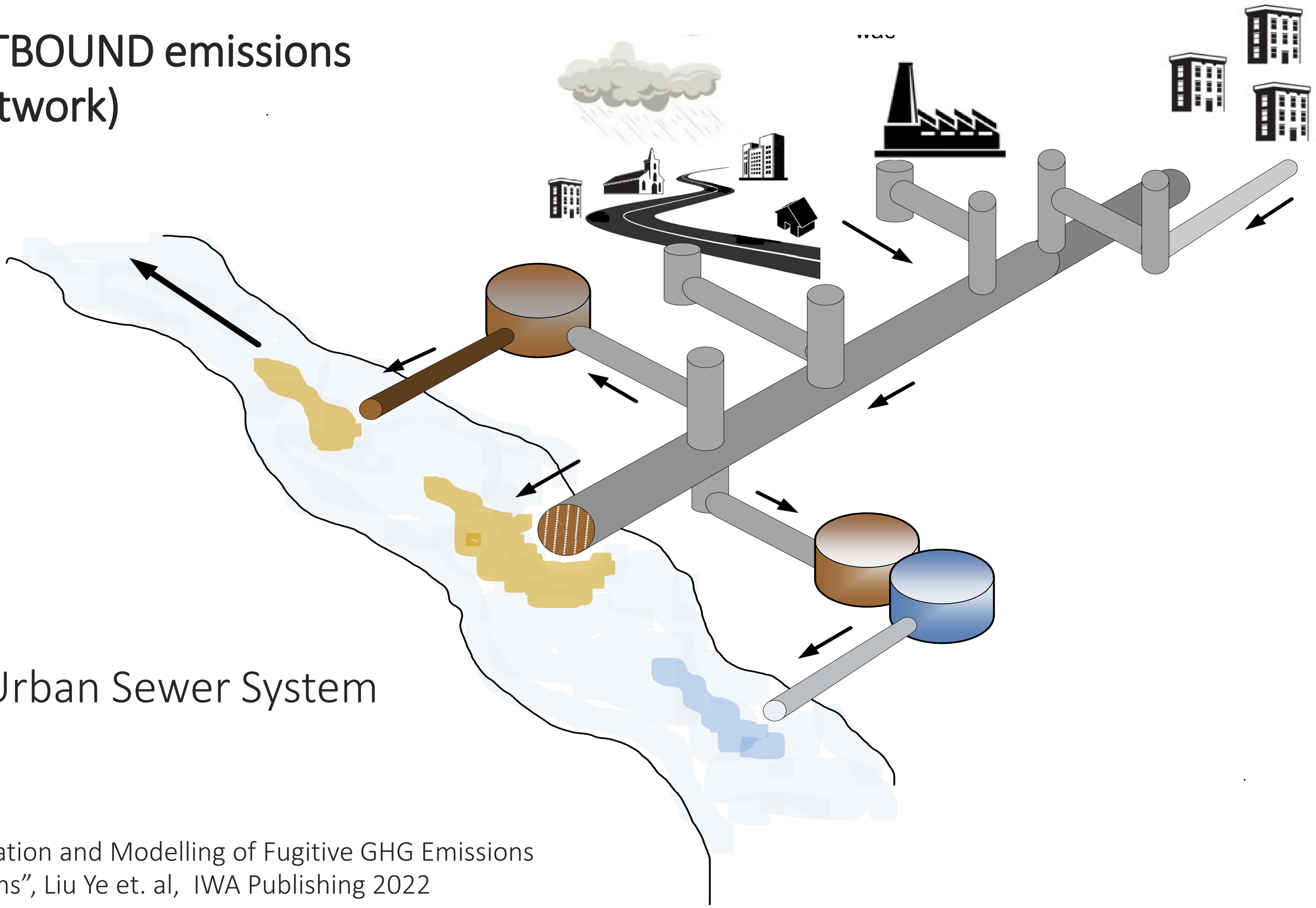
INBOUND way to reduce emissions (biodegradable wastewaters)



IINGEN UNAM, Morgan Sagastume et al., 2010

Overall Recommendations

MIND the OUTBOUND emissions
(e.g. sewer network)



Scheme of Urban Sewer System

Adapted from "Quantification and Modelling of Fugitive GHG Emissions from Urban Water Systems", Liu Ye et. al, IWA Publishing 2022

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