Dissemination Webinar

GHG EMISSIONS FROM THE DOMESTIC WASTEWATER SECTOR IN INDIA

CONCEPT NOTE

Day/Date: Tuesday, March 5, 2024;
Time: 09:00 am – 10:30 am IST/GMT (+5:30 Hrs.)
Mode: Webinar via Zoom | **Duration:** 90 minutes

Background

India, a nation with a population that has surged from around 683 million in 1981 to an astounding over 1.3 billion in 2021, faces an immense challenge in managing its wastewater. As per India's Central Pollution Control Board (CPCB), the daily generation of sewage is about 72,368 million liters (MLD). While the total sewage treatment capacity is 31,841 MLD spread across 1,469 sewage treatment plants (STPs), the operational capacity is only 26,869 MLD and over 1,093 STPs, indicating a significant gap.[1]

Wastewater treatment facilities represent a significant source of anthropogenic greenhouse gas (GHG) emissions. Within these treatment processes, three prominent GHGs—carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)—are generated. These gases originate from various mechanisms, including aerobic microbial degradation and the combustion of organic matter, anaerobic degradation of organics, and nitrification and denitrification processes responsible for CO_2, CH_4, and N_2O emissions, respectively. According to a GHGPI[2] estimate, within the waste sector in India, the domestic wastewater collection and treatment stand out as the primary source of GHG emissions, accounting for a significant 55.7% of total waste sector emissions in 2018.

[1] CPCB Sewerage Data of India, 2021, accessed on 10th September 2023

[2] Green House Gas Platform India, https://www.ghgplatform-india.org/

The Objective

Tetra Tech and TERI (The Energy and Resources Institute, India) developed a study under the Global Methane Initiative (GMI) focused on GHG emissions from the domestic wastewater sector in India. The study analyzed publicly available sources[3] and compiled a comprehensive report providing national estimates of GHG emissions from the domestic wastewater sector, specifically methane emissions. The findings from the study are planned for dissemination among relevant stakeholders through this webinar.

The webinar aims to discuss the discrepancies in GHG accounting (focused on methane emissions) presented by different sources to foster a deeper understanding. Additionally, the webinar will share international experiences in GHG emissions Inventorization in the domestic wastewater sector. By engaging with stakeholders, our objective is to collaboratively explore potential solutions and actions for more accurate assessments of methane emission accounting from the wastewater sector in India.

Key Takeaways

- Insights into the status of GHG emissions from the domestic wastewater sector in India.
- Understanding the GHG accounting data disparities and their implications.
- Exploration of potential mitigation strategies and solutions.

Join us in this conversation to foster awareness, collaboration, and actionable solutions for effective wastewater management and reduced GHG emissions in India and the Developing World.

[2] National level greenhouse gas estimates, GHG Platform India, September 2022 I Indian Network for Climate Change Assessment, India: Green House Gas Emissions 2007 I India's First Biennial Update Report (BUR1) I India's Second Biennial Update Report BUR2 I India's Third Biennial Update Report BUR3

Target Audience

The webinar invites participation from a diverse range of stakeholders, including government representatives at state and federal levels, policymakers, researchers, academicians, industry representatives, funders, NGOs, and international organizations.

Tentative Agenda

Time Slot IST (GMT +5:30 Hrs.)	Activity	Speaker
9:00 – 9:05 AM	Meet and greet	**Mr Khalil Ullah Khan** Associate Fellow, TERI
9:05 - 9:15 AM	Welcome Address	**Ms Monica Shimamura** Wastewater and Biogas Program Manager, The United States Environmental Protection Agency (USEPA)
9:15 – 9:25 AM	Keynote Address – Government of India	**Ms Leena Nandan*** Secretary, Ministry of Environment, Forest and Climate Change (MoEF&CC), Government of India
9:25 – 9:45 AM	GHG Emissions from the Wastewater Sector in India - Report Findings	**Dr Nupur Bahadur** Senior Fellow & Associate Director, TERI
9:45 – 9:55 AM	Q&A	**Moderator** **Dr Ujjwal Bhattacharjee** Renewable Energy Director, Tetra Tech
9:55 – 10:15 AM	International Experience in Domestic Wastewater GHG Emissions Inventory	**Mr Leodegario Lopez** Wastewater Expert, Tetra Tech
10:15 – 10:25 AM	Q&A	**Moderator** **Dr Ujjwal Bhattacharjee**, Renewable Energy Director, Tetra Tech
10:25 – 10:30 AM	Concluding Remarks and Vote of Thanks	**Ms Monica Shimamura** Wastewater and Biogas Program Manager, USEPA

* TBC-To be confirmed

Scan the QR Code for Registration

Global Methane Initiative Wastewater Sector

Monica Shimamura
Wastewater Sector Lead and US Co-Chair GMI Biogas Subcommittee

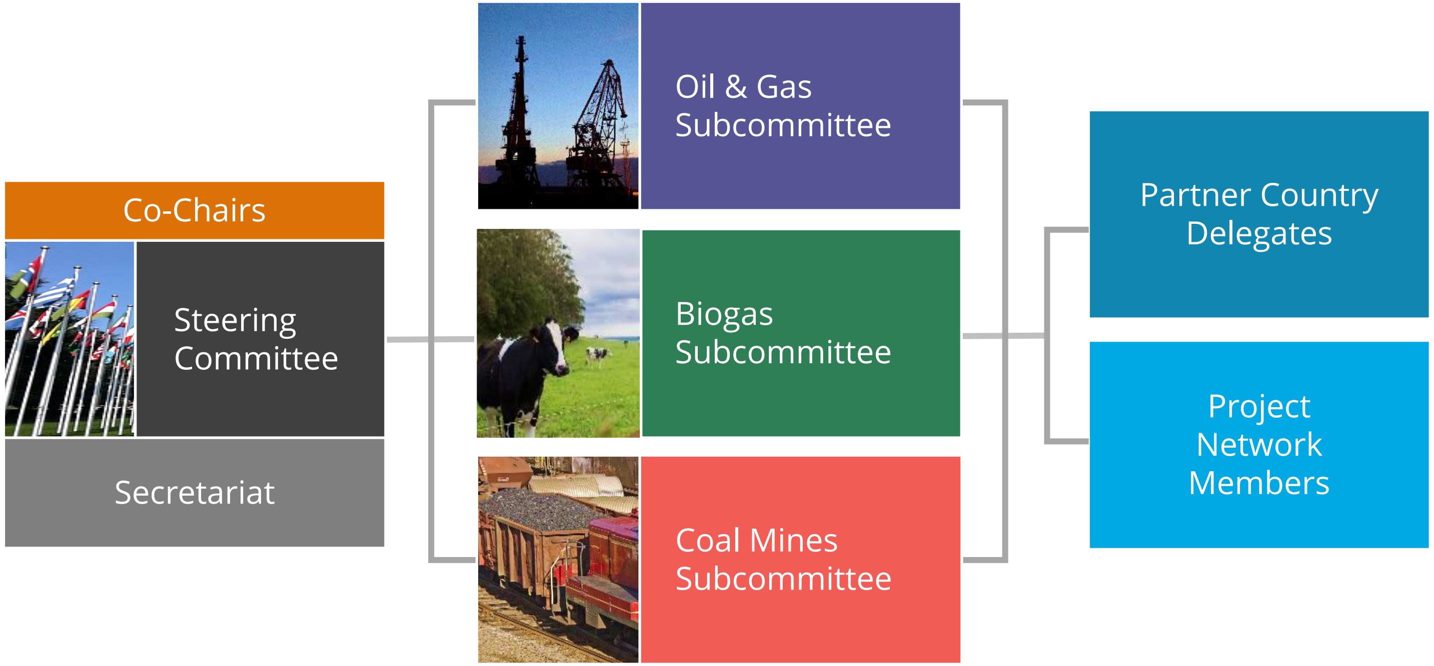
Global Methane Initiative

Global Methane Initiative (GMI)

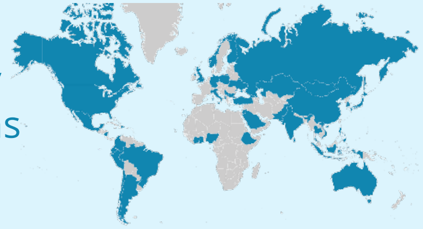
Global Methane Initiative
Leading methane action since 2004

GMI is an international public-private partnership focused on reducing barriers to the recovery and use of methane as a valuable energy source.

- 47 Partner Countries
- 1,000+ Project Network members
- Alliances with international organizations focused on methane recovery and use



GMI Partner Countries represent approximately 75% of methane emissions from human activities.



GMI Accomplishments *Since 2004*

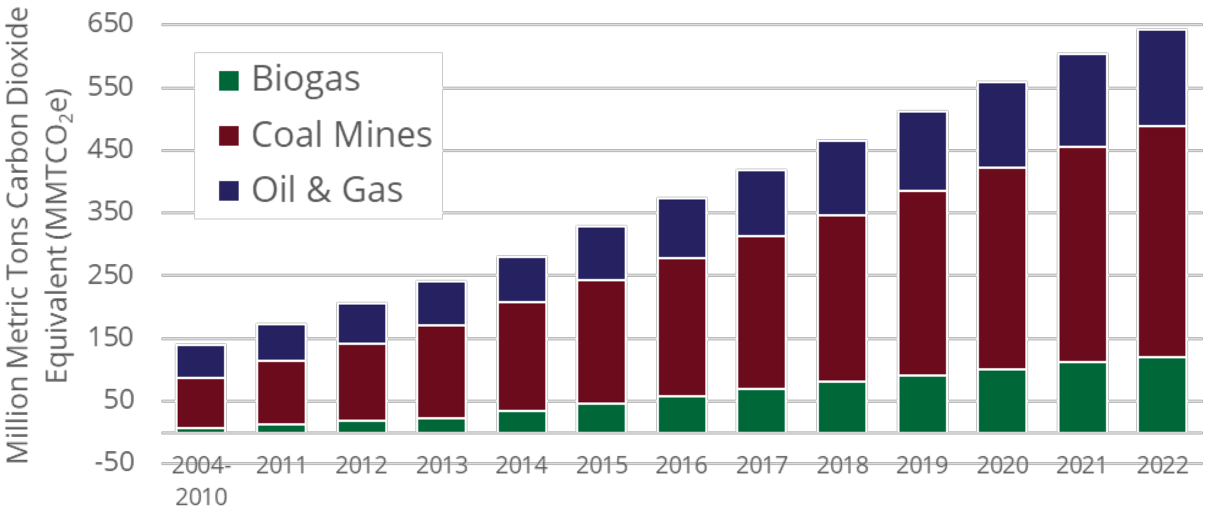
- Grown from 14 to 47 Partner Countries
- More than $650 million in leveraged funding for projects and training
- More than 1,000 Project Network members
- Conducted or developed nearly 2000 assessments, pre-feasibility studies, feasibility studies, study tours, reports, guidances and site visits
- Provided trainings for more than 50,000 people in methane mitigation
- Developed more than 60 tools and resources for methane mitigation

Global Methane Initiative
Leading methane action since 2004

Since 2004, GMI has reduced CH_4 by nearly

643 $MMTCO_2e$

including approximately **40 $MMTCO_2e$** achieved in 2022



643 $MMTCO_2e$ is approximately equivalent* to the CO_2 emissions from any one of the following:

274 Billion liters of gasoline consumed

327 Billion kilograms of coal burned

78 Trillion smartphones charged

* epa.gov/energy/greenhouse-gas-equivalencies-calculator

GMI’s Methane Mitigation Activities *Since 2004*

Nearly **2,000**	More than **400**	Approximately **1,150**

Assessments
identifying opportunities for emissions reductions

- Measurement studies
- Prefeasibility studies
- Publications/reports
- Study tours/tools/models
- Demonstration projects
- Policy analyses

Capacity Building/ Information Sharing Activities
fostering best practices

- Workshops
- Trainings
- Websites
- Outreach efforts

Partnership Activities
building relationships to foster action

- Site visits
- Conferences
- Webinars
- Informational meetings
- Steering Committee meetings
- Subcommittee meetings

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Ways GMI Biogas Subcommittee Can Support the Methane Mitigation Efforts

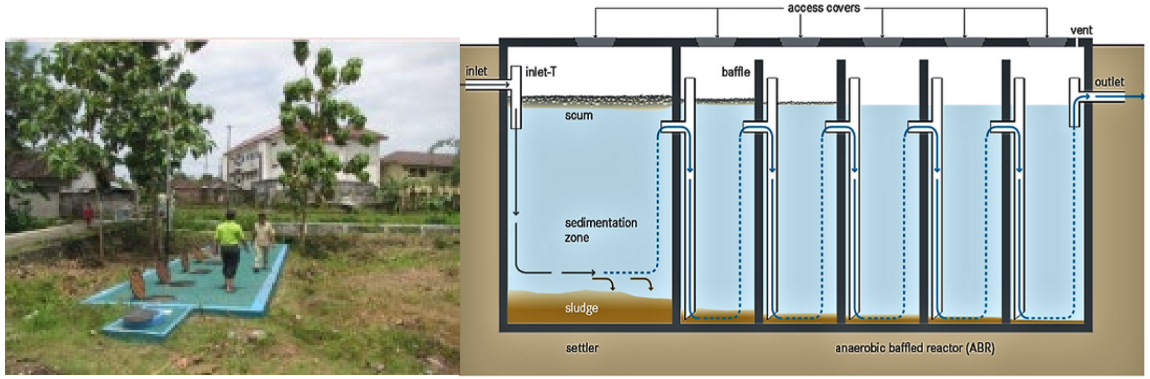
- Convene experts to exchange information
  - For example, Subcommittee meetings, webinars
- Share tools and resources to assist countries to develop and implement:
  - Baseline emissions and resource assessments
  - Greenhouse gas inventories
  - Measurement, reporting and verification
- Explore full spectrum of options for methane mitigation
  - E.g., alternative waste treatment options, feed and manure additives, biogas to replace fossil fuels, soil carbon benefits from digestate
- Facilitate and provide platform for training, capacity building, and advice to member countries

Subcommittee Action: Four Part Workshop Series: Mobilizing Methane Action at Open Dumpsites and Landfills - Tuesday, 5 March 2024 at 11:00 AM – 12:30 PM EST (UTC -5)

Greenhouse Gas Emissions Inventory for the Wastewater Sector in Indonesia

- **Objective** – Understanding the potential for methane emissions reduction from wastewater sector in Indonesia.

  - Estimate potential electricity generation from existing centralized facilities using the EPA's BioWATT tool.
  - Estimate the methane capture potential.
  - Analyze three industries (palm oil, tofu, fish processing) and the possibilities of methane capture.
  - Develop recommendations on increasing methane capture and use as an energy source from the wastewater sector in Indonesia.



DEWAT treatment unit using an anaerobic baffled reactor

- **Wastewater Sector in Indonesia** – Bulk of the population is served by decentralized water treatment systems (DEWATS).

- In 2006, the estimated economic costs of poor wastewater sanitation in Indonesia amounted to $6.3 billion, equivalent to $28.60 per capita or 2.3% of the country's gross domestic product.

Greenhouse Gas Emissions Inventory for the Domestic Wastewater Sector in India

- To assist target countries in conducting accurate GHG emission inventories, a clear understanding of the country's current practices and methodologies used for GHG inventory is critical. Therefore this project was undertaken to study the methodologies and accuracy of the emission estimates being reported by the Government of India to UNFCCC in their biannual update reporting.

- The primary objectives of the study are:
    - Review the wastewater (WW) ecosystem in India
    - Inventorize the centralized & decentralized wastewater treatment plant
    - Summarize GHG emission sources across the WW value chain
    - Compare the GHG emissions from the domestic wastewater sector in India from publicly available sources
    - Analyze existing reporting methodologies employed by the Government of India and identify opportunities for improvement.

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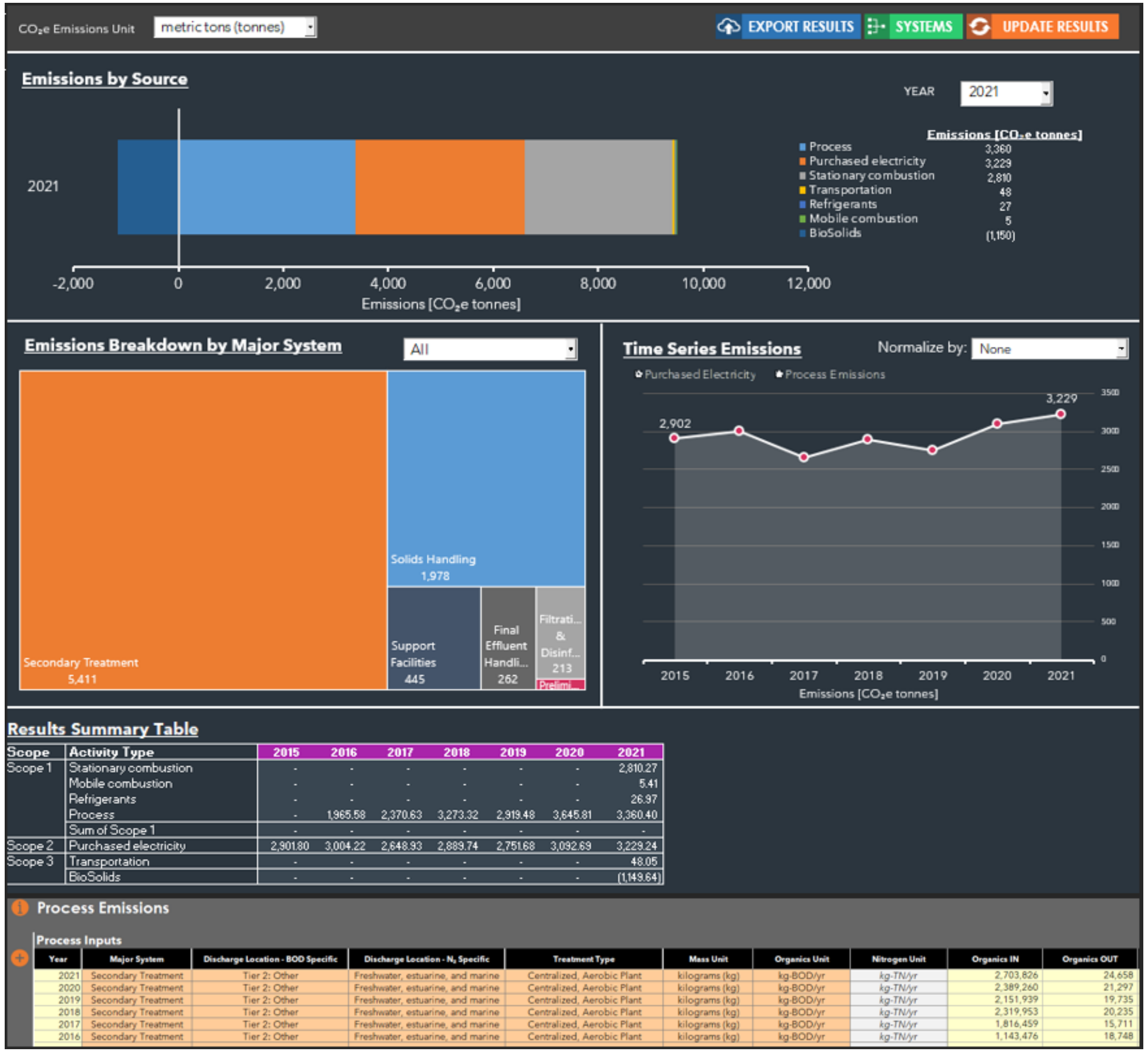
ESTIMATING WW GHG EMISSIONS FROM URBAN HOTSPOTS - A TIER 2/3 APPROACH

- Perform Tier 2/3 analyses of wastewater emissions for selected global urban hotspots. Compare emissions to Tier 1/2 analyses performed using WGGIT
- Employ tool designed for input of Tier 3 utility data from WWTPs, utilizing Tier 2 values to fill gaps
- Translate Tier 2/3 utility data to IPCC equation factors allowing for direct comparison to Tier 1/2 analysis methods in WGGIT tool
- Assess contribution of high-concentration industrial waste on wastewater emissions in hotspot areas.
- Holistic tool that includes Scope 2, Scope 3, and other Scope 1 emissions relevant to operation of a WWTP



Fact Sheet - Methane Mitigation from Municipal Wastewater Treatment Plants

- Provides an overview of methane emissions generated in both wastewater collection systems and at wastewater treatment plants (WWTP).
- Topics include
  - wastewater collection systems,
  - conventional activated sludge (CAS) treatment systems,
  - aerobic/aerated lagoon treatment systems, and anaerobic lagoon treatment systems.
  - Biosolids management and opportunities for methane mitigation and use are also described.
- Summary table identifies some of the opportunities and challenges for methane mitigation for each type of treatment system.

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BIOGAS SECTOR
Wastewater Treatment

Methane Mitigation from Municipal Wastewater Treatment Plants

The Global Methane Initiative (GMI) is a voluntary, international, multilateral partnership that aims to reduce methane emissions and advance the abatement, recovery, and use of methane as a valuable energy source. Methane (CH_4) is a potent greenhouse gas (GHG); it is the second most abundant, human-caused GHG and accounts for about 20 percent of global emissions. The Intergovernmental Panel on Climate Change (IPCC) has identified methane reduction strategies as critical opportunities to address climate change (IPCC, 2021). Reducing methane emissions associated with wastewater treatment can play a significant role in reaching global climate mitigation goals (Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions, United Nations Environment Programme and Climate and Clean Air Coalition [2021]).

Wastewater treatment plants (WWTP) have the potential to release methane, which is generated through anaerobic decomposition of organic material and emitted during collection, treatment, and management of wastewater liquids and solids. Most developed countries rely on wastewater treatment systems that are aerobic and emit small amounts of methane from the liquids treatment stream. However, in some developing countries, liquids treatment systems tend to be decentralized, less technologically advanced, and anaerobic (for example, latrines, septic tanks, Imhoff tanks, and settling ponds); this results in greater rates of methane emission. Regardless of the liquids treatment process (aerobic or anaerobic), the management of biosolids can generate significant methane emissions. This fact sheet reviews the points and processes at which methane generation and release are most likely for three types of WWTP systems, examines biosolids management and its potential for methane generation and emission, and provides suggestions for methane abatement, capture, and use.

Methane Generation and Emission in Wastewater Collection and Treatment Systems

Methane can be generated in both wastewater collection systems and at wastewater treatment plants (WWTP). The following sections provide an overview of these emission sources.

Wastewater Collection System

Wastewater is generated and transported to the WWTP through a network of pipes which leads to anoxic (i.e., oxygen deficient) and anaerobic conditions in the collection system that can potentially generate methane in the wastewater before it enters the WWTP. When the raw wastewater is agitated through pumping, changes in hydraulic profile, or entry to the WWTP, the dissolved methane can be emitted. Therefore, the headworks, where the sewer lines daylight into the WWTP facility, is an area of concern for emissions of sewer gases including methane. Recently, predictive models have been developed to assess methane emissions from sewers (Conveyance Asset Prediction System [CAPS], 2020); these models can help develop and evaluate methane mitigation strategies for pre-treatment activities. However, each wastewater system must be evaluated holistically for methane mitigation opportunities.

Layout of a WWTP with a CAS treatment system and primary and secondary sludge anaerobic digestion.

Conventional Activated Sludge (CAS) Treatment System

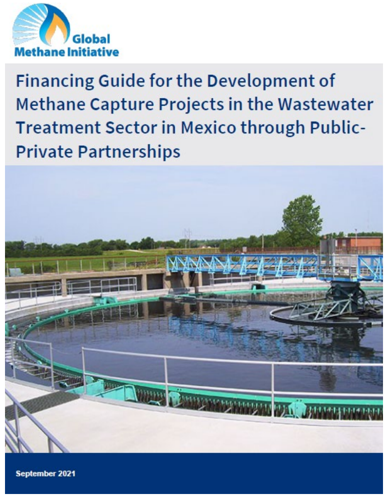
Liquids Stream Treatment. For most conventional activated sludge treatment systems, treatment is primarily aerobic, with few emissions associated with treatment of the liquids stream. In addition to the headworks, primary clarifiers can be a potential minor source of methane emissions. Subsequent liquids treatment processes such as in aeration basins, secondary clarifiers, and disinfection units, generate minimal methane emissions. Figure 1 shows the process flow diagram for liquids stream treatment in a conventional, activated sludge treatment system.

Solids Stream Treatment. Solids stream treatment is more often the largest source of methane emissions, but the quantity of emissions varies depending on how the solids are managed. Storage of sludge can promote anaerobic conditions and generate methane if the holding time is not managed properly. Methane generated in the waste

September 2023 globalmethane.org/biogas 1

Financing Guide for the Development of Methane Capture Projects in the WWT Sector in Mexico through PPP

- Provides an overview of the benefits of methane recovery and reuse to support sustainability goals
- Reviews key agencies, partners and the framework for wastewater PPPs in Mexico.
- Provides information on how to prepare the project proposal
- Provides information on the review process to support successful project development.

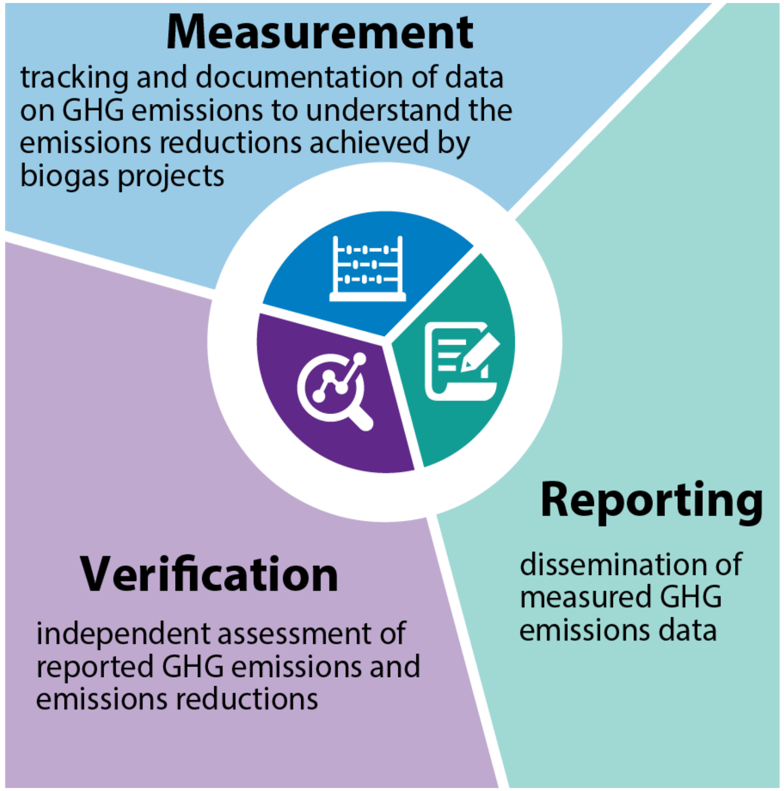


Prepared by the USEPA under the auspices of the GMI

- Provides case studies of successful PPPs implemented in the WWT sector
- Provides recommendations to support future project development and a list of resources

Measuring, Reporting, and Verification (MRV) Resources

- Policy Maker's Handbook for Measurement, Reporting, and Verification in the Biogas Sector
  - An online platform with high-level guiding principles for conducting MRV for biogas projects.
- MRV Webinar Series: MRV Best Practices for Biogas Projects
  - The recording of the latest webinar on 24 May will soon be available on the GMI website: globalmethane.org/events/details.aspx?eventid=706



For more information, visit the GMI website: globalmethane.org/biogas/index.aspx#tools

GMI Tools for Biogas

Biogas Wastewater Assessment Technology Tool (BioWATT)

- Provides a quick and preliminary assessment of wastewater-to-energy projects.
- Biogas production estimate for various wastewater-to-energy technologies,
- electricity generation potential from the produced biogas,
- GHG savings associated with biogas-generated electricity,
- Preliminary assessment of the WWTP’s electricity demand that can be met through biogas-generated electricity;
- Preliminary design parameters of major components of a wastewater-to-energy project, such as required digester volume, required gas holder volume, and total combined heat and power (CHP) electric power output, and
- Impact on a WWTP’s operating expenses (OPEX) by investing in energy generation technology

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Save the date!
2024 Global Methane Forum: *Mobilizing Methane Action*

Goals:

- Convene global government, science, industry and finance thought leaders to mobilize ambitious action on methane
- Highlight methane mitigation activities underway to achieve the goals, including of the Global Methane Pledge
- Share information about technical, policy, financing, and regulatory challenges and solutions related to methane policy and project development

Dates and Location:

- 18-21 March 2024, UN Palais des Nations, Geneva, Switzerland

Additional information is posted here:

- https://www.globalmethane.org/2024forum and at https://unece.org/sustainable-energy.

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UNECE

Global Methane Hub

CLIMATE & CLEAN AIR COALITION
TO REDUCE SHORT-LIVED CLIMATE POLLUTANTS

We look forward to welcoming you in Geneva!

Thank you!

Monica Shimamura
Wastewater Sector Lead
and
US Co-Chair GMI Biogas Subcommittee

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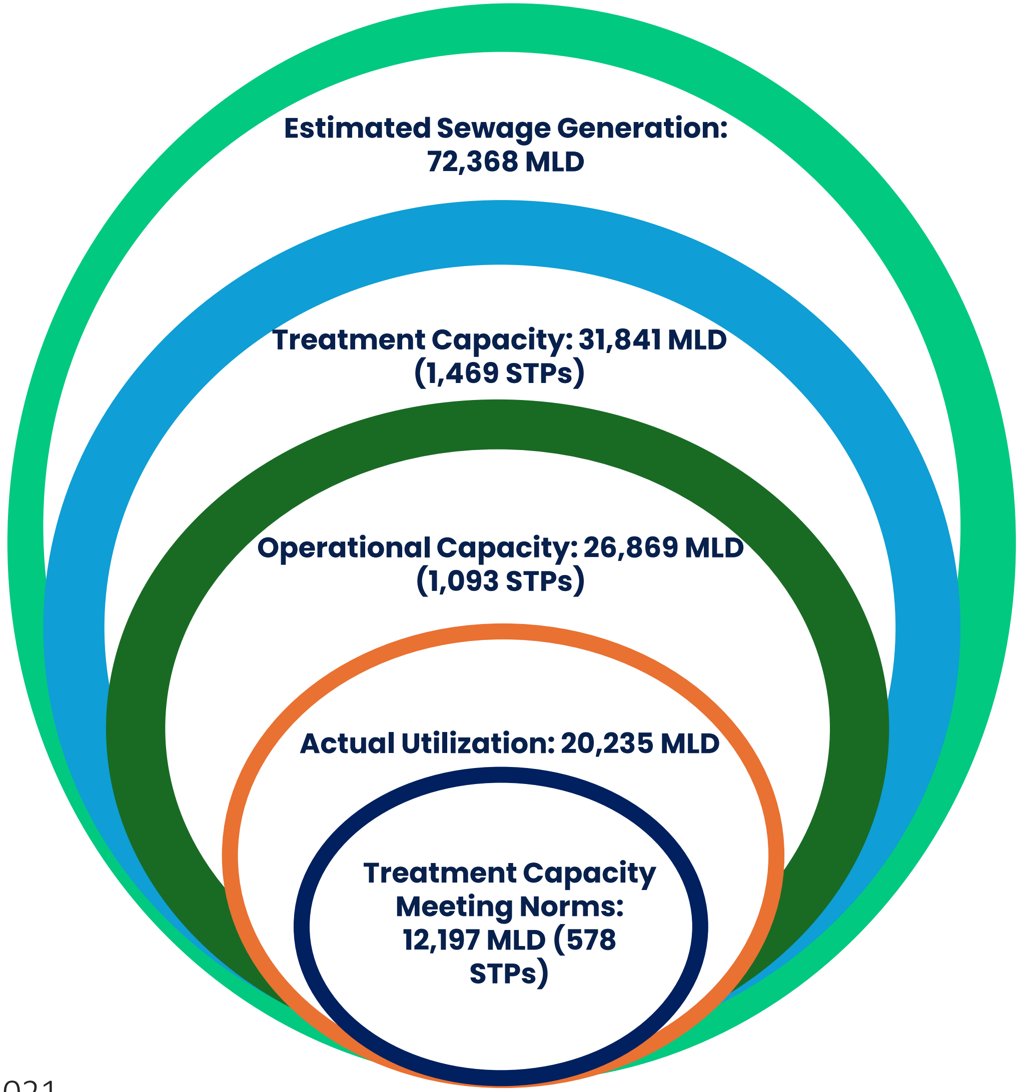
GHG Emissions from the Domestic Wastewater Sector in India

Dr. Nupur Bahadur, Senior Fellow and Associate Director, TERI

March 05, 2024; New Delhi, India

Wastewater (Sewage) Ecosystem in India

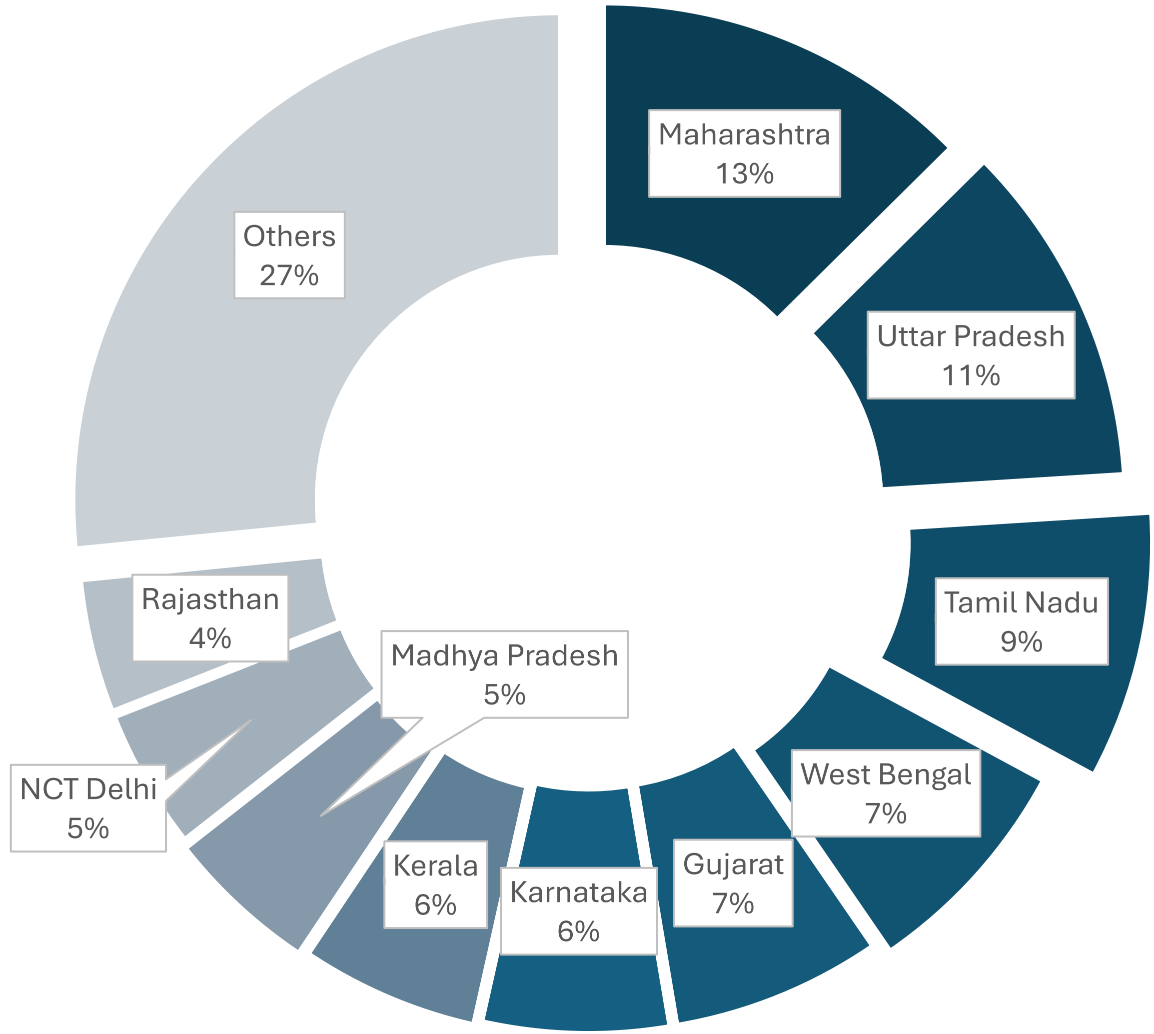
- 72,368 MLD wastewater is generated and only 20,235 MLD gets treated.
- The government of India has been making substantial investments in expanding the wastewater treatment infrastructure.
- Wastewater treatment facilities represent a significant source of anthropogenic GHG emissions.
- Addressing GHG emissions in the wastewater sector is pivotal for India



Source: Central Pollution Control Board (CPCB), March 2021

State-wise Contribution in Sewage Generation

- 10 states alone contribute to 73% of total sewage generation.
- Maharashtra tops the list contributing 13% to the total sewage generated.



Source: Central Pollution Control Board (CPCB), March 2021

Top Ten Sewage Generating States in India

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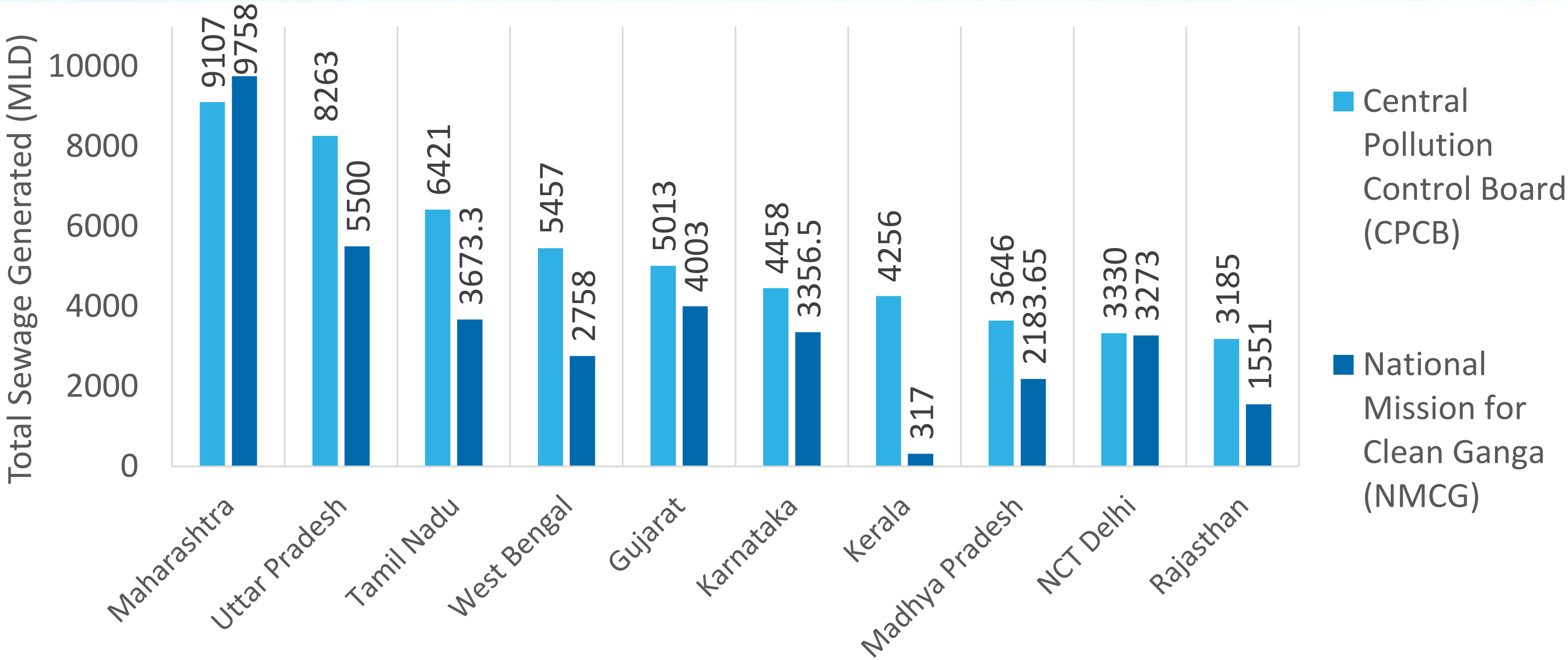
#	State	Total Sewage Generation (MLD)	Number of STPs Installed	Cumulative Capacity of STPs in MLD	Sewage Treatment Capacity as percentage of total Sewage Generation
1	Maharashtra	9107	154	6890	76%
2	Uttar Pradesh	8263	107	3374	41%
3	Tamil Nadu	6421	63	1492	23%
4	West Bengal	5457	50	897	16%
5	Gujarat	5013	70	3378	67%
6	Karnataka	4458	140	2712	61%
7	Kerala	4256	7	120	3%
8	Madhya Pradesh	3646	126	1839	50%
9	NCT Delhi	3330	38	2896	87%
10	Rajasthan	3185	114	1086	34%
	National Estimate	**72,368**			

Source: CPCB, March 2021

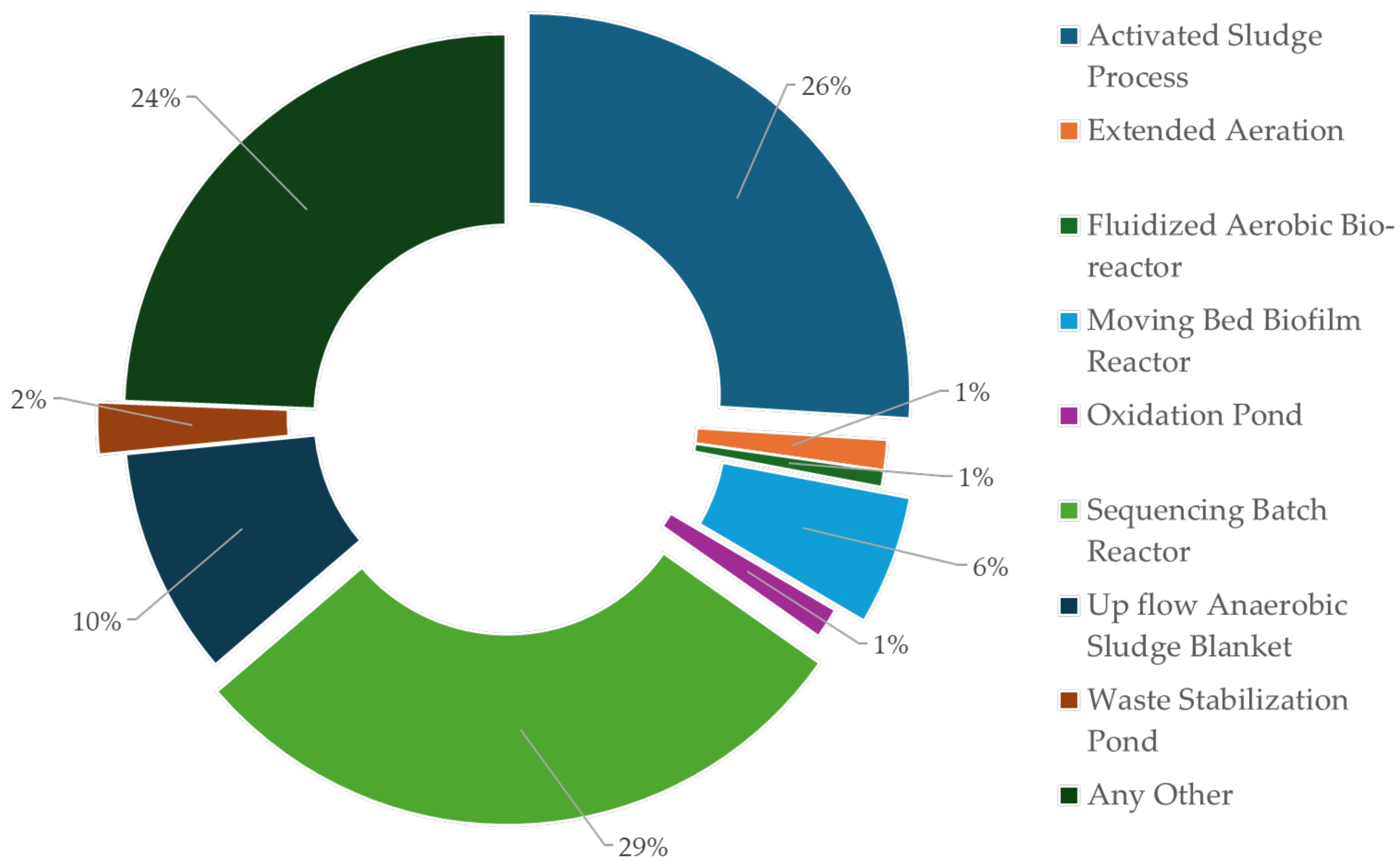
Comparison of Sewage Generation Data Reported by CPCB & NMCG



- Notable variation between the two datasets, with some states like Uttar Pradesh & Kerala showing significant differences.
- This underscores the importance of accurate sewage generation assessments nationwide

Source:
Central Pollution Control Board (CPCB), March 2021
3rd Quarterly report of Central Monitoring Committee constituted by NGT, NMCG dated Feb 2021

Treatment Technologies Used in India

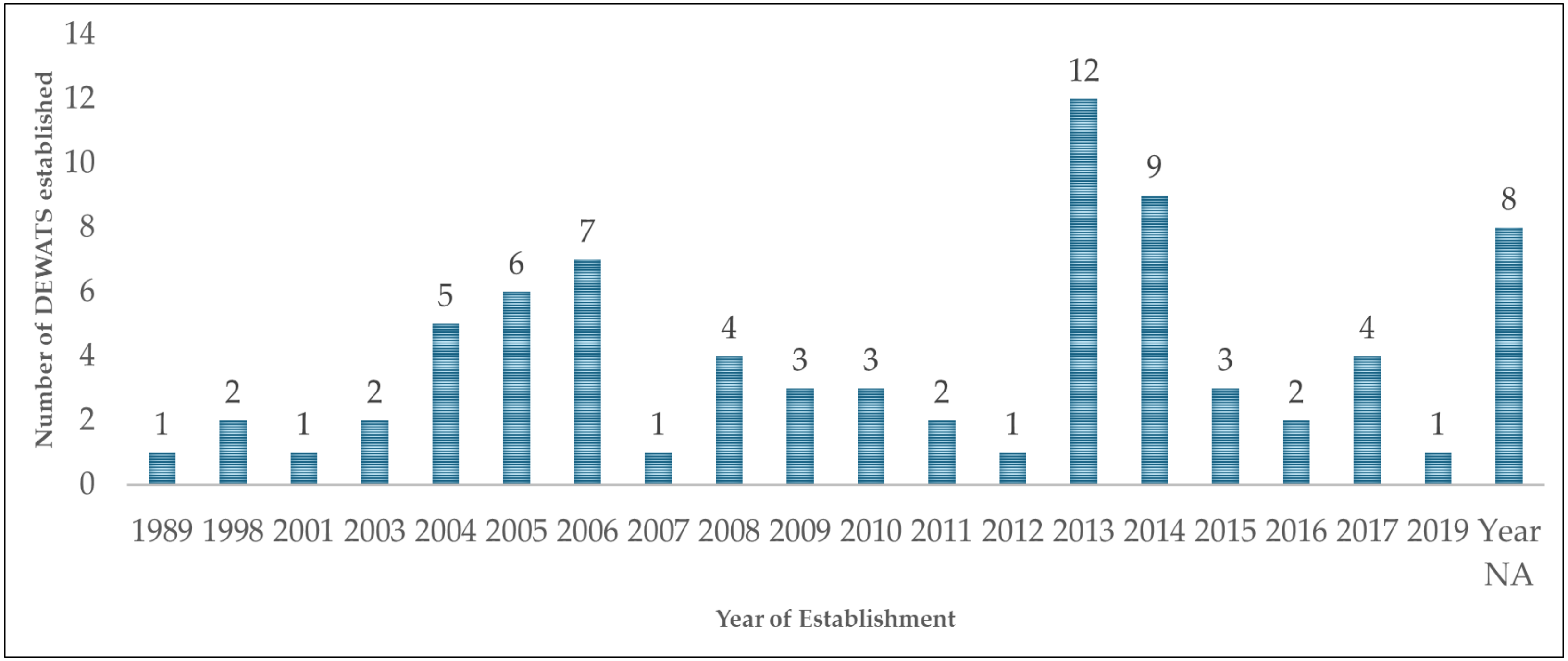


- SBR and ASP are most commonly adopted technologies.

Source: CPCB, March 2021

Decentralized Wastewater Treatment Systems (DEWATS) in India

Global Methane Initiative



- DEWATS involve treating, releasing, or reusing wastewater near its source and can treat both domestic and industrial wastewater for wastewater flows from 1 to 1,000 m3/day.
- A notable increase in DEWATS occurred from 2004, with the establishment and subsequent years witnessed a rise, reaching a peak of 12 plants in 2013.

Source: Anju Singh et al., 2019.

Estimates of GHG Emissions from Domestic Wastewater

Potential Sources of GHG Emissions

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On Site/direct emissions

- CO_2 from Anaerobic Decomposition
- CO_2 from Conversion of Organic Matter
- CH_4 from Anaerobic Digestion Process
- N_2O from Denitrification Process

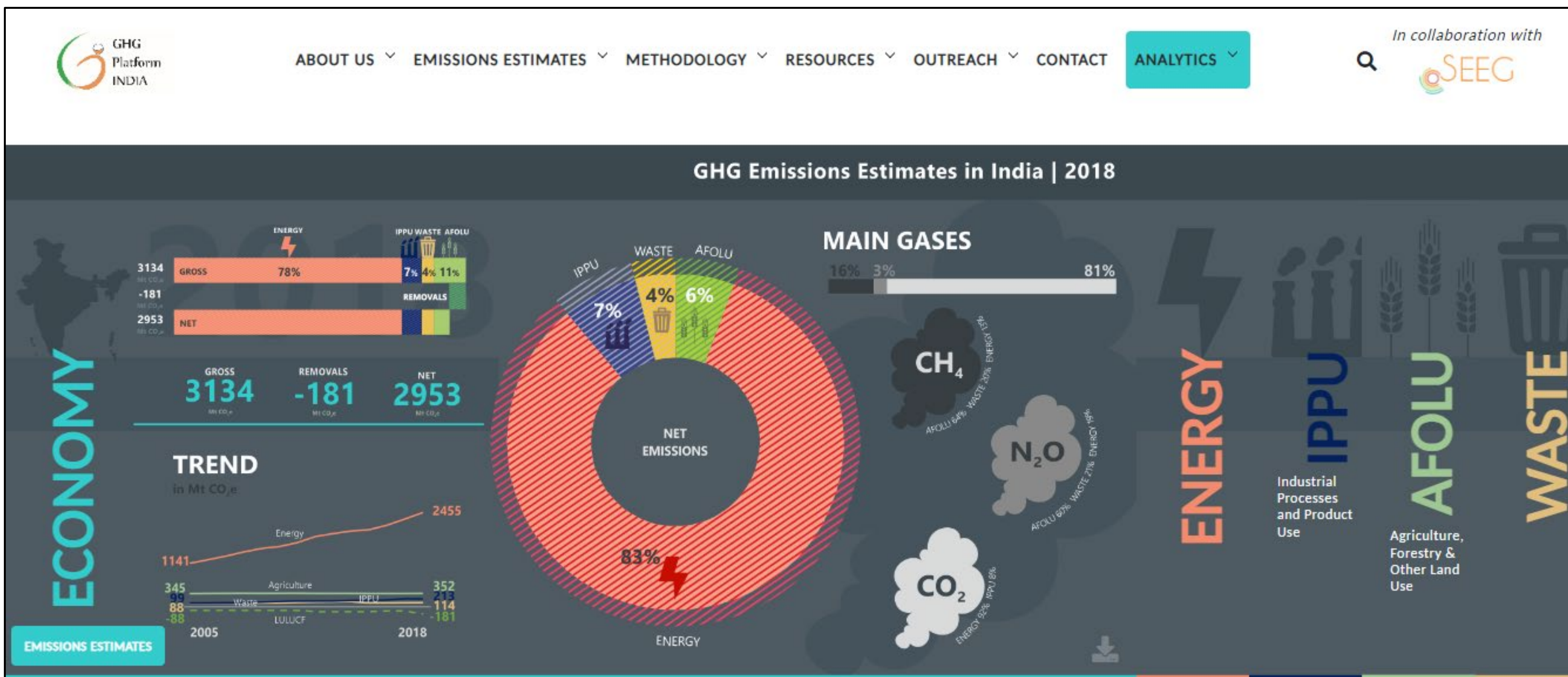
Off Site/ in-direct emissions

- Transportation
- Disposal of Sludge
- Energy Consumption
- Purchased Raw Materials

Note: According to the IPCC Guideline, 2006, Direct/on-site CO2 emissions from wastewater treatment plants are biogenic and therefore not included in the total emissions

Study Approach

- GHG Platform – India (GHGPI) provides independent estimation and analysis of India's GHG emissions across various sectors.
- Platform published a report in 2022 on National GHG estimates from the Waste Sector for the period 2005 to 2018 which is a major source of data for this study.
- The GHGPI estimates were then compared to the estimates given in India's Biennial Update Reports (BURs) submitted to the UNFCCC.



GHG Emissions from the Waste Sector in India

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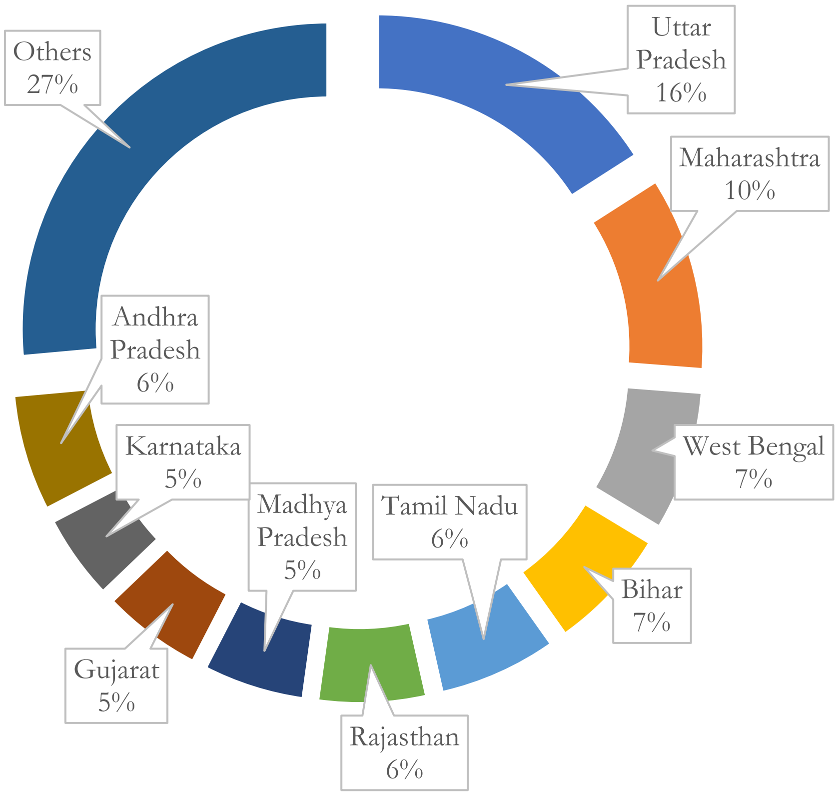
IPCC ID	Source Category	GHG Emission (million tonnes of CO_2e based on GWP values from the IPCC Second Assessment Report (AR2)		
		2005	2018	Percent Change (2005 – 2018)
4	Total from Waste Sector	88.23	114.50	29.77%
4A	Solid Waste Disposal	7.05	13.23	87.66%
4D	Total Wastewater Treatment and Discharge	81.18	101.27	24.75%
4D1	Domestic Wastewater Treatment and Discharge	43.82	63.76	45.50%
4D2	Industrial Wastewater Treatment and Discharge	37.36	37.51	0.40%

Source: GHGPI

State Share in GHG Emissions from Domestic Wastewater during 2005 – 2018

Sr No.	Name of State	Cumulative GHG emissions from the domestic wastewater sector (2005-2018) (million tonnes CO_2e)
1	Uttar Pradesh	120.47
2	Maharashtra	77.69
3	West Bengal	56.08
4	Bihar	49.50
5	Tamil Nadu	47.43
6	Rajasthan	43.34
7	Madhya Pradesh	40.56
8	Gujarat	39.93
9	Karnataka	34.19
10	Andhra Pradesh	46.74
	National	**755.70**

Source: GHGPI



- Uttar Pradesh has the highest emissions, around 16% of cumulative national GHG emissions from the domestic wastewater.

Sewage Generation versus GHG emissions

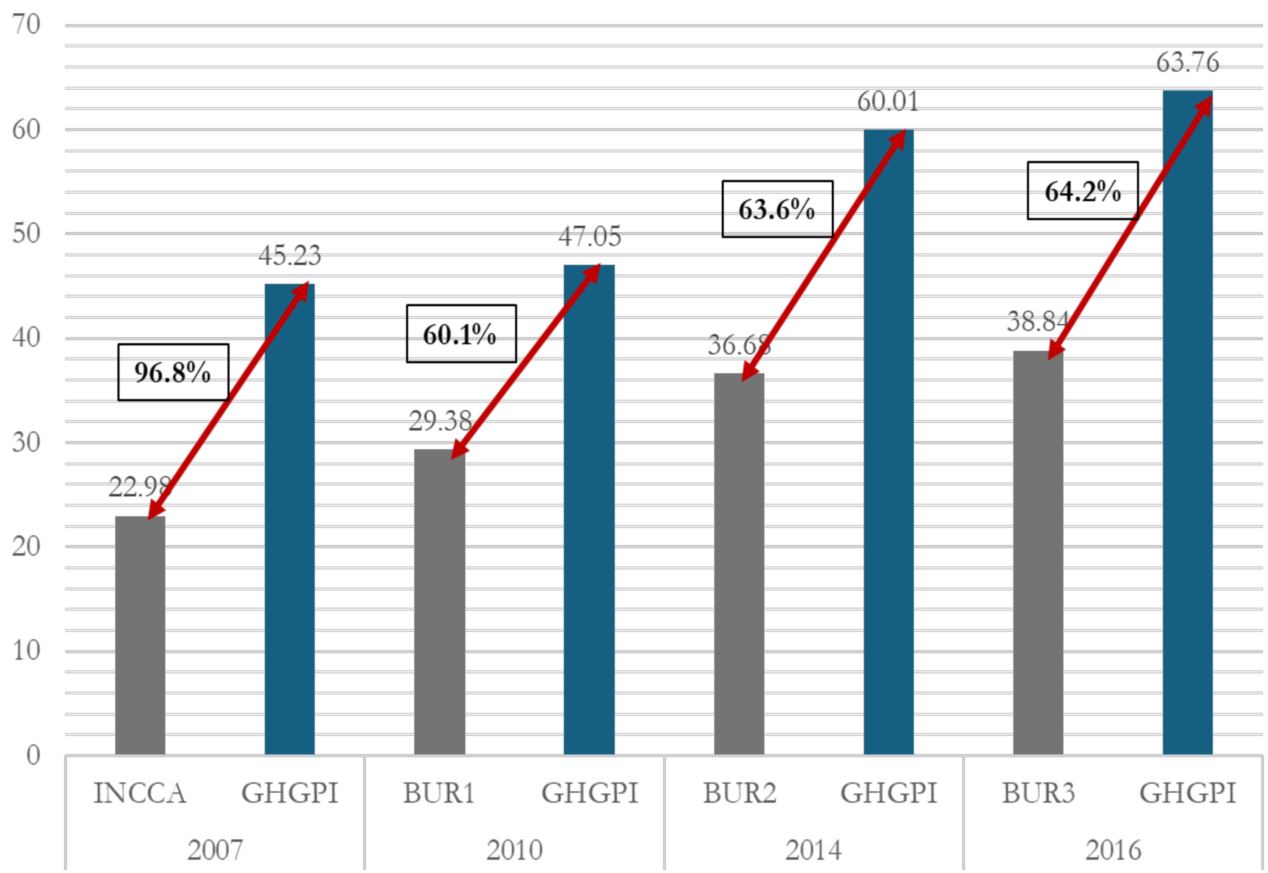
#	Name of State	Contribution in Total Sewage Generation
1	Maharashtra	13%
2	Uttar Pradesh	11%
3	Tamil Nadu	9%
4	West Bengal	8%
5	Gujarat	7%
6	Karnataka	6%
7	Kerala	6%
8	Madhya Pradesh	5%
9	NCT Delhi	5%
10	Rajasthan	4%

#	Name of State	Contribution in GHG emissions from Domestic wastewater
1	Uttar Pradesh	16%
2	Maharashtra	10%
3	West Bengal	7%
4	Bihar	7%
5	Tamil Nadu	6%
6	Rajasthan	6%
7	Madhya Pradesh	5%
8	Gujarat	5%
9	Karnataka	5%
10	Andhra Pradesh	6%

Karnataka and Delhi are among the top 10 sewage-generating states but not in terms of GHG emissions, which shows they have well managed plants.

Source: GHGPI

Comparison of GHGPI Estimates with National GHG Inventories for Domestic Wastewater



References:

1. INCCA - Indian Network for Climate Change Assessment, India: Green House Gas Emissions 2007 (INCCA)
2. BUR1 - India's First Biennial Update Report (having reference point of 2010)
3. BUR2 - India's Second Biennial Update Report (having reference point of 2014)
4. BUR3- India's Third Biennial Update Report (having reference point of 2016)

Note: BUR's mention that the IPCC Tier I and Tier II with country-specific data were used to calculate the GHG emissions from the wastewater sector. However, the reports do not provide the data used.

Key Takeaways and Way-forward

- Emissions from the domestic wastewater sector amounted to 43.82 million tonnes of CO_2e in 2005, rising to 63.76 Million tonnes of CO_2e in 2018 and forecasted to 78.38 million tCO_2e by 2025.
- In 2018, domestic wastewater treatment and discharge emerged as the primary contributor, constituting 55.7% of total GHG emissions from the waste sector.
- The biennial reports of the Government of India do not give explicit clarifications on the data used for the estimation of GHG emissions from the domestic wastewater sector. This restricts the study from concluding the specific reasons for such huge variations in the reported estimates.

Way-forward:

- Strengthen the baseline data for sewage generation for each state along with the type of treatment technology used.
- Developing Tier II & Tier III methods with on-field calculations is crucial for deriving an accurate estimation of India-specific methane emissions.

Global Methane Initiative

International Insights on GHG Inventories

Leodegario López, M.Eng.
Wastewater Specialist, Tetra Tech

Global Methane Initiative

Content

- IPCC Background
- IPCC Model for Domestic Wastewater Discharge
- GHG Emission Sources
- Country Examples

IPCC Guidelines on Wastewater - 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 a 3-Tier methodology for emission factor (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

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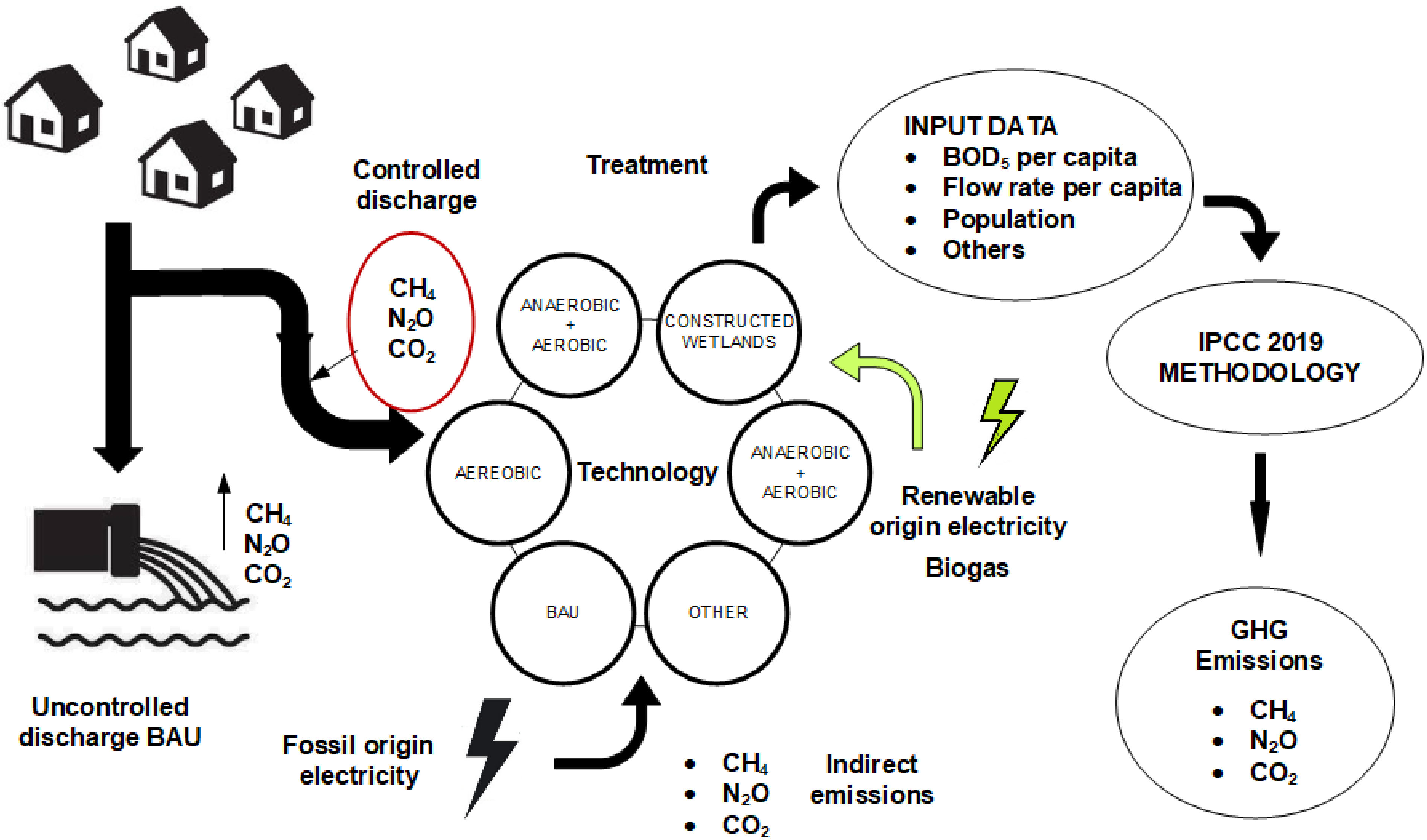
IPCC Modelling Approach



Emissions Sources

Direct and Indirect Emissions from Wastewater Treatment

- Direct emissions of CO_2, N_2O and CH_4 produced from wastewater micro-organisms 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)

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GHG 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 N2O and CH4

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Wastewater GHG Emissions Assessment – Australia

Australia *(Department of Industry, Science, Energy & Resources, 2021; OPC)*

The Tier-2 approach for Australia is outlined in the National Greenhouse and Energy Reporting (Measurement) Determination 2008, under subsection 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 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 sludge of different types.
  - *Method 2:* Considers an approach aligned with Method 1 but with more specific consideration of a facility. This is based on the 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.
- The fourth method in GHG emission assessment relates to a Tier 3 approach defined as a facility-specific measurement of emissions by continuous or period emissions monitoring – but this is not included as a method for CH4 emissions estimation.

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Wastewater GHG Emissions Assessment– 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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Wastewater GHG Emissions Assessment– 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

- 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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Wastewater GHG Emissions Assessment- 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) has introduced a country-developed EF for WWTPs with intentional nitrification and denitrification due to 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 report 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

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**

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

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

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WW GHG Emissions Assessment – Mexico

- **Mexico** (Noyola et al. 2016)
  - GHG emissions reduction up to 34% depending on the technology
  - Anaerobic + aerobic treatments produce -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%

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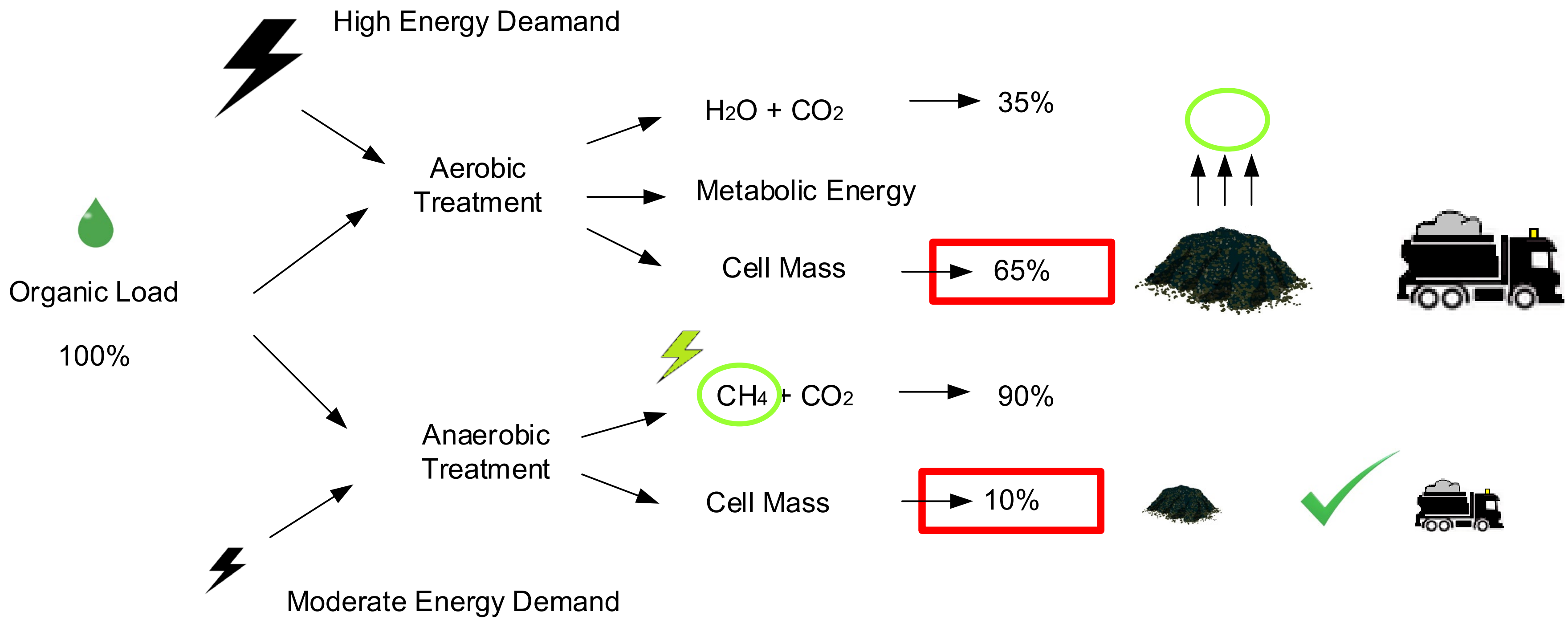
IPCC International Best Practice

- 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)

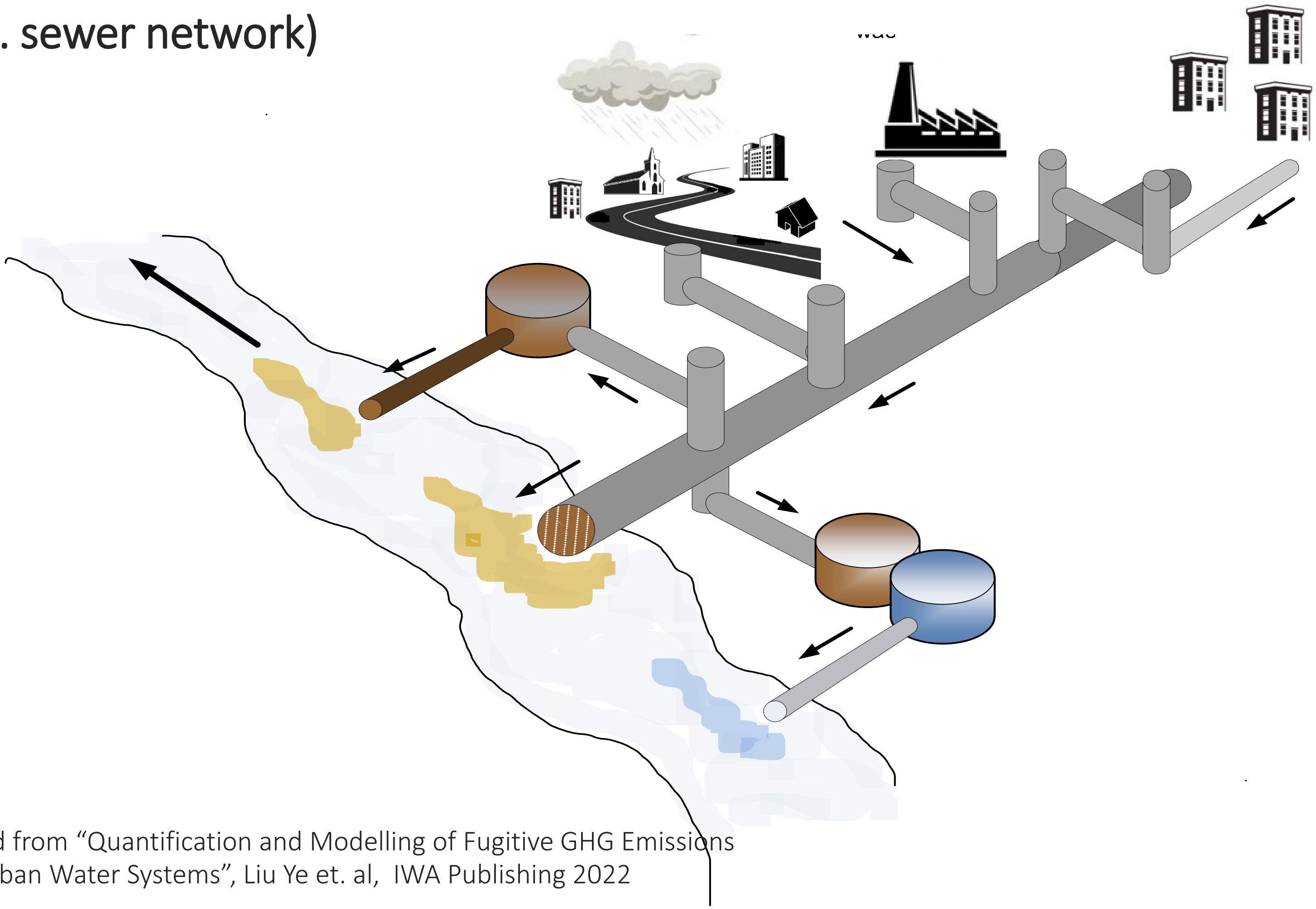
Mass & Energy Balance



IINGEN UNAM, Morgan Sagastume et al., 2010

Overall Recommendations

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



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