
Photo clicked by CWAS team at Pirana STP, Ahmedabad Municipal Corporation

Approaches towards mitigating methane from India’s wastewater system

Center For Water and Sanitation, CRDF, CEPT University

CWAS CENTER FOR WATER AND SANITATION | CRDF CEPT RESEARCH AND DEVELOPMENT FOUNDATION | CEPT UNIVERSITY

Approaches for mitigating methane from India’s wastewater systems

Key aspects of the project

Mitigating methane emission from wastewater systems

01 Quantification and identification of methane mitigation potential from wastewater for cities of Maharashtra

- On field methane emissions estimation.
- Localized emission factor for Indian cities.
- Methane capture potential estimates/feasibility for sanitation technologies.
- Feasible business models and preliminary market assessment

02 Generating evidences for approaches to mitigate methane from sanitation systems

- Understanding the feasibility of installation of a methane capture unit.
- Backward and forwards linkages of resource recovery product

03 Dissemination and Capacity building support to govt. officials and scale up

- Resource material preparation for dissemination of findings
- Capacity building workshops and dissemination of learning to state and national level

Renewable energy and Improving sanitation condition on National and International Agenda

National and International agenda focus on renewables and improving WASH services to tackle climate change

International agenda

- Various international program focus on using methane as a resource and using as source for clean energy. Global Methane Pledge focus on reducing methane emission by at least 30 % from level in 2020 till 2030.

- SDG 6 highlighting the access to clean water and sanitation with ensuring availability and sustainable management of water and sanitation for all. SDG 7 highlighting the access to affordable, reliable, sustainable and modern energy for all.

National agenda

- SBM 2.0 and AMRUT 2.0 focus on improving overall sanitation condition in India across the urban areas with focus on circularity

- National level programs like SATAT and GobarDHAN focus on making clean energy from waste.

Initiative aligning with the national agenda of NDCs and policies

Various national level programs focus on non fossil fuel-based energy

1986 — Environment Protection Act

2008 — **National Urban Sanitation Policy**
Included used water component and focus on 3 R concept

First Biogas Standards

2014 — **Swachh Bharat Mission**
SBM 2.0 (Phase 2, 2020-21) targets ODF-plus, waste management, biomethanation, and mechanized desludging with urban-rural treatment integration.

2015-17 — **AMRUT & National Policy on FSSM**
Includes sludge management in urban sanitation, with FSSM adopted in 2017

First revisions in biogas standards

2018 — **Gobardhan Scheme**
Part of the "Waste to Wealth" initiative, with financial and technical support up to ₹50 lakhs per district

2018 — **SATAT initiative**
Encourages establishing CBG plants, ensuring market linkage for biofuel in automotive fuels.

National policy for biofuels

2019 — **Draft National Resource Efficiency Policy**
focus on reducing primary resource consumption, creating higher value with less material, and minimizing waste

2021-22 — **Waste to Energy Programme**
It focuses on energy recovery from sewage sludge through incineration and anaerobic acid on a dry matter basis.

Swachh Bharat Mission (2.0)
Included usedwater component and focus on 3 R concept

- Fertilizer control order for inclusion of fermented organic mater
- Biogas projects under the priority sector

2021-26 — **Biogas Programme (MNRE)**
Provides Central Financial Assistance (CFA) for setting up biogas plants

Biogas injected into Natural gas grid

2022 — **The Energy Conservation (Amendment) Bill, 2022**
Energy efficiency and conservation, mandating the use of non-fossil sources by designated consumers, and enabling carbon credit trading

2024 — **Draft Liquid Waste Management Rules**
Sets reuse targets for bulk water consumers: 20% by 2027-28, 50% by 2030-31. Guides sewage sludge management with strict monitoring for safe agriculture and biomethanation potential.

Solid waste | Wastewater | Both | Agriculture & Livestock

DST have also floated proposal for methane mitigation and monitoring

There is an opportunity to tap the potential from sanitation and usedwater services

Quantification and identification of methane mitigation potentials across sanitation service chain

Quantify methane across the sanitation sector

- On-field emission quantification
- Developing emission factors

Assessing methane as a resource

- Understanding methane potential for different technologies
- Exploring Methane emissions into resource

Assessment of current practices and methane quantification across the sanitation service chain

Landscape assessment of current practices in the sanitation sector

- Mapping best practices and current situation.
- Understanding technical, financial, and operational models of existing STPs

Assessing Market & Potential Model

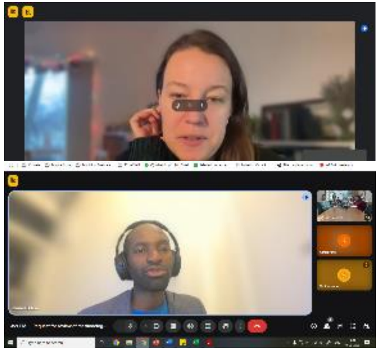
- Understanding market potential for recovered resource usage.
- Market provider for STPs with methane recovery unit.
- Exploring viable model

Overall approach for conducting quantification of methane across sanitation service chain

Desk review → **Field visits to build inventory** → **Discussion with domain experts** → **Finalisation of methodology and on-field testing**

Literature review of existing studies related to GHG emissions for sanitation value chain.

Field visits and surveys were carried out in four cities- Ichalkaranji, Satara, Wai and PCMC, to identify septic tanks, maintenance holes, STPs, and discuss with experts and government stakeholders



Discussion with academic professionals and sector professionals having expertise and knowledge related to emissions in sanitation sector

Finalisation of methodology based on discussions with experts and implementing the quantification activity across the sanitation chain

In-depth literature review was conducted to understanding the linkages of methane across sanitation service chain

Inaccurate IPCC factors

- Field data shows actual CH_4 & N_2O emissions are varying compared to IPCC defaults[1].

Containment Emissions

- Septic tanks and pits are one of the sources of methane[1].

Local climatic, demographic factor impact

- Rainfall, temperature, and use patterns influence the methane concentration and performance of the onsite containment system[1].
- The emissions from the STPs vary based on the treatment technologies[2].

Call for More Data

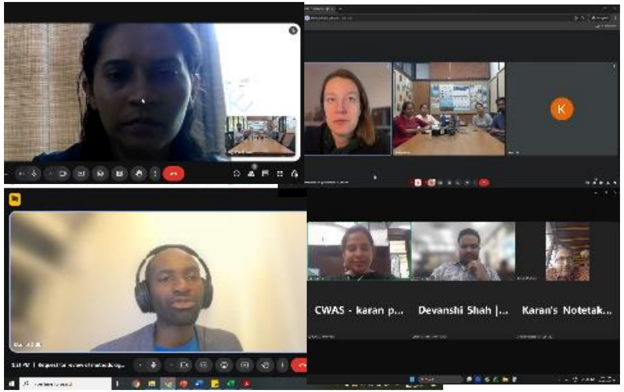
- More field monitoring and a local-level database are needed for decision making[3].
- Field monitoring across sanitation value chain will provide more clarity on factors affecting emissions and building solutions to use it as a resource.

Source – 1. Manga, M., & Muoghalu, C. C. (2024). Greenhouse gas emissions from on-site sanitation systems: A systematic review and meta-analysis of emission rates, formation pathways and influencing factors. Journal of Environmental Management, 357, 120736. https://doi.org/10.1016/j.jenvman.2024.120736; 2. Song, C., Zhu, J.-J., Willis, J. L., Moore, D. P., Zondlo, M. A., & Ren, Z. J. (2023). Methane emissions from municipal wastewater collection and treatment systems. Environmental Science & Technology, 57(6), 2248-2261. https://doi.org/10.1021/acs.est.2c04388. 3. Reid, M. C., Guan, K., Wagner, F., & Mauzerall, D. L. (2014). Global methane emissions from pit latrines. Environmental Science & Technology, 48(15), 8727-8734. https://doi.org/10.1021/es501549h

Based on literature and discussion with sector experts, a methodology is developed for quantification of methane across sanitation service chain

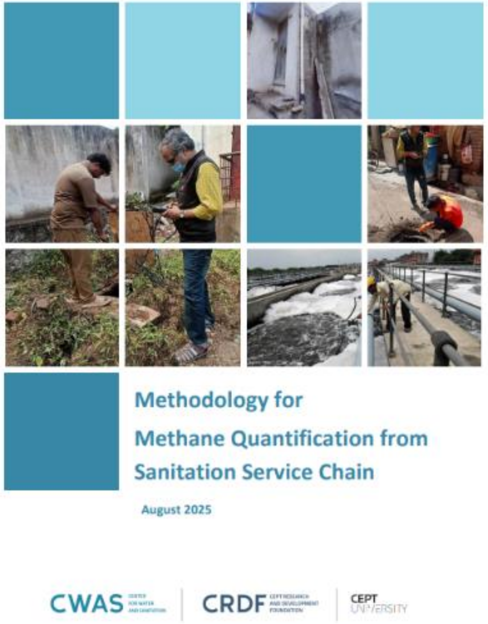
Literature review and learning from SWM sector and others

Discussion with experts



- Academic institutions
- Sector partners and researchers
- Professionals working in remote sensing domain

Methodology Note


Methodology for
Methane Quantification from
Sanitation Service Chain

August 2025

CWAS | CRDF | CEPT UNIVERSITY

Identified various sensors, gas analyser, and laboratories available in the market for quantifying methane

Handholding gas analyzers

- Handheld sensor with electro-chemical methane sensor providing 2 additional gas measurements:
  - CH_4 (methane) , O_2 oxygen) , CO (Carbon monoxide).

Fixed ambient air quality sensors

- Multiple air quality monitoring (P1): 4 Parameters – CH_4, NO, NO_2, Wind speed and wind direction. 300-meter radius monitoring; with active air suction and gas detection
- Single parameter monitoring (P2): CH_4 – 150-meter radius monitoring; with active air suction and gas detection

Lab-based Process

- Identifying laboratories that carry out gas chromatography tests as well as effluent tests
- Biochemical methanation Potential, COD, VSS and more

Flux Chamber

- Flux chambers not available in market
- Exploring the customizable solutions and fabrication of the flux chamber with vacuum suction pump

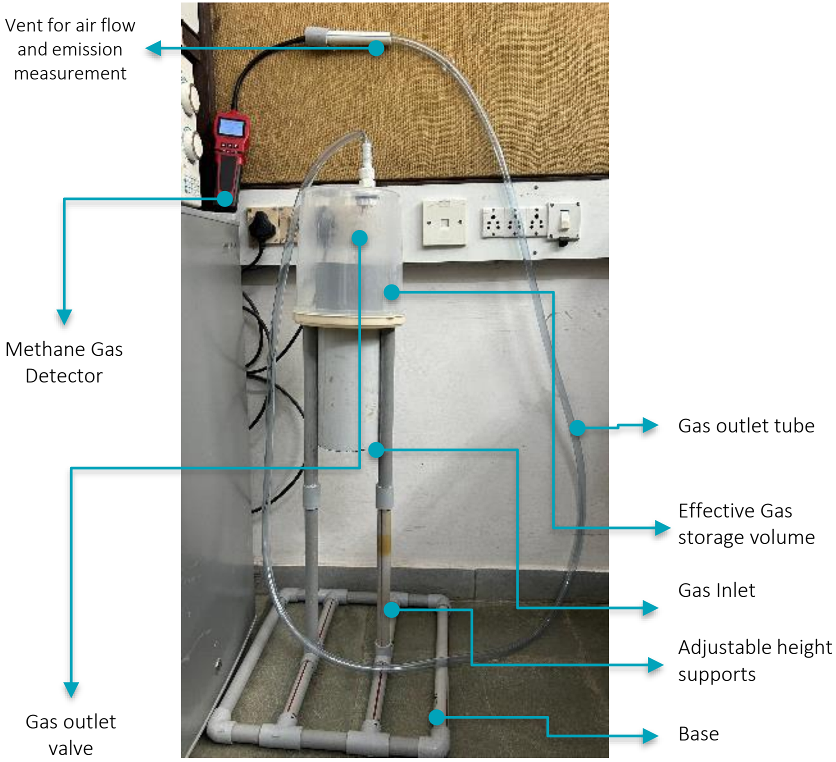
Low-cost sensors

- Testing low-cost methane sensors by validating readings with gas analyzers

Exploring the sensor-based drones for mapping and quantification of emissions through remote sensing- work in progress

In-house flux chamber development

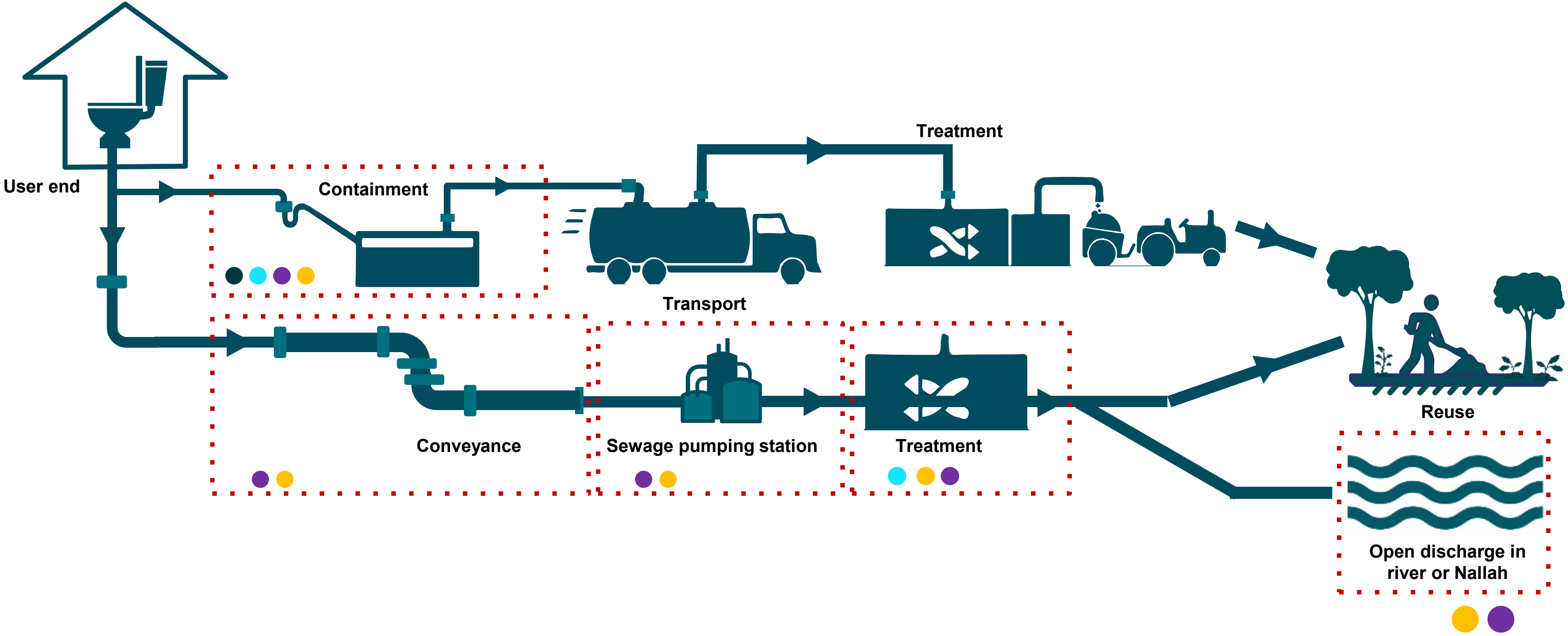
Detachable setup is handy for transport and on field applications



Glimpse during fabrication

Pilot testing

Exploring quantification through gas analyser, flux chambers, low-cost sensors and lab-based testing

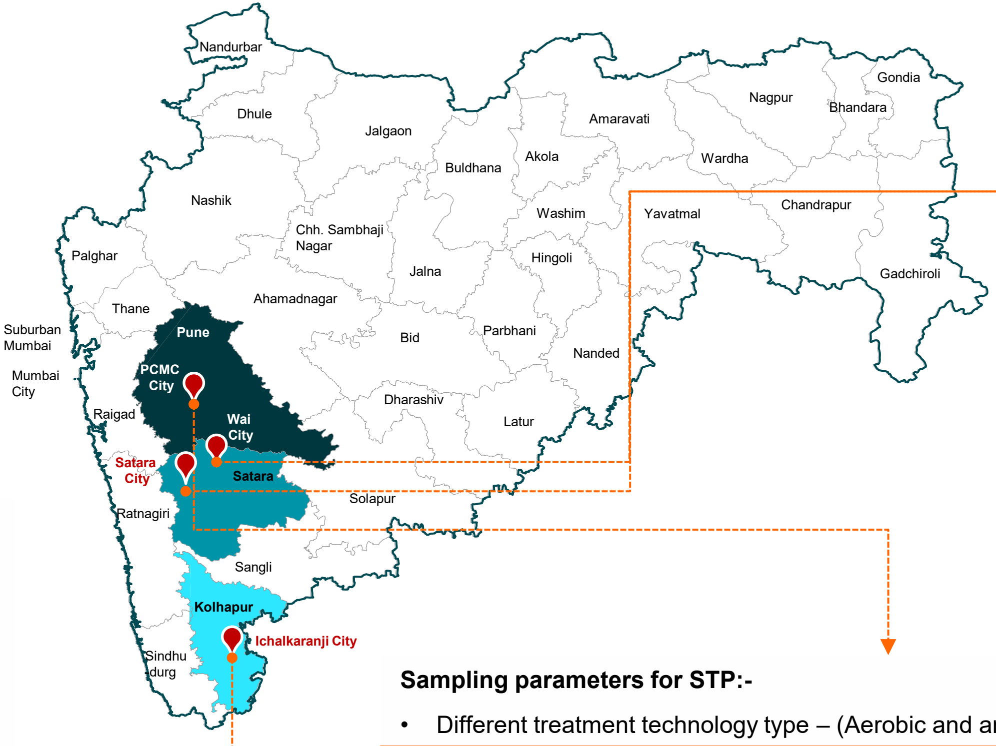


- Portable methane gas analyzer using the stack approach
- Through lab-based effluent and sludge sampling
- Flux chamber and gas analyser
- Through low-cost IoT-based sensor systems

Cities selected for on field emission quantification

Selection of cities based on:

- Sanitation system coverage – (onsite, offsite, combine system)
- Type of sanitation treatment facilities – (FSTPs, STP - (anaerobic or aerobic)
- Different operational and management models and conditions of sanitation services provision
- Different climatic conditions



Sampling parameters for Sewage pumping station:-

- Surrounding Land Use
- Chocking frequency and sewer flow
- Elevation (in low-lying areas and with higher slopes)
- Pumping based or gravity based
- Sewer system age
- Maintenance frequency

Sampling parameters for septic tank :-

- Different HHs size.
- Different built typology
- Septic tank dimension and no. of chambers
- Septic tank emptying frequency
- Build year
- Number of toilets in the property
- Number of households connected to the septic tank

Identification of septic tank sample locations to access the difference between various septic tanks having different parameters to access the on field GHG emissions

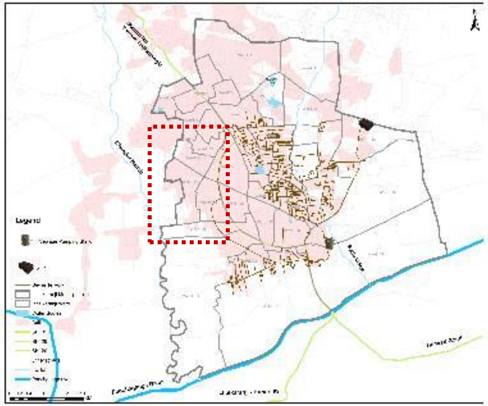
Sampling parameters for STP:-

- Different treatment technology type – (Aerobic and anaerobic).

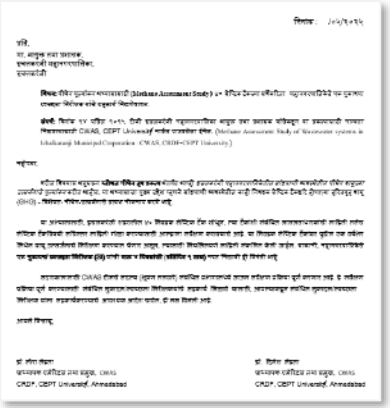
Identification of septic tank sample locations to access the difference between various septic tanks having different parameters. Identification of sampling points at STP (aerobic technology), pumping station and sewer network sample locations to access the on field GHG emissions

Inventory of Septic tank survey, maintenance hole selection and STP selection on field

1. Identified area with septic tank in a selected cities
2. Prepared a household survey form
3. Conducted a household survey
4. Selection of Household for methane measurement based on survey results
5. Profiling of sewerage pumping station and STPs
6. Taking permission of city officials for measurements at SPS and STPs
7. Started measurements at identified Households, SPS and STPs
8. Analysis of measurement results

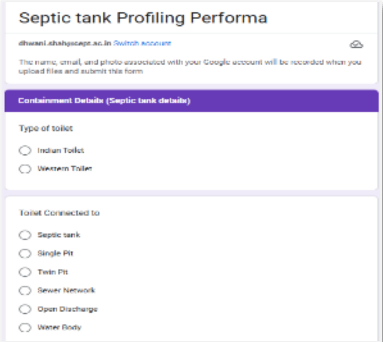


Identified area with septic tank in a selected cities



Permission letter from city officials to conduct study

Prepared a household survey form



Conducted household surveys

Initiated on field emission quantification at Ichalkaranji and Pimpri Chinchwad Municipal Corporation

Quantification from vent pipe of a residential septic tank

Image source: Clicked by CWAS team

Quantification at residential septic tanks connected to drains and soak pit

Image source: Clicked by CWAS team

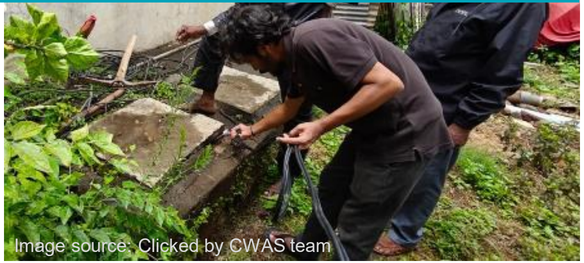


Image source: Clicked by CWAS team

Quantification at Sewage pumping station (wet well) and inlet chamber of STP

Image source: Clicked by CWAS team

Quantification at Primary Treatment unit - Clarifloculator of STP

Image source: Clicked by CWAS team

Quantification at sludge drying bed of STP

Image source: Clicked by CWAS team

On field methane concentration

Septic tanks and other containments

Different impacting factors –
Climatic conditions, water usage, septic tank condition, sludge condition dried or fresh sludge

Sewage Treatment plant

Readings are taken across different components of STPs covering different technologies

Exploring pumping stations and sewer network

Setting up the regime and sampling methodology for pumping station and maintenance hole

Next steps:

- **Continue the activity of quantification of methane emissions for understanding the influence of seasonal variation**
- **Derive the local emissions factor for cities**

Assessing and identifying methane as a resource across sanitation service chain

Quantify methane across the sanitation sector

- On-field emission quantification
- Developing emission factors

Assessing methane as a resource

- Understanding methane potential for different technologies and across sanitation value chain
- Exploring Methane emissions into resource

Assessment of current practices and methane quantification across the sanitation service chain

Landscape assessment of current practices in the sanitation sector

- Mapping best practices and current situation.
- Understanding technical, financial, and operational models of existing STPs

Assessing Market & Potential Model

- Understanding market potential for recovered resource usage.
- Market provider for STPs with methane recovery unit.
- Exploring viable model

Exploring efforts to mitigate methane emissions across sanitation service chain

Exploring scope for strengthening and refurbishment of existing infrastructure

Explore the interlinkages between the sanitation, agriculture, and SWM sectors to enhance the methane capture potential

An array of exploratory approaches to mitigate methane across the sanitation sector

Exploring opportunities to enhance the existing O&M models.

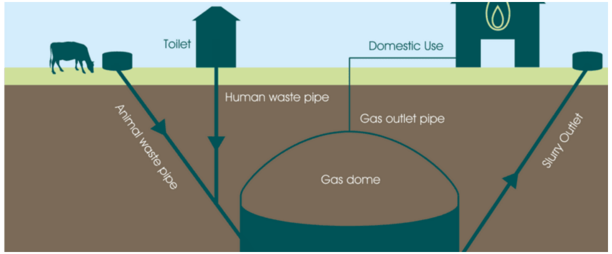
Capacity building and training for operation and maintenance of infrastructure.

Assessing and identifying methane as a resource across sanitation service chain

Resource to Recovery options – At Septic tank (Community level and Household)

Regular septic tank emptying at 3 – 5 years

Reducing the COD and BOD load leading to reduction of methane generation and improving efficiency



Capturing the household level methane gas generated from pit and using it as cooking fuel

Exploring the septic tank level methane capture unit with micro gas scrubber.

Resource to Recovery options – At STP


Image source: Clicked by CWAS team at Delawas STP

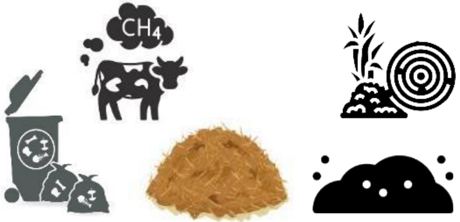
Improving the working efficiency of pretreatment and primary treatment with reducing the mixing of industrial effluent in the domestic used water

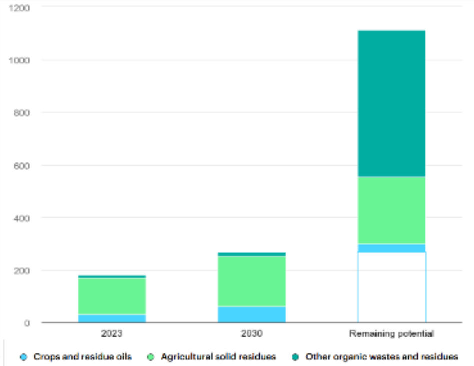

Image source: Clicked by CWAS team at Delawas STP

Enhancing the sludge management process and incorporating the digestor unit for capturing the methane from sludge.

Energy Generation | **Compost Generation** | **Construction Material** | **CNG and cooking fuel**

Resource to Recovery options – Combined with allied sector





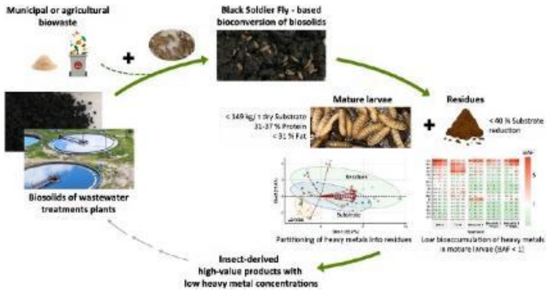
Integrating the different feedstock from different allied sector to enhance the energy generation and gas generation potential

Source: IEA (2025), Feedstock use and potential in India, 2023, 2030 and potential, IEA, Paris https://www.iea.org/data-and-statistics/charts/feedstock-use-and-potential-in-india-2023-2030-and-potential, Licence: CC BY 4.0

CWAS Center for Water and Sanitation | CRDF CEPT Research and Development Foundation | CEPT University | Global Methane Hub

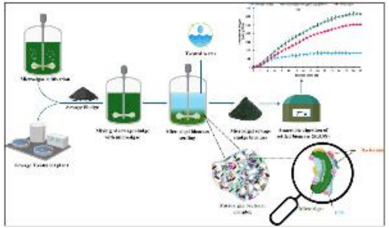
Literature and discussion with partners for enhancing methane as resource

Exploring the bacteria and algae consuming the methane as food for survival



Using Solider flies and fighter flies to reduce the methane emissions from wastewater systems

Source: Bohm, K., Hatley, G. A., Robinson, B. H., & Gutiérrez-Ginés, M. J. (2022). Black Soldier Fly-based bioconversion of biosolids creates high-value products with low heavy metal concentrations. *Resources Conservation and Recycling*, *180*, 106149. https://doi.org/10.1016/j.resconrec.2021.106149



Using algal bloom for enhancing the methane production from the wastewater system.

Source: Tiwari, H., & Prajapati, S. K. (2025). Insights on the use of activated sewage sludge for microalgae harvesting and improved biogas production. ACS Sustainable Resource Management, 2(6), 985–992. https://doi.org/10.1021/acssusresmgt.5c00014

Enhancing the methane potential generation and capture – through engagement with allied sector

Engagement and discussion with sector partners – GERMI and TERI

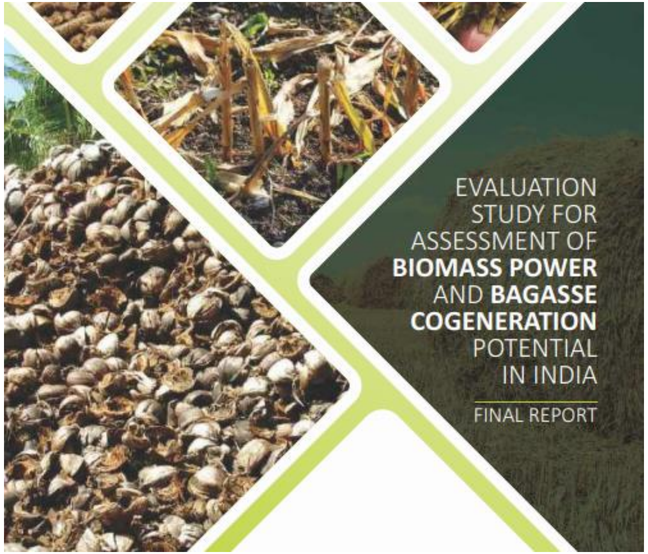


Image Source: Cover page of report Evaluation Study For Assessment Of Biomass Power And Bagasse Cogeneration Potential In India prepared by ASCI published by MNRE, India; 2021

Collaborative research with different institutions working on methane reduction, feedstock assessment and biofuels

Landscape assessment of current practices in the sanitation sector

Quantify methane across the sanitation sector

- On-field emission quantification
- Developing emission factors

Assessing methane as a resource

- Understanding methane potential for different technologies
- Exploring Methane emissions into resource

Assessment of current practices and methane quantification across the sanitation service chain

Landscape assessment of current practices in the sanitation sector

- Mapping best practices and current situation.
- Understanding technical, financial, and operational models of existing STPs

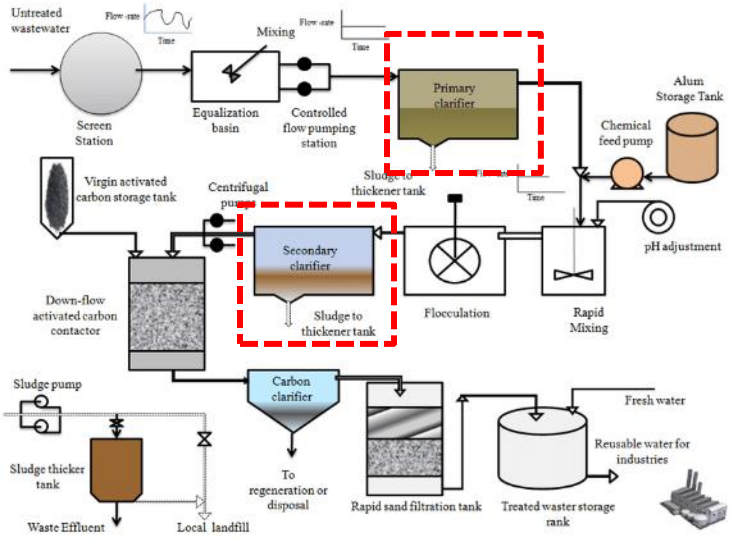
Assessing Market & Potential Model

- Understanding market potential for recovered resource usage.
- Market provider for STPs with methane recovery unit.
- Exploring viable model

Understanding treatment processes to identify affecting factors behind methane generation at STPs is essential

1469 STPs are installed in India out of only **~11 STPs** captures methane

Major technologies contribution	
Aerobic treatment	**Anaerobic treatment**
Activated Sludge Process	Upflow Anaerobic Sludge Blanket
Moving Bed Biofilm Reactor	Waste Stabilization Pond
Oxidation Pond	MBR and FMBR
Aerated Lagoon	Electro Coagulation
Sequential Batch Reactor	



Treatment technology

Tapping wastewater and sludge components of the treatment process and its backward and forward linkages

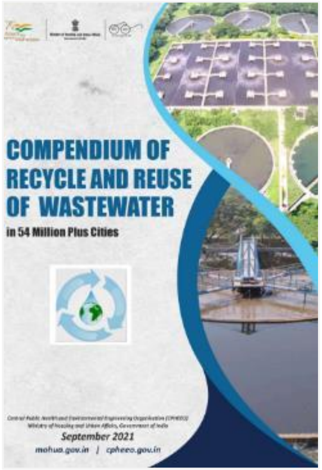
Understand the methane capture potential for the wastewater sector and understand possible business models

Our assessment highlights the need to understand influencing factors such as sludge quality, plant efficiency, reuse market, and governance.

Source: 1. National Inventory of Sewage Treatment Plants June 2020, https://cpcb.nic.in/openpdffile.php?id=UmVwb3J0RmlsZXMvMTIyOF8xNjE1MTk2MzIyX21lZGlhcGhvdG85NTY0LnBkZg==

Landscape assessment and review of existing practices helps to understand the current scenario in India

Local governments have adopted approaches to capture methane from sewage treatment plants (STPs) and Solid waste management(SWM) plants and convert it into a resource



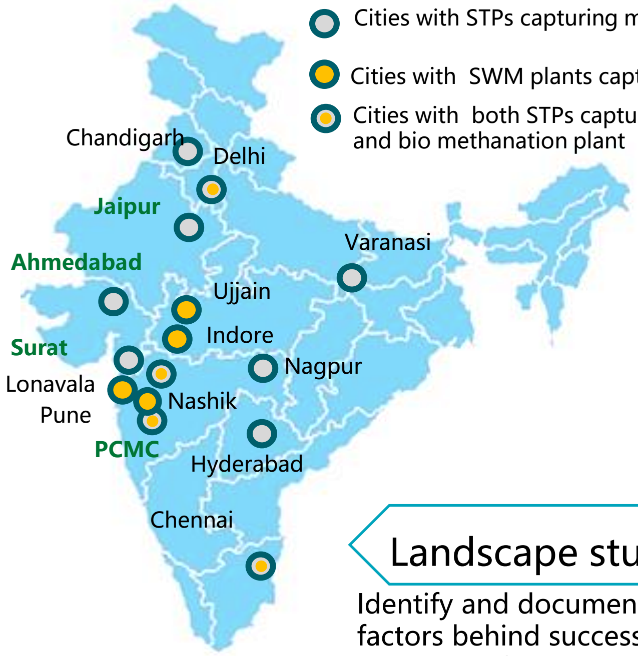
Literature review

Secondary research

REFERENCE LIST

ENVIRO has designed and installed economically viable biogas based power plants for following clients

Power Generation	Plant Capacity	Place	Client
800 KWe	122 MLD STP	Anjana	Municipal Corporation, Surat
1000 KWe	100 MLD STP	Hebbal	Bangalore Water Supply & Sewerage Board
625 KWe	60 MLD STP	Koyambedu	Chennai Water Supply & Sewerage Board
625 KWe	84 MLD STP	Variav	Municipal Corporation, Surat
750 KWe	66 MLD STP	Dindoli	Municipal Corporation, Surat
635 KWe	100 MLD STP	Bamroli	Municipal Corporation, Surat
250 KWe	200 MLD STP	Bhesan	Municipal Corporation, Surat



- Cities with STPs capturing methane
- Cities with SWM plants capturing methane
- Cities with both STPs capturing methane and bio methanation plant

Landscape study

Identify and document factors behind success and challenges faced through site visit....

Challenges

Success

Checklist

The study captures various aspects

1. STP technology and methane capture type

- Types of STP technologies (e.g., anaerobic digesters, advanced AD, biogas upgrading)
- Methane capture methods (flaring, direct use, purification, adsorption technologies)

2. Operational and Contractual Arrangements

- Role and involvement of private operators and stakeholders
- Contract models—value, duration, and risk-sharing
- Funding mechanisms and financing structures

3. Business and Financial Models

- Payment structures and revenue models (e.g., pay-per-unit methane, carbon credits)
- Risk mitigation and allocation (technical, financial, operational)

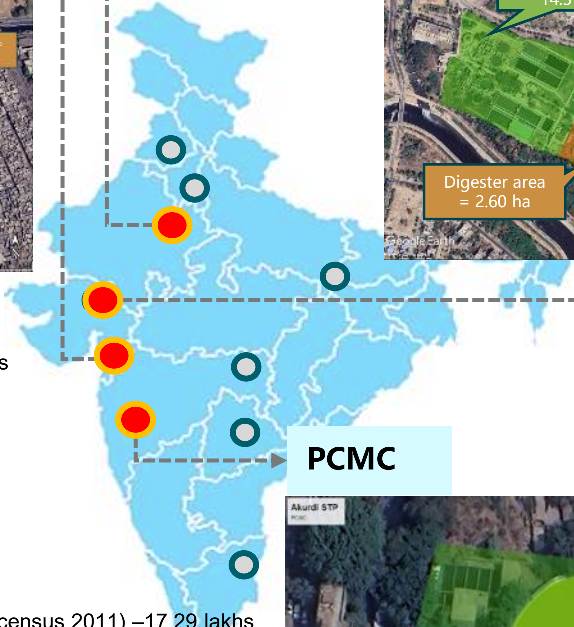
4. Monitoring and Performance Evaluation

- Types of STP technologies (e.g., anaerobic digesters, advanced AD, biogas upgrading)
- Methane capture methods (flaring, direct use, purification, adsorption technologies)

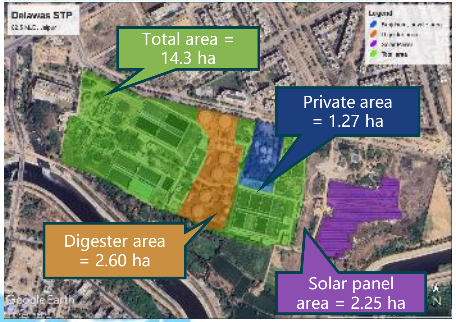
Visited cities STPs with Aerobic treatment technology

Surat

- Population (census 2011) –9.8 lakhs
- Projected population (2023) – 82.32 lakhs
- Water Supply – 1611.3 MLD
- Total Sewage generation –1062.5 MLD
- Sewerage coverage –99.7 %
- Utilisation 100%

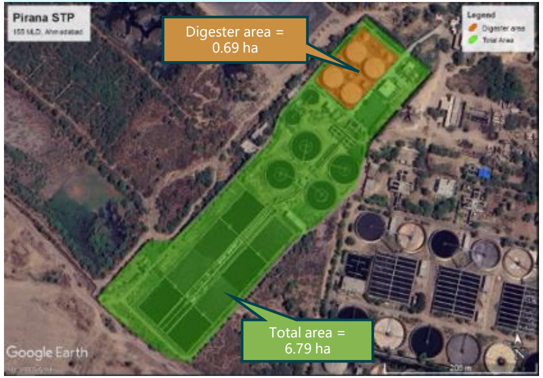


Jaipur



- Population (census 2011) – 30.46 lakhs
- Projected population (2023) – 42.07 lakhs
- Water Supply – 495 MLD
- Total Sewage generation – 400 MLD
- Sewerage coverage – 70 %
- Delwas STP receives about 50 % of the total connected sewage load

Ahmedabad



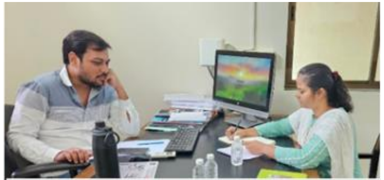
- Population (census 2011) – 55 lakhs
- Projected population (2023) –74 lakhs
- Water Supply – 1750 MLD
- Total Sewage generation – 1363 MLD
- Sewerage coverage – 97 %
- Pirana receives 155 MLD load

PCMC

- Population (census 2011) –17.29 lakhs
- Projected population (2023) – 36 lakhs
- Water Supply – 615 MLD
- Total Sewage generation –492 MLD
- Sewerage coverage –96 %

Majority of STPs use methane as a resource to generate power


Discussion with STP operator


Discussion with Private Contractor


Gas holding Ballons


Discussion with Operators


Combitreat unit with 3 Basins

Aspect	Surat (Aanjana STP)	Jaipur (Delawas STP)	Ahmedabad (Pirana STP)	PCMC (Akurdi STP)
Use of methane as a resource	Electricity generation	Electricity generation For CNG generation- sell it to nearby private buyer	Electricity generation	Electricity generation
Electricity generated and taken from grid	40% from biogas, rest from grid (paid by ULB), Need to pay penalty if used more	17,000 unit/day, 17,415 Unit/day from grid (paid by ULB) -Need to pay penalty if used more	60% from biogas, rest from grid (paid by ULB)	60% from biogas, rest from grid (paid by ULB)
Reuse / Resource Recovery	Sometimes to water the nearby gardens and plants of road dividers, rest disposed to nearby Khadi	Treated water to housing colony; sludge reused	Treated water sold to industry @ ₹10/MLD	Treated water reused internally (not sold)
Benefits	• Significant **energy cost savings** through in-house power generation • Promotes **resource recovery** and partial usage of non fossil fuel-based energy in operations • Penalty clauses helps ULB to track the performance of private			

Next steps:

- Conduct visits to other case studies
- Understanding current engagement models towards operation and resource recovery – Analysing its success, gaps and challenges

Way forward

Quantify methane across the sanitation sector

- Continuation of on field methane quantification activity and initiation of lab testing
- Validating the estimations with existing theoretical estimates
- Derive local emissions factor for cities

Assessing and identifying methane as a resource across sanitation service chain

- Identify methane capture/ mitigating options at septic tanks/ pumping stations/ STP
- Enhancing the potential of methane as resource

Landscape assessment of current practices in the sanitation sector

- Understanding other practices and exploring the opportunities for improvement
- Developing different pathway solutions for sanitation sector to move towards sustainability

Assessing Market & Potential Business Model

- Understanding the private service providers perspective
- Exploring viable model and creating enabling environment for backward and forward linkages
- Developing resource material for decision making

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Thank you

About us

The Center for Water and Sanitation (CWAS) is a part of CEPT Research and Development Foundation (CRDF) at CEPT University. CWAS undertakes action-research, implementation support, capacity building and advocacy in the field of urban water and sanitation. Acting as a thought catalyst and facilitator, CWAS works closely with all levels of governments - national, state and local to support them in delivering water and sanitation services in an efficient, effective and equitable manner.

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