Fabrication of bio-digester for rural villages to convert organic and food waste into energy

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Submitted By:

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Final Project Report of Unnat Bharat Abhiyan

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Project Information	
Title of the Project	Fabrication of bio-digester for rural villages to convert organic and food waste into energy
Name of the Subject Expert Group	Centre for Research in Environment, Sustainability Advocacy and Climate Change (REACH)
Name of village(s) where project development activities were carried out	Kalivanthapattu
Date of commencement	20.02.2024
Planned date of closure	20.08.2024
Actual date of closure	31.08.2024

Project Progress

1. Description of the project (Technology, Methodology etc.,):

In recent years Food waste is the major problem arises in the environment; India is handling 68.7 tons of food wastes per household. It is proven that food waste occupies major part of the Municipal solid wastes because of the easy disposal in landfills and dumping yards. According to Food and Agricultural organization (FAO),Due to inefficient supply and fragmented food chain nearly 40% of food is wasted in India every year. The current method followed to handle food wastes is and landfills and incineration, though this method will have environment and economic issues. Landfilling method can create leachate under the soil which could easily pollute the quality of water and soil and the releasing of methane is a major greenhouse gas and pave way for global warming which is 84 times more powerful than carbon-dioxide. The usage of fossil fuels and the effect of greenhouse gases (GHGs) on the environment have initiated research efforts into the production of alternative fuels from bioresources. In this context, biogas from waste and residues can play a critical role in the energy future.

2. **Objectives as stated in the project proposal:**

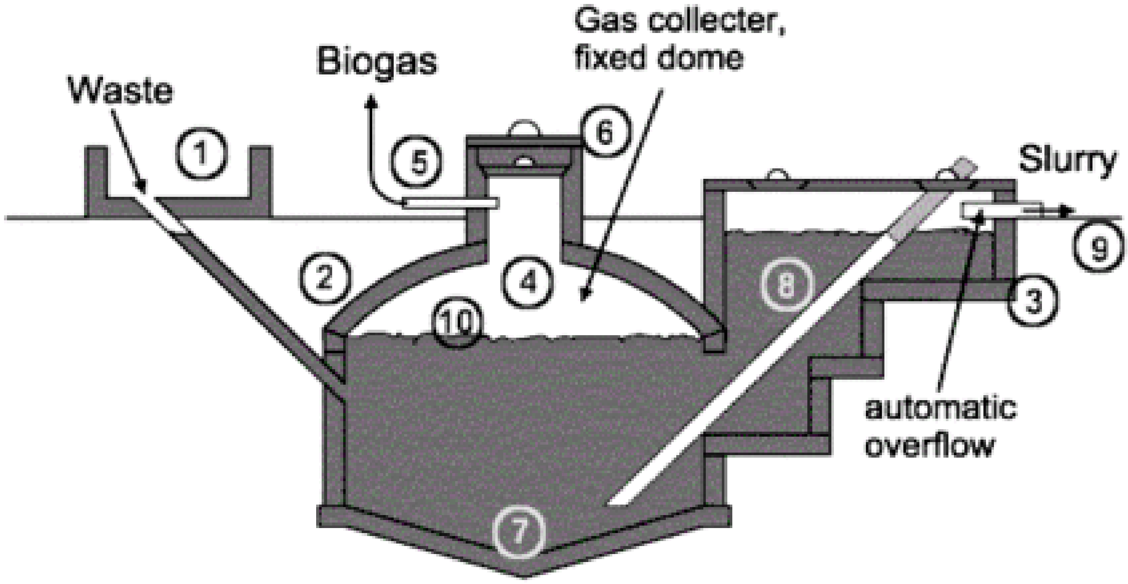
- Bulleted list of objectives, Pls add more rows as required

  - To design a multiphase anaerobic digester for waste treatment.
  - Operational parameters and Additives of the digester should be Identified
  - Hydraulic retention time of the digester should be reduced.
  - To fabricate a bio-digestive stove with methane collection bag.

3. Deviation made from original objectives, if any, while implementing the project and reasons there of:

Nil

4. Design specifications and drawings of the product



5. **Complete details on implementation- methods adopted, data collected supported by necessary table, charts, diagrams &photographs**

Methods Adopted

1. Feedstock Preparation

- **Collection**: Food waste and Vegetable peels was collected from School kitchen, households, and markets. The waste was segregated at the source to remove non-organic materials such as plastics, metals, and other contaminants.
- **Sorting**: After collection, the waste was sorted to ensure that only organic material was used. This included fruits, vegetables, grains, and small amounts of meat and dairy products.
- **Pre-treatment**: The waste was then shredded to reduce particle size, which increases the surface area and improves the efficiency of the anaerobic digestion process. To ensure uniformity, the shredded waste was mixed thoroughly to create a homogeneous feedstock. This step is critical for consistent gas production.

2. Reactor setup

Reactor A: Installation of a 500-liter digester for anaerobic digestion of kitchen waste under mesophilic conditions (35°C-45°C), serving as the control setup without any additives, focusing on biogas production.

Reactor B: Implementation of an experimental 500-liter digester (Reactor B) utilizing nickel as an additive to enhance digestion efficiency, operating under mesophilic conditions (35°C-45°C) with an organic loading ratio (OLR) of 40:60. Nickel addition of 242mg/L coincides with food waste loading.

Reactor C: Deployment of a 500-liter digester (Reactor C) with biochar as an additive to improve digestion performance under mesophilic conditions (35°C-45°C). Biochar addition of 72.6g initiated simultaneously with food waste loading.

Fig. 1. 500 Litres digester installed in kalivanthapattu

Table 1. Feedstock characteristics on day 1

Characteristics	A	B (Biochar)	C (Nickel)
pH	8.03	8.01	7.7
TS (%)	12.3	16.3	17.2
VFs (%)	11.24	17.3	19.5
Moisture Content (%)	81.7	80	84.2

Table 2. Methane production rate of the reactor A on ambient temperature at control stage

HRT	OLR	**CH_4(%)**	m^3	pH	Temperature
1st day	50:50:00	**0**		7.02	32
10th day	50:50:00	**7%**	10.16	5.92	29
15th day	50:50:00	**18%**	26.13	6	29
20th day	50:50:00	**27%**	39.20	6.45	35
25th day	50:50:00	**29%**	42.10	5.77	30
30th day	50:50:00	**39%**	56.62	6	34
Mean		**20**		6.19	31.5

Table 3. Methane production rate of the reactor B on ambient temperature

HRT	OLR	**CH_4 (%)**	m^3	pH	Temperature
1st day	50:50:00	**0**		7.04	30
10th day	50:50:00	**9%**	13.05	6.9	33
15th day	50:50:00	**15%**	21.78	6.8	34
20th day	50:50:00	**29%**	42.10	7.3	35
25th day	50:50:00	**44%**	63.92	6.6	31
30th day	50:50:00	**49%**	71.16	8.2	32
Mean		**24.3**		7.14	32.5
SD		**0.20**		0.57	1.87

Table 4. Methane production rate of the reactor C on ambient temperature

HRT	OLR	**CH_4 (%)**	m^3	pH	Temperature
1st day	50:50:00	**0**		7.04	30
10th day	50:50:00	**9%**	13.05	6.9	33
15th day	50:50:00	**12%**	17.42	6.8	34
20th day	50:50:00	**29%**	42.10	7.3	35
25th day	50:50:00	**37%**	53.7	6.6	31
30th day	50:50:00	**44%**	63.9	8.2	32
Mean		**21.9**		7.14	32.5
SD		**0.17**		0.57	1.87

6. Current status of the project

The biogas project has been successfully implemented and is now fully operational. The digester is continuously processing kitchen waste collected from school students, which serves as the primary feedstock. The project has achieved a good yield of methane, confirming the effectiveness of the anaerobic digestion process. The biogas produced is of sufficient quality and quantity to be used for cooking purposes within the school. This sustainable approach not only provides a renewable energy source but also helps in managing kitchen waste efficiently. The system is expected to continue producing methane consistently, ensuring a reliable supply for the school's cooking needs.

7. Pictures from field supporting the claims (Pictures from each stage of the project and each stage of process. They shouldbe substantiated with relevant information explaining the process)

8. Collaboration with NGO's/government/ industry or any other organization, if any – Output and working model

Nil

9. Sustenance of project post completion of the project and handing over

The biogas project has reached its completion phase and has been successfully handed over to the school administration.

To ensure its long-term sustainability, several measures have been put in place:

- Prior to the handover, comprehensive training sessions were conducted for the school staff and designated personnel. These sessions covered operational protocols, maintenance procedures, safety measures, and troubleshooting techniques to ensure smooth daily operations.

- Detailed manuals outlining the standard operating procedures (SOPs) have been provided. These guidelines cover aspects such as feedstock collection, digester monitoring, biogas utilization, and routine maintenance schedules.

- **T**he project includes integrated monitoring tools that allow for real-time tracking of parameters like temperature, pH levels, and gas production rates. This ensures that any deviations can be promptly addressed, maintaining optimal operational efficiency.

- Regular maintenance support has been provided for ensuring that technical support is available for any major repairs or system upgrades in the future.

10. Project completion summary

The biogas project, aimed at converting kitchen waste from school students into a sustainable energy source, has been successfully completed. The project involved the installation and commissioning of a biogas digester that processes organic waste to produce methane, which is now being utilized for cooking purposes in the school.

The biogas system was designed to handle the daily kitchen waste generated by the school. It has been configured to operate efficiently with the specific type and quantity of waste available. Since its implementation, the system has consistently produced a reliable amount of methane. This has significantly reduced the school's reliance on traditional cooking fuels, providing a more sustainable and cost-effective alternative. The project includes a long-term maintenance plan, community engagement strategies, and a financial model to ensure its continued success post-completion. The project not only addresses waste management but also contributes to environmental education and sustainability within the school community. With the completion of this project, the school is now equipped with a functional, eco-friendly energy solution that will benefit both the environment and the students for years to come.

11. Lessons learnt and replicability

- One of the key lessons from this project is the importance of proper waste segregation at the source. Ensuring that only organic waste is collected significantly improves the efficiency of the biogas production process and prevents contamination in the digester.

- The project highlighted the necessity of regular monitoring of parameters such as pH, temperature, and gas output to ensure optimal performance. Implementing a routine maintenance schedule helps prevent any operational disruptions.
- The success of the project was enhanced by tailoring the biogas system to the specific needs and conditions of the school, such as the type of waste produced and the available space. Flexibility in design and operation is crucial for meeting local requirements.

12. Potential scalability of the model

Different School Sizes: The model can be easily adjusted to cater to schools of various sizes. For smaller schools, a compact digester can be installed to handle lower volumes of waste. Larger institutions can implement multiple digesters or larger capacity systems to process higher amounts of organic waste.

Urban and Rural Communities: The model can be scaled up to serve entire communities, particularly in urban or semi-urban areas where waste management is a significant challenge. Community-based biogas plants can collect organic waste from households, markets, and institutions, converting it into energy for communal use.

13. Other relevant information, if any

Nil

Project Impact

1. **Output of the project (activities carried out - Quantity of waste collected etc.,)**

The biogas project has yielded significant results through its daily operations, providing both a sustainable waste management solution and a reliable source of renewable energy for the school.

- The project successfully collects approximately 4 kg of food waste each day from the school's kitchen. This waste, primarily composed of leftover food from students' meals, includes organic materials such as fruit and vegetable scraps, grains, and small amounts of dairy products. This regular and consistent collection process ensures a steady supply of feedstock for the biogas digester.
- The project has demonstrated consistent performance, with daily operations running smoothly. The system's ability to handle the daily influx of waste and produce usable methane on an ongoing basis is a testament to its successful implementation.
- Beyond energy production, the project also serves as an educational tool, teaching students about renewable energy, waste management, and environmental sustainability.

2. **Outcomes of the project (objectives achieved- 1000kg of waste is converted into biogas, 100 kg is converted etc.,)**

- Through theoretical calculations based on the type and quantity of feedstock, the project has estimated a methane production of nearly 180 m^3. While this figure is not an exact measured value, it provides a robust indication of the system's capacity to convert organic waste into biogas.
- The methane produced is of sufficient quality for practical use, with a high enough methane content to be effectively utilized as a cooking fuel. This reflects the system's efficiency in maintaining the necessary conditions for optimal biogas production.
- The methane generated is burned daily, providing a clean and sustainable energy source for the school’s cooking needs. This replaces or supplements traditional cooking fuels, contributing to reduced energy costs and a smaller carbon footprint for the school.

3. **Impact of the project on the adopted villages (Environmental impact -Eg: 200 tons of CO2 mitigated, 1000 L of water saved/year; Economic impact - Eg: INR 1 Lakh is generated from biogas plant/year; Societal impact- Eg: Number of families benefitted; health impact, employment generated, Women brought into workforce etc.)**

By utilizing methane for energy, the project has effectively mitigated the release of CO_2 that would have resulted from the decomposition of organic waste in landfills. Based on the conversion factor, 170 m^3 of methane equates to approximately 240 tons of CO_2 mitigated annually. The biogas produced from this project is being used as a substitute for Liquefied Petroleum Gas (LPG), which currently costs INR 1,200 per cylinder. The project has generated enough methane to tackle the demand on LPG.

The use of clean biogas as a cooking fuel has significantly improved indoor air quality, reducing the health risks associated with traditional biomass fuels. This has led to a decrease in respiratory issues and other health problems within the community.

4. **Cost-benefit analysis of earlier solution vs adopted proposal**

The traditional system provided a simple, familiar solution for both waste disposal and cooking energy.
No Initial Investment: The community did not need to make any significant upfront investments to maintain this system. The installation of the biogas digester and related infrastructure required a one-time investment, covering costs for the digester, piping, and biogas storage facilities. While the initial investment for the biogas system was higher than the cost of continuing with the traditional methods, the long-term savings in fuel costs and waste management make the biogas solution more economically viable. The reduced need for LPG alone results in significant yearly savings that outweigh the maintenance costs of the biogas system.
Environmental Impact: The biogas system offers a substantial reduction in greenhouse gas emissions compared to the earlier solution, aligning with global efforts to combat climate change. It also reduces environmental degradation associated with landfills.

5. Other information, if any

Nil

Financial position

S. No	Budget Head	Funds Sanctioned	Expenditure	% of total Cost
1	Site preparation cost	15000	15000	
2	Equipment/ Machinery cost	60000	59360	
3	Running cost/ Manpower cost/ Electricity cost	15000	18000	
4	Miscellaneous Expenses	10000	12000	
Total		100000	104360	**100 %**

Did you secure funds from any other source, if yes, please specify the amount and the organization.

Project Feedback

Link of feedback videos of villagers (If any)	
Comments from the SEG	
Comments from National Coordinating Institute (NCI)	
Clarification from Participating Institute (PI)	