International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 2, pp 7-10, February-2025

https://doi.org/10.47001/IRJIET/2025.902002

Design & Development of Waste Management & Energy Conservation

[1]Prof. Shubham A. Kale, [2]Rohini S. Wakare, [3]Yallama B. Karani, [4]Aarti U. Chavan, [5]Neha A. Bhande, [6]Vaishnavi V. Shetake

[1]Professor, DKTE's Yashwantrao Chavan Polytechnic, Ichalkaranji, Maharashtra, India

[2,3,4,5,6]Student, DKTE's Yashwantrao Chavan Polytechnic, Ichalkaranji, Maharashtra, India

***Abstract* - This project focuses on converting organic waste into biogas through anaerobic digestion, providing a sustainable solution for waste management and renewable energy generation. The system efficiently processes biodegradable waste to produce methane-rich biogas for electricity, heating, or cooking, while the byproduct, digestate, serves as organic fertilizer. This approach reduces waste, mitigates greenhouse gas emissions, and promotes energy conservation, offering an eco-friendly and scalable solution to environmental and energy challenges.**

Keywords: Biodegradable Waste, Waste Management, Renewable Energy Generation.

I. INTRODUCTION

Waste management is one of the most pressing challenges in modern society, with increasing amounts of organic and inorganic waste accumulating in landfills. Among the various solutions, converting waste into energy presents a sustainable and environmentally friendly approach. This project focuses on generating gas from waste, particularly biogas, which is a renewable source of energy.

Biogas is primarily produced through the anaerobic digestion of organic waste, such as food scraps, agricultural residues, and animal manure. This process involves the breakdown of organic matter by microorganisms in an oxygen-free environment, leading to the production of methane (CH_4) and carbon dioxide (CO_2). The methane content makes biogas a viable energy source that can be used for cooking, heating, electricity generation, or even as fuel for vehicles.

The hardware design of the waste decomposition system integrates various mechanical and electronic components to facilitate the breakdown of organic material. It includes a crusher to reduce the size of the waste and motors to drive both the crushing and stirring processes. Sensors like ultrasonic, DHT11, MQ4, and moisture sensors are embedded within the system to monitor environmental conditions such as temperature, humidity, and gas emissions.

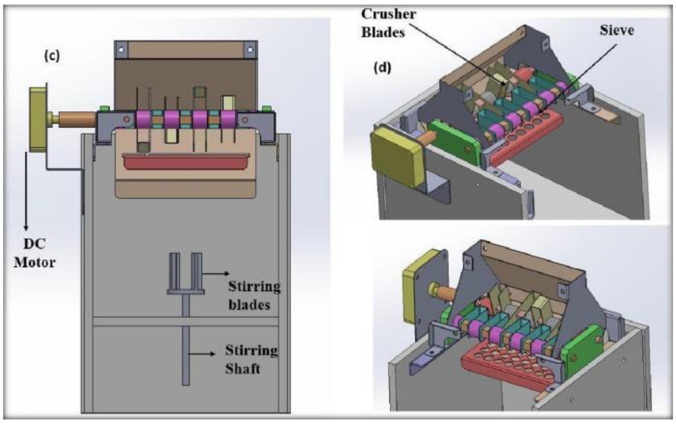

Figure 1: System design

II. METHODOLOGY

1. Waste Input: Organic waste is fed into the bioreactor.

2. Anaerobic Digestion: Microbes break down the waste to produce biogas (mainly methane).

3. Gas Collection & Purification: The biogas is collected and purified to remove unwanted

4. Control and Monitoring: The microcontroller monitors the entire process, adjusting parameters for optimal efficiency, and can display data on an LCD or send it to an IoT platform for remote monitoring.

III. BLOCK DIAGRAM

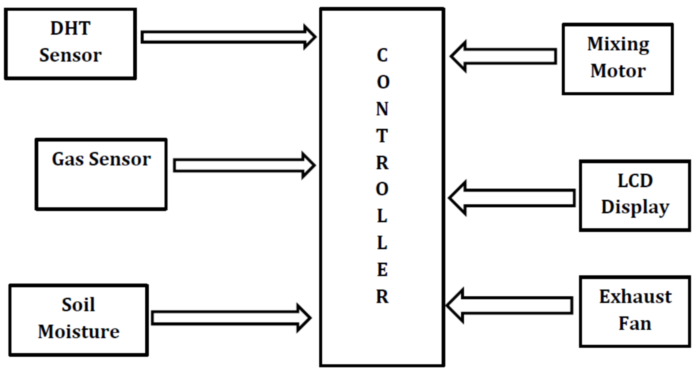

Figure 2: Block Diagram for Waste Decomposition

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 9, Issue 2, pp 7-10, February-2025

https://doi.org/10.47001/IRJIET/2025.902002

IV. WORKING

The working of our project is complete by following process:

1. **Waste Collection and Initial Processing:** The system begins with the collection of organic waste, which is initially placed into a crusher bucket. An ultrasonic sensor is employed to detect the presence of waste within the bucket. Upon detection, the crusher motor is activated, initiating the crushing process. The crushed waste is then directed through a sieving mechanism to separate fully crushed waste from partially crushed fragments. Partially crushed waste is returned to the crusher for further processing; ensuring that only adequately crushed material proceeds to the next stage.
2. **Decomposition Chamber:** The fully crushed waste is transferred to a closed chamber designed to facilitate the decomposition process. The chamber is equipped with a temperature sensor, moisture sensor and methane gas sensor. These sensors continuously monitor the internal conditions of the chamber and the collected data is displayed on a central display board.
3. **Internal Environmental Monitoring and Control:**

3.1 Temperature Regulation:

- Temperature control is crucial for optimal waste decomposition. The system includes mechanisms to address temperature deviations.
- Temperature Decrease: If the temperature falls below a predetermined threshold, a notification. In response, an external heater is activated to raise the temperature.
- Temperature Increase: Conversely, if the temperature exceeds a specified upper limit, a notification. An exhaust fan is then engaged to cool the chamber and stabilize the temperature.

3.2 Moisture Management

Maintaining appropriate moisture levels is essential for effective decomposition. The moisture sensor monitors the chamber’s humidity. When moisture levels drop below the optimal range, the system triggers a water sprinkler to add moisture, thereby ensuring the waste remains adequately hydrated for decomposition.

3.3 Methane Production Monitoring

Methane production is a key indicator of successful decomposition. The methane gas sensor detects the concentration of methane gas generated during the decomposition process. When methane levels reach a significant threshold a notification is sent to a LCD module, indicating the progress of the decomposition process.

The output of our project is biogas which is used for various applications. The application of this project is to produce electrical energy by using the biogas.

V. SCHEMATIC DIAGRAM

The schematic diagram serves as a crucial visual representation of the waste decomposition system, illustrating the interconnections and functional relationships between various components. It provides a clear and concise overview of the system's design, showcasing the flow of waste material and the interaction of mechanical and electronic elements involved in the decomposition process. The diagram typically includes essential components such as the waste input section, crusher, stirring mechanism, sensors, control unit, actuators, compost extraction drawer, and power supply. By delineating how each component operates and communicates with one another, the schematic diagram aids in understanding the operational workflow of the system.

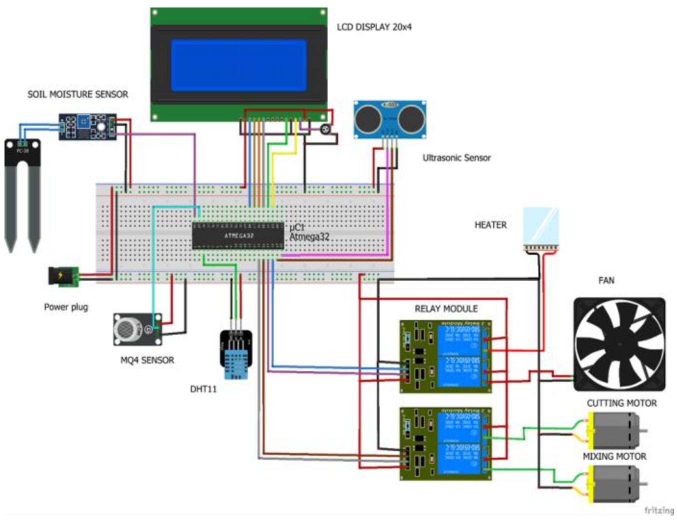

Figure 3: Schematic diagram

VI. ADVANTAGES

a) Environmental Benefits

1. **Waste Reduction:** Reduces the volume of waste sent to landfills, minimizing pollution and conserving natural habitats.
2. **Resource Recovery:** Facilitates recycling and reuse, preserving finite resources.
3. **Energy Efficiency:** Promotes efficient energy use, reducing the carbon footprint.
4. **Pollution Control:** Reduces air, water, and soil pollution through better waste handling and energy-saving technologies.

ISSN (online): 2581-3048
Volume 9, Issue 2, pp 7-10, February-2025
https://doi.org/10.47001/IRJIET/2025.902002

5. **Greenhouse Gas Reduction:** Limits methane emissions from landfills and CO_2 emissions through renewable energy solutions.

b) Economic Benefits

1. **Cost Savings:** Reduces waste disposal and energy bills for organizations and municipalities.
2. **Job Creation:** Generates employment opportunities in recycling, renewable energy, and waste management sectors.
3. **Revenue Generation:** Converts waste into valuable resources like compost, recycled materials, or energy (e.g., biogas, electricity).
4. **Long-Term Savings:** Decreases dependency on fossil fuels and reduces costs associated with environmental cleanup.

c) Social Benefits

1. **Public Health Improvement:** Reduces exposure to harmful waste, improving air and water quality for communities.
2. **Awareness and Education:** Encourages sustainable practices among individuals and businesses.
3. **Community Engagement:** Promotes community participation in recycling and energy conservation programs.

VII. APPLICATIONS

1. **Smart Waste Collection:** IoT-enabled bins for real-time monitoring of waste levels to optimize collection routes, reducing fuel consumption and emissions.
2. **Recycling Plants:** Systems to sort, segregate, and process recyclable materials for reuse.
3. **Composting Units:** Organic waste management solutions to convert biodegradable waste into compost for agriculture.
4. **Waste-to-Energy:** Conversion of industrial byproducts into energy sources like biofuels or biogas.
5. **Heat Recovery Systems:** Capturing waste heat from industrial processes to generate power or heat water.
6. **Zero-Waste Communities:** Projects aimed at diverting waste from landfills entirely through recycling and composting.

VIII. FUTURE SCOPE

1. **Smart waste management.**
2. **Blockchain for Recycling:** Ensuring transparency and traceability in waste collection and recycling processes.
3. **Enhanced Biogas Systems:** Higher efficiency in generating renewable energy from organic waste.
4. **Energy Storage:** Development of high-capacity batteries to store renewable energy for later use.
5. **Smart Energy Systems:** Real-time energy monitoring and demand-side management through advanced sensors and AI.
6. **Cost-Effective Solutions:** Long-term savings for municipalities and industries through efficient waste and energy systems.

IX. CONCLUSION

The design and development of waste management and energy conservation systems is a crucial step toward achieving sustainability and environmental protection. This project addresses pressing global challenges such as waste accumulation, energy shortages, and climate change by integrating innovative technologies and efficient practices. By transforming waste into valuable resources and optimizing energy use, the project contributes to reducing pollution, conserving natural resources, and lowering greenhouse gas emissions. It supports the principles of a circular economy, promotes renewable energy adoption, and enhances the quality of life in both urban and rural communities. This project focuses on transforming waste into valuable resources and optimizing energy usage, contributing to sustainability, reduced pollution, and renewable energy adoption. It supports a circular economy, benefits various sectors.

REFERENCES

[1] Online Available in: Waste to Energy Plants https://pib.gov.in/PressReleaseIframePage.aspx?PRID=1811073.
[2] Online Available in: https://bestcurrentaffairs.com/waste-energy-plants operational-India.
[3] A.Zahedi, "Energy Investigation of feasibility of establishing waste to energy facility in Australia", IEEE Xplore. https://doi.org/10.1109/ICSMC.1994.400281.
[4] International Journal of Creative Research Thoughts (IJCRT).
[5] Gojiya; Dipankar Deb, "On Feasibility of Biomass Power Plant with Agricultural Waste Processing A. Gojiya and D. Deb, Senior Member", IEEE Xplore 17721142 , (2018).
[6] International Journal for Research Trends and Innovation.
[7] International Research Journal of Engineering and Technology.

ISSN (online): 2581-3048
Volume 9, Issue 2, pp 7-10, February-2025
https://doi.org/10.47001/IRJIET/2025.902002

Citation of this Article:

Prof. Shubham A. Kale, Rohini S. Wakare, Yallama B. Karani, Aarti U. Chavan, Neha A. Bhande, & Vaishnavi V. Shetake. (2025). Design & Development of Waste Management & Energy Conservation. *International Research Journal of Innovations in Engineering and Technology - IRJIET*, 9(2), 7-10. Article DOI https://doi.org/10.47001/IRJIET/2025.902002

****