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Bioenergy Generation from Market Vegetable Residues Using Agr-Based Digestion Technology

Operational Study of a Municipal Biogas Facility at Bowenpally

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***Abstract*—Large urban vegetable markets generate substantial quantities of organic residues that require systematic handling to prevent environmental degradation. Converting this biodegradable material into useful energy resources provides an opportunity to address both waste disposal and energy supply challenges. Anaerobic digestion technology enables the controlled decomposition of organic matter in oxygen-free conditions, producing combustible gas and nutrient-rich slurry.**

The present work evaluates the performance of a vegetable waste digestion system operating at a municipal wholesale market. The facility processes approximately 10 tonnes of biodegradable material per day and produces gaseous fuel, electrical power, and stabilized manure. Operational observations demonstrate that organized waste-to-energy systems can reduce landfill burden, improve sanitation standards, and contribute to renewable energy production in densely populated regions.

***Index Terms*—Organic waste utilization, Biogas production, Renewable power generation, Anaerobic digestion system, Bio-CNG upgrading.**

I. INTRODUCTION

Municipal vegetable trading centers are continuous sources of biodegradable refuse generated from unsold produce, trimming losses, and spoiled stock. When this material is disposed of without treatment, it can create odor nuisance, attract pests, and release harmful gases into the atmosphere. Effective processing of organic residues is therefore essential for maintaining hygienic market conditions and protecting environmental quality.

Biogas technology offers a practical engineering solution for stabilizing organic waste while simultaneously recovering energy. Microbial activity inside a sealed digester converts biodegradable matter into methane-rich gas. The recovered gas can be used to operate generators or cooking systems, whereas the digested residue can be applied to soil as a natural fertilizer. Adoption of such systems supports sustainable infrastructure development and reduces dependence on fossil-based fuels.

II. LITERATURE REVIEW

Earlier technical investigations have demonstrated that controlled biological digestion is a reliable method for extracting energy from organic materials such as food scraps, agricultural residues, and market waste. Many municipalities have implemented decentralized digestion plants to manage biodegradable refuse more efficiently and reduce transportation costs associated with landfill disposal.

Studies focusing on vegetable market waste indicate that this feedstock is well suited for digestion due to its high moisture content and rapid biodegradation characteristics. Operational records from similar installations show consistent gas generation and measurable reductions in environmental pollution indicators. These findings confirm the technical feasibility of integrating digestion units into urban waste management strategies.

III. METHODOLOGY

The investigation was carried out by monitoring routine plant activities and recording operational parameters related to waste handling and energy recovery. The overall procedure used in the facility is summarized below.

3.1. Data Sources

Primary Observations - Quantity of incoming biodegradable waste - Volume of gas generated Electrical output from generator units - Daily plant operating conditions

Secondary References - Government technical guidelines - Engineering manuals on digestion systems - Published research studies on renewable energy

3.2. Process Sequence

The transformation of vegetable residues into usable energy follows a structured sequence of operations:

1. Collection of organic waste from market vendors
2. Removal of non-biodegradable contaminants
3. Mechanical size reduction of waste material
4. Mixing of shredded waste with water to create pumpable slurry
5. Retention of slurry inside an airtight digestion chamber
6. Capture and storage of generated gas
7. Withdrawal of stabilized digestate for agricultural use

3.3. Design and Operating Parameters

Parameter	Typical Value
Daily waste feed	10 tonnes/day
Water-to-waste ratio	1: 1
Slurry density	1000 kg/m³
Retention duration	25 days
Daily slurry flow	10 m³/day
Effective digester capacity	250

3.4. Biological Conversion Stages

Organic matter inside the digester undergoes a sequence of microbial reactions that gradually convert complex compounds into methane gas. These stages include:

1. Breakdown of complex organic molecules into simpler components
2. Formation of organic acids from intermediate products
3. Conversion of acids into methane precursors
4. Production of methane and carbon dioxide gases

The resulting gas mixture is collected and directed to power generation equipment, while the remaining material becomes a nutrient-enriched soil conditioner.

IV. RESULTS AND PERFORMANCE EVALUATION

Continuous operation of the digestion unit demonstrates that vegetable waste can be effectively transformed into valuable energy resources. The system minimizes waste accumulation in the market environment and supports local electricity production using renewable fuel.

Average Daily Output

Performance Indicator	Observed Quantity
Organic waste treated	10 tonnes/day
Gas generation	30 kg/day
Electrical energy produced	500–600 kWh/day
Organic manure recovered	1–2 tonnes/day

Operational Benefits

- Decrease in uncontrolled waste dumping
- Generation of locally produced renewable electricity
- Production of soil-enriching organic fertilizer
- Improvement in sanitation and workplace conditions
- Reduction in greenhouse gas emissions

These observations confirm that properly managed digestion facilities can operate reliably under routine municipal conditions.

V. BIO-CNG UPGRADING POTENTIAL

Raw biogas can be refined through purification processes that remove moisture, carbon dioxide, and trace impurities. The upgraded gas, commonly known as Bio-CNG, possesses combustion characteristics comparable to conventional compressed natural gas. This refined fuel can be supplied to transport vehicles, industrial burners, or decentralized power systems.

Implementation of gas upgrading technology enhances the economic value of digestion plants and contributes to long-term energy sustainability.

VI. ADVANTAGES OF THE SYSTEM

- Converts biodegradable waste into useful energy products
- Reduces pressure on municipal landfill facilities
- Generates renewable electricity from locally available resources
- Produces environmentally safe organic fertilizer
- Supports cleaner urban environments
- Encourages circular resource utilization practices

VII. CONCLUSION

The operational assessment confirms that organized digestion of vegetable market residues is an effective engineering approach for managing organic waste streams. The system simultaneously addresses sanitation challenges and energy requirements by transforming discarded biomass into fuel and fertilizer. Expansion of similar installations across urban markets can strengthen waste management infrastructure and promote renewable energy adoption in developing regions.

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