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Sustainable Biogas Production from Banana Waste in India: Experimental and Analytical Study

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ABSTRACT :

India, being a major world producer of bananas, produces significant amounts of banana waste that are posing grave environmental and disposal problems. This research discusses the possibility of utilizing banana waste to produce biogas as an alternate source of renewable energy through anaerobic digestion. Experimental study with a combination of cow dung, banana leaves, and banana peels was conducted to determine Total Solids (TS), Volatile Solids (VS), Fixed Solids (FS), pH fluctuation, and volume of biogas produced over 25 days. The research indicates optimum biogas production on the 15th day of incubation with ancillary solid content and pH corresponding with optimum microbial activity. These results indicate that banana waste can be successfully converted into renewable biogas, supporting energy production and waste management in rural India.

Acknowledgement

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Introduction

India yields about 70 million tons of bananas every year. Such high production generates a vast amount of waste like peels, leaves, and pseudostems. Lack of proper disposal has caused unfavorable environmental impacts. Anaerobic digestion for the production of biogas is a viable way to utilize this waste in the form of renewable energy. Four phases of anaerobic digestion are hydrolysis, acidogenesis, acetogenesis, and methanogenesis. The generated biogas, mostly methane, is recoverable for cooking, heating, electricity production, and use as a fuel for transportation.
This work seeks to explore the viability of utilizing banana waste in biogas generation, evaluate its advantages and limitations, and suggest suggestions for upscaling this solution in India.

Literature Review

Multiple studies have documented the potential of banana waste in biogas production. Kalia et al. (2000), for example, reported greater methane yields from banana stem under thermophilic condition. Tock et al. (2009) reported Malaysia's potential to produce 949.65 MW from banana biomass. Muranga et al. (2011) optimized particle size for digestion of matooke peel, while Jena et al. (2017) recorded 65.28% methane yield from semi-dried banana leaves.

Materials and Methodology

Materials	Quantity Used
Banana peel	600gm

Banana leaves	75gm
Cow dung	225gm
Water used for cow dung	1.5 litre
Water used for banana waste	0.7 litre

Materials Used

Banana peels: 600 g (2-6 mm)

Banana leaves: 75 g (5-8 mm)
Cow dung: 225 g

Water: 1.5 L (cow dung), 0.7 L (banana waste)

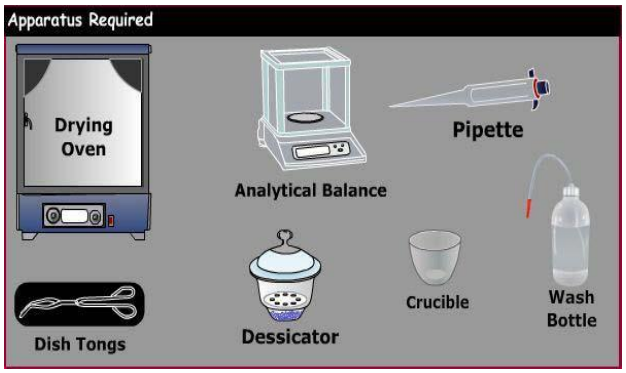
Experimental Setup

A 5-liter airtight container was utilized. An IV set attached to a tube harvested biogas formed. A hole for sample collection was covered with a plastic pipe. All the joints were covered with M-seal and adhesive to avoid leakage.

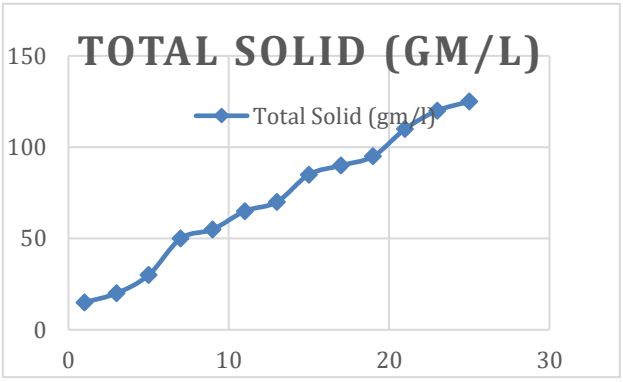
Laboratory Tests

Total Solids (TS)

TS was tested every alternate day. It rose consistently from 15 g/L (Day 1) to 125 g/L (Day 25), which testified to active microbial digestion.



Apparatus required for "Total Solid" test



Total solid

Days	Total Solid (gm/l)
1	15
3	20
5	30
7	50
9	55
11	65
13	70
15	85
17	90
19	95
21	110
23	120
25	125

The total solid value of slurry are as follows

Volatile Solids (VS)
VS rose from 10 g/L (Day 1) to 85 g/L (Day 25), reflecting greater biodegradable content.

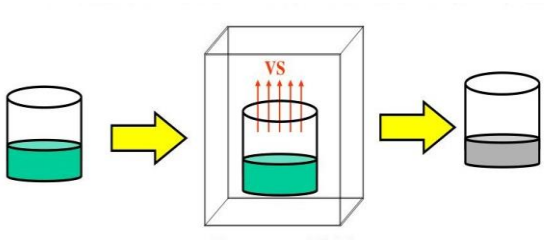
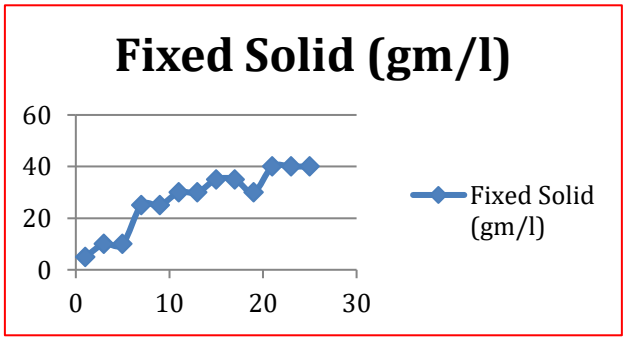


Figure : Volatile Solid

Muffle Furnace

Sample
Fixed Solids (FS)
FS also increased from 5 g/L to 40 g/L, obtained by subtracting VS from TS.



The fixed solid of slurry are as follows :-

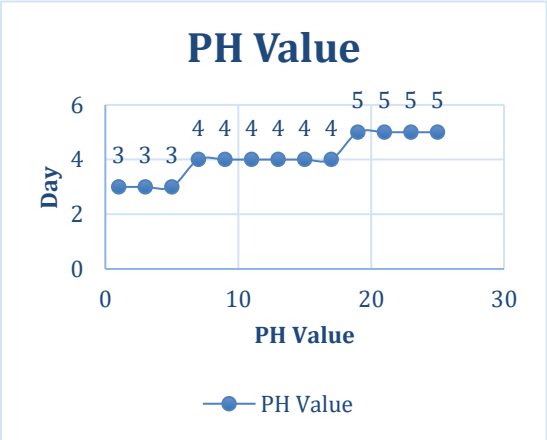
Days	Fixed Solid
1	5
3	10
5	10
7	25
9	25
11	30
13	30
15	35
17	35
19	30
21	40
23	40
25	40

pH Test

pH began at 3 and increased slowly to 5 on Day 25, indicating a more neutral state conducive to methanogenesis.

The PH value of slurry are as follows :-

Day	PH Value
1	3
3	3
5	3
7	4
9	4
11	4
13	4
15	4
17	4
19	5
21	5
23	5
25	5



Biogas Production

Biogas production was quantified through water displacement. The highest production was recorded on Day 15 (16,503.48 cm³) followed by a slow decrease. This is consistent with microbial growth phases.

Conclusion

This research validates the viability of banana waste as a successful feedstock for biogas production. The consistent increase in solids and pH, as well as the pattern of biogas yield, establishes the prospect of anaerobic digestion. Optimization and scaling are areas of concern. The advantages for rural

energy, waste management, and sustainability are great nonetheless.

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