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Energy Recovery from Organic Fraction of Municipal Solid Waste and Food Waste by Anaerobic Digestion

Vaishali Misal, Samir Deshmukh
*Department of Mechanical Engineering Prof. Ram Maghe Institute of Technology and Research (**Amravati** University) Badnera, Amravati Maharastra, India*
Department of Mechanical Engineering Prof. Ram Maghe Institute of Technology and Research (Amravati University) Badnera, Amravati Maharastra, India
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Abstract: Food and Municipal waste is the single largest component of the waste stream by weight. These organic wastes needs to be managed in a sustainable way to avoid depletion of natural resources, minimize risk to human health, reduce environmental burdens and maintain an overall balance in the ecosystem. Anaerobic digestion is a promising technology which could effectively address the problem of waste disposal yielding valuable outputs like biogas and fertilizers. Anaerobic digestion of a mix of food, Cow dung, and Municipal waste and Mix wastes has been carried out in a 20-liter digester within 14 weeks. The wastes were an aerobically digested in an anaerobic digester at ambient temperature. The objective of this paper was to study the performance of the anaerobic process used food, Cow manure, Municipal waste and Mix wastes as substrates in a four digester for biogas production .And comparing yielding rate in four reactor. The feed consisted of food, Cow manure, Municipal waste and Mix wastes were collected from a traditional market. The total waste weight was 250 gm, mixed manually once in the feeding. pH in the range of 6.8-7.4 and temperature of 28-46°C. The gas generated is clean and smokeless can be effectively used for different energy application. The sludge remaining after the digestion has good manorial value.From the observation Biogas produced in four reactor, Cow manure is an excellent substrate for the production of biogas when co-digested with other kinds of waste materials such as organic industrial waste, household waste and sewage sludge.
Keywords: *Biomass, digester, gasification, yield*

I. INTRODUCTION

Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tons of MSW daily. The MSW amount is expected to increase significantly in the near future as the country strives to attain an industrialized nation status by the year 2020. Poor collection and inadequate transportation are responsible for the accumulation of MSW at every nook and corner.The management of MSW is going through a critical phase, due to the unavailability of suitable facilities to treat and dispose of the larger amount of MSW generated daily in metropolitan cities. Unscientific disposal causes an adverse impact on all components of the environment and human health. Generally, MSW is disposed of in low-lying areas without taking any precautions or operational controls. Therefore, MSWM is one of the major environmental problems of Indian megacities. It involves activities associated with generation, storage, collection, transfer and transport, processing and disposal of solid wastes.

Food waste is the single largest component of the waste stream by weight. The food waste includes uneaten food and food preparation leftovers. In light of rapidly rising costs associated with energy supply, waste disposal and increasing concern with environmental quality degradation, conversion of food wastes to energy is a more economically viable solution. AD is a promising technology which could effectively address the problem of food waste disposal thereby yielding valuable Outputs like biogas and fertilizers. Thus AD could be an alternative for processing huge amount of food waste. AD without any pretreatment, but with energy recovery is the most attractive method for treating solid wastes (Last Ella*et al.*, 2002).

Cow manure is an excellent substrate for the production of biogas when co-digested with other kinds of waste materials such as organic industrial waste, household waste and sewage sludge even though its methane yield as a single substrate is low (IEA,2005) . The reasons for its low methane yield as a single substrate are its high water content and high fraction of fiber. However, cow manure serves as an excellent "carrier" substrate during the mixed digestion of wastes and allows anaerobic digestion of concentrated industrial waste, which would be difficult to treat separately (Angelidaki and Ellegaard, 2003).

Municipal solid waste generation: overview

- Approximately 55 million tons of MSW are generated in urban areas of India annually (1.5 lakh tones per day).
- It is estimated that the amount of waste generated in India will increase at a rate of approximately 1-1.33 % annually(http://www.technologyreview.in)
- Every year a total of 4400 million cubic meters of liquid waste (Sewage) are generated in urban areas of India
- The per capita of MSW generated daily, in India ranges from about 200 gm. in small towns to 600 gm. in cities (Collection efficiency is around 70%).
- Municipal solid waste (MSW) includes household garbage and rubbish, street sweeping, construction and demolition debris, sanitation residues, trade and non-hazardous industrial refuse and treated bio-medical solid waste.

Agricultural and food waste generation: overview

- Around 180 million MT of fruits, vegetables and perishables (food stuffs), are produced per year in India.
- However, storage capacity exists only for 23.6 million MT in 5,386 cold storages across the country, of which, 80 per cent is used only for potatoes.
- Around 25 to 30 % of fruits and vegetables and 5 to 7 per cent of food grains in India get wasted.
- Estimated production of fruits and vegetables in India is 150 million tones and the total waste generated is 50 million tones (30%) per annum.

II. METHODOLOGY

Determination of physical and chemical properties The relevant physical and chemical properties of Municipal waste ,food waste ,cow manure were studied by conducting laboratory tests. The purpose of this exercise was to ascertain the suitability of Municipal waste, Food waste, and Cow manure for producing biogas.

Following are the details of the methods used for these measurements.

First the sample of known weight of the Municipal waste, food waste and cow manure and all mixture was taken for the measurement of moisture content, using a moisture meter. Then this procedure was repeated every day for 60 days and the gas yield was monitored and recorded on a daily basis. Several test runs of 60 days duration were conducted round the year.

The following physical and chemical parameters were regularly monitored during the course of the study.

1. Hydrogen ion concentration (pH): - The pH of the reactor liquid was measured every day at 12 noon, while charging the feedstock, using pH meter.
2. Temperature: Daily ambient temperature in the laboratory was recorded at 12 noon.
3. Gas yield: The volume of gas collected at atmospheric pressure was measured using a calibrated glass jar.
4. The biogas generated was checked for its methane (CH4) content on daily basis by flame test. The exact measurement of methane was taken once in each test run on 30th day, using atomic absorption Spectrophotometer.

III. OBSERVATION

Table I: pH Readings.

Sr.No.	Reactors	pH
1	Food Waste Reactor	6.5
	Cow Manure Reactor	7
	All Mix Reactor	6.8
	Municipal Waste	6.9
2	Food Waste Reactor	6.6
	Cow Manure Reactor	7
	All Mix Reactor	6.9
	Municipal Waste	7
3	Food Waste Reactor	6.9
	Cow Manure Reactor	7.2
	All Mix Reactor	7
	Municipal Waste	7.2

The above table shows the pH reading of different feedstock. It was measured by pH Meter in lab once in a day.

Table II: Comparison between Reactors

Days.	Food Waste	Cow Manure	All Mixture	Municipal waste
Day 1	10	10	0	0
Day 2	20	40	15	10
Day 3	30	80	25	15
Day 4	40	120	35	20
Day 5	50	160	45	25
Day6	60	200	55	30
Day7	70	250	65	40
Day8	80	320	80	55
Day9	100	410	100	80
Day10	120	500	150	100
Day11	150	650	200	125
Day12	200	750	250	140
Day13	250	800	300	160
Day14	300	850	350	190
Day15	350	900	400	240
Day16	400	950	450	300
Day17	600	1000	500	400
Day18	800	1200	550	500
Day19	1000	1250	600	600
Day20	1200	1400	750	650
Day21	1250	1500	800	655
Day22	1300	1600	850	660
Day23	1400	1700	900	700
Day24	1450	1800	950	750
Day25	1500	1900	1000	800
Day26	1550	2000	1050	820
Day27	1600	2100	1100	840
Day28	1650	2200	1150	870
Day29	1700	2300	1200	900
Day30	1750	2400	1250	950

Above table shows every day readings in Different reactor. It is found by comparing highest gas yield rate in cow manure reactor.

Table III: Effect of Ambient Temperature on Biogas Generation Rate

Sr.No	Temperature	Different Models	Biogas Generate {Lit/kg}
1	28°C	Food Waste Reactor	200.1
		Cow Manure Reactor	250
		All Mix Reactor	150
		Municipal Waste	148
2	29°C	Food Waste Reactor	200.5
		Cow Manure Reactor	251.5
		All Mix Reactor	150.2
		Municipal Waste	148.1
3	30°C	Food Waste Reactor	205
		Cow Manure Reactor	260
		All Mix Reactor	152
		Municipal Waste	149
4	31°C	Food Waste Reactor	210
		Cow Manure Reactor	270

		All Mix Reactor	155
		Municipal Waste	150
5	32°C	Food Waste Reactor	215
		Cow Manure Reactor	285
		All Mix Reactor	200
		Municipal Waste	155
6	33°C	Food Waste Reactor	225.5
		Cow Manure Reactor	300
		All Mix Reactor	205
		Municipal Waste	200
7	34°C	Food Waste Reactor	235
		Cow Manure Reactor	310
		All Mix Reactor	210
		Municipal Waste	205
8	35°C	Food Waste Reactor	240
		Cow Manure Reactor	315
		All Mix Reactor	215
		Municipal Waste	210
9	36°C	Food Waste Reactor	245
		Cow Manure Reactor	320
		All Mix Reactor	220
		Municipal Waste	215
10	37°C	Food Waste Reactor	250
		Cow Manure Reactor	330
		All Mix Reactor	225
		Municipal Waste	230
11	38°C	Food Waste Reactor	265
		Cow Manure Reactor	350
		All Mix Reactor	235
		Municipal Waste	235
12	39°C	Food Waste Reactor	280
		Cow Manure Reactor	375
		All Mix Reactor	245
		Municipal Waste	240
13	40°C	Food Waste Reactor	300
		Cow Manure Reactor	400
		All Mix Reactor	255
		Municipal Waste	245

Over the range of temperature observed during Experimentation, the gas generation rate was lowest for the range of 28 °C–32 °C and was found highest for the range of 36 °C to 40 °C.

To study the biochemical methane potential of waste

Table V: Methane Produced in Reactor.

Reactor	Methane %
Food waste	65-67
Cow manure	62-65
All mixture	60-62
Municipal waste	50-58

Above table gives the methane potential of different reactor. It is measured by analyzer in PKV Akola .From observation highest methane produced in food waste.

IV. RESULT AND DISCUSSION

Comparison between four reactors

In this section we are going to make a conclusion on the determined experimental value. On the basis of their values we draw the graphs of different feeding material and accordingly measures the Biogas in Measuring Flask.

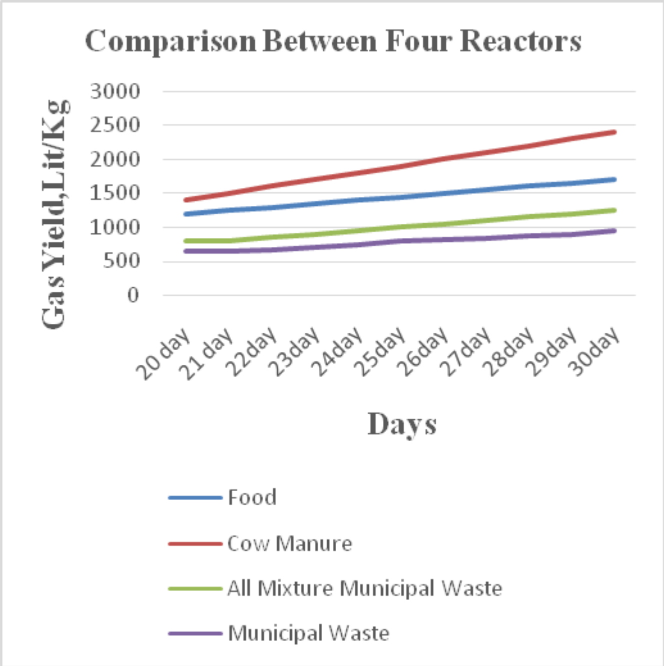

Fig.1 Biogas yield from Food, Cow manure, All mixture and Municipal waste (Lit/Kg)
Graph Shows per day generation of biogas from observation cow manure gives maximum value.

Effect of ambient temperature

The biogas generation rate was found to be dependent on the ambient temperature.

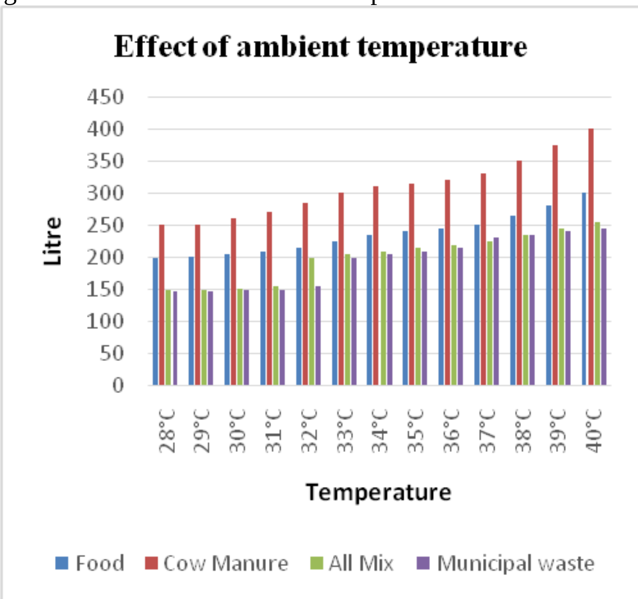

Fig.2 Effect of ambient temperature on biogas yield

Above graph shows the biogas generation rate was found to be dependent on the ambient temperature. Over the range of temperature observed during experimentation, the gas generation rate was lowest for the range of 28 °C–32 °C and was found highest for the range of 36 °C to 40 °C.

Nutrient value of slurry and sludge after decomposition

Any composed organic material ,which has high percentage of primary nutrients like nitrogen ,phosphorus and potassium along with other secondary and tertiary nutrients can be used as organic manure. Availability of good quality organic manure which helps in sustainability soil fertility is an important reason behind popularity of biogas plant in India. Carried out analysis of digested slurry of different feedstock.

Constituents	Decomposed food (%)	Decomposed Cow dung (%)	Decomposed All mixture (%)	Decomposed Municipal waste(%)
Nitrogen	0.50	1.55	1.09	1.09
Phosphorus	0.15	0.69	0.34	0.34
Potassium	0.43	1.66	0.83	0.83

V.CONCLUSION

The above investigation leads to following conclusions

- The biogas generation rate was found to be dependent on the ambient temperature. Over the range of temperature observed during experimentation, the gas generation rate was lowest for the range of 28 °C–32 °C and was found highest for the range of 36 °C to 40 °C.
- With the biogas generation potential of 200–225 l/kg input, biogas required to meet the cooking energy need of one family for one day will be produced by using 8–10 kg of municipalwaste or food waste or cow manure or all mix waste.
- Looking at the availability of Municipal waste, Food waste Cow Manure , in India, it is estimated that Cow manure alone has the potential to generate 72 million cubic meter of biogas, which will be capable of meeting cooking energy requirement of additional 100,000 household in India. The biogas generation can be further augmented by using Food and Municipal Waste.
- Cow manure is an excellent substrate for the production of biogas when co-digested with other kinds of waste materials such as organic industrial waste, household waste and sewage sludge even though its methane yield as a single substrate is low.
- Increase in biogas yield due to co digestion of cattle manure together with waste materials in anaerobic digestion process. Today, co-digestion of different substrate has become a standard technology.

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