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SUSTAINABLE CONVERSION OF KITCHEN WASTES INTO FUELS AND ORGANIC FERTILIZERS

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ABSTRACT

Recent advances in technology and public awareness on waste management intend interest in rapid biodegradation of potential fraction of solid municipal waste into production of biogas and compost other than land filling due to its high rate of decomposition process. Anaerobic digestion has the advantage of biogas production and can lead to efficient resource recovery and contribute to the conservation of non-renewable energy sources. Anaerobic digestion (AD) of kitchen waste has been recognized as one of the best options for treating waste biomass into alternative fuel. Anaerobic digestion is very sensitive to change in pH value and it is important to maintain pH of 6.5-7.5 for healthy system. The temperature of the slurry inside digester and the ambient also affects the anaerobic digestion process. Methane, as main constituent of biogas is taken as the potential source clean energy. The prime objective of this experiment is to utilize the kitchen waste in a floating drum digester to produce biogas which will meet different energy demand. This technology has demonstrated high flexibility in term of feedstock quality and high efficiency in biogas production per ton of waste processed. The anaerobic digestion of Kitchen waste in a floating drum digester reports to obtain biogas 55-60% production which may be used as fuel due to high methane content. In addition, the residue left after digestion may be used as organic fertilizer to soil due to significant content of nitrogen, phosphorous and potassium (NPK).

KEYWORDS: Anaerobic digestion, kitchen wastes, floating drum digester, NPK value.

I. INTRODUCTION

In the era of urbanisation, the rate of energy consumption is rising with an unpredicted rate with each passing day. To meet the growing energy demand, the country has been depending on hydroelectric power and fossil Power. Development of renewable and sustainable energy source is the best solution to the country's energy demands [1]. Biogas is assumed as a green sustainable gas produced by the anaerobic digestion of organic food stocks. It is a renewable energy source, like solar and wind energy. Furthermore, biogas can be produced from regionally available raw materials and recycled waste and is agreed environmentally friendly and neutralising green house effect. Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as kitchen waste, manure, sewage, municipal waste, green waste, plant material, and crops [2]. Biogas comprises potential amount of methane (CH_4), carbon dioxide (CO_2), hydrogen sulphide (H_2S) and and remained amounts of moisture. The gases methane, hydrogen, and carbon monoxide (CO) can be combusted or oxidized with the presence of oxygen (O_2) [3]. This energy release allows biogas to be used as fuel. Biogas can be used as fuel in any country for heating purposes, such as cooking and other more. It can also be used in anaerobic digester where it is typically used in a gas engine to convert the energy in the gas into electricity and cooking [4]. Biogas can also be cleaned and upgraded to other natural and petroleum gas standards when it becomes bio methane.

Anaerobic methenogenesis is a favorable and effective technology at present to produce biogas to meet energy requirements while the organic residue may be regarded as a useful fertilizer. Biogas is a type of renewable energy that can be produced from the decomposition of animal and plant wastes and is composed of methane, carbon dioxide and trace impurities like hydrogen, hydrogen sulphide and some nitrogen [5].

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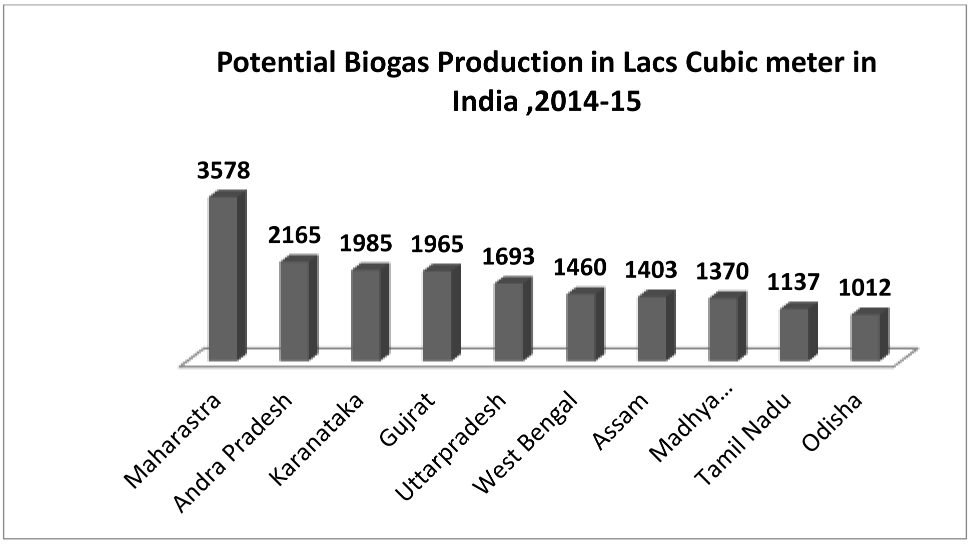
In Indian scenario, biogas can be a substitute for traditional fuels and can meet the rural energy demand and also provide a clean source of energy. It is a renewable energy source and can become a replacement for natural gas and Liquid petroleum gas. Different tests that can help in accessing biogas as a contender for new generation energy source are controlled cooking test, kitchen performance test, boiling test etc [6].



Graph 1 Statistical data of biogas production in India [MNRE]

Based on the nature and skill of feeding biogas plant, it would be broadly divided into 3 types namely batch type which is the one in which the organic waste materials to be digested under anaerobic condition are charged only once into a container which may be called as digester and no more feeding will be there till the end of operation. Semi continuous type in which a predetermined quantity of feed material mixed with water is charged into the digester from one side at specified interval of time say once a day and the digested material equivalent to the volume of the feed flows out of the digester from the other side. The digestion volume remains always constant and third type which is continuous type in which the feed material is continuously charged to the digester with simultaneous discharge of the digested material. Current study deals with the design of an operating and maintenance of the digester for the smooth operation and efficient gas production. The procedure is designed thorough study of the bio digester at different loading conditions. It also deals with the importance of biogas slurry as an organic fertilizer which is a by-product of bio gasification and its utilization. Enrichment and application of biogas slurry as manure.

II. MATERIALS AND METHODS

2.1 Characterization of Kitchen Wastes

The Municipal solid wastes mainly collected in the form of kitchen wastes fed to digester for generating biogas following anaerobic digestion process. Biodegradable waste includes any organic matter in waste which can be broken down into carbon dioxide, water, methane or simple organic molecules by micro-organisms by the action of nature processes.

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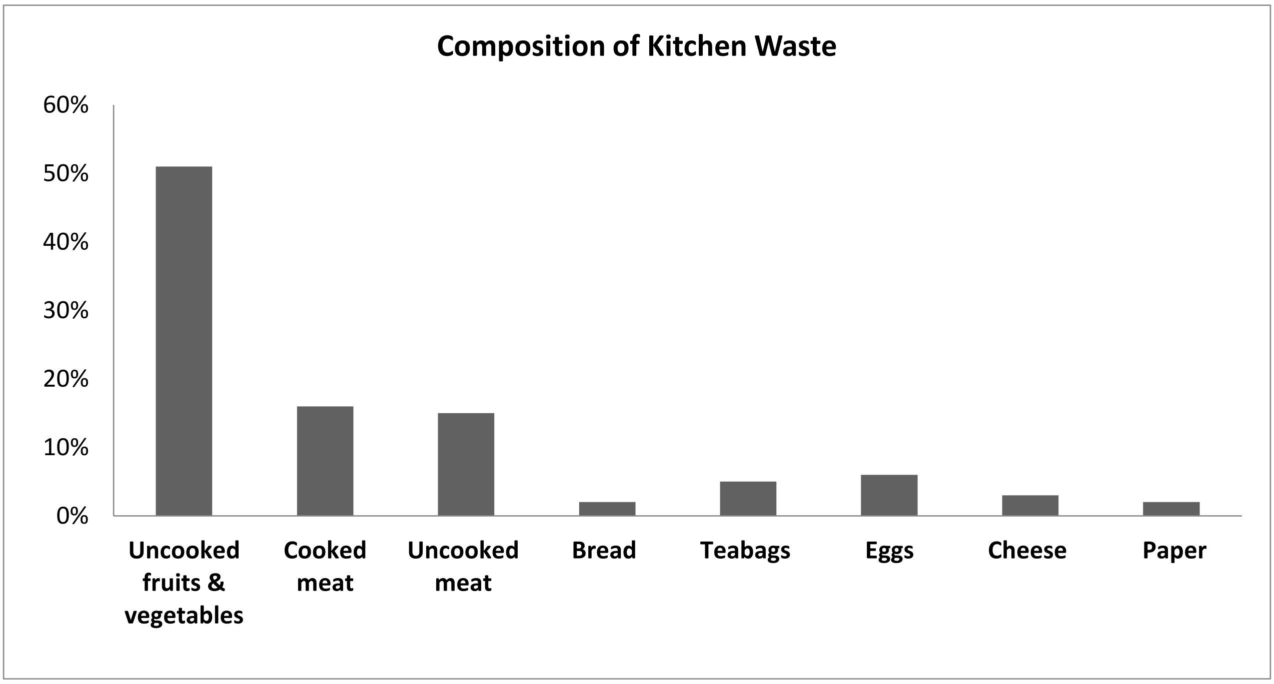
Fig 1 Biodegradable Kitchen waste

Average composition of kitchen waste was analysed on various occasions. Over 50 % of waste was composed of uncooked vegetable & fruit waste. Eggs, raw meat, the main source of pathogens were relatively low in mass at 1.5% & 1.2% also about 15% of cooked meat was found.



Graph 2 Composition of Kitchen wastes

2.2 Composition of Digester Gas

Biogas produced from anaerobic processes is primarily composed of Methane (CH_4), Carbon dioxide (CO_2), with smaller amounts of Hydrogen sulphide (H_2S), Ammonia (NH_3), Hydrogen (H_2), Nitrogen (N_2), Carbon monoxide (CO) and Oxygen (O_2). Due to the high fraction of methane, biogas can be utilized for energy generation. However, because of the contaminants present in biogas, it cannot always be substituted for natural gas in energy generation equipment.

Table 1 Composition of Biogas

Component	Concentration (by volume)
Methane (CH_4)	(55-85) %
Carbon dioxide (CO_2)	(35-40) %
Water (H_2O)	(2-7) %
Hydrogen sulphide (H_2S)	(2%)
Ammonia (NH_3)	(0-0.05) %
Nitrogen (N)	(0-2) %
Oxygen (O_2)	(0-2) %
Hydrogen (H_2)	(0-1) %

2.3 Biogas plant Specification

A floating-drum plant consists of a cylindrical or dome-shaped digester and a moving, floating gas-holder, or drum. The gas-holder floats either directly in the fermenting slurry or in a separate

Fig 2 Biogas plant set up feeding slurry

Water jacket. The floating drum has an internal and external spider guide frame that provides stability and keeps the drum upright as explained in Fig 2. If biogas is produced, the drum moves up, if gas is consumed, the gas-holder sinks back. Floating-drum plants are easy to understand, operate and provide biogas at a constant pressure.

Table 2 Specification of Biogas Digester

Capacity of dome	Height (mm)	Inlet height (mm)	Diameter (mm)	Weight (kg)
1000L	1540	1480	1000	70

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2.4 Sample Specification

The following samples are prepared and fed to the digester under different ambient conditions and the volumes of gas production have been observed. The operating parameters have been adjusted and corresponding gas productions have been reported.

Sample-1

Water	Kitchen Waste	Poultry	Temperature ^{0}C	Humidity	P^H value
8kg	6kg	2kg	38	62%	6.34
8kg	6kg	2kg	42	58%	6.34
10kg	8kg	2kg	43	57%	6.34

Sample-2

Water	Kitchen waste	Cow dung	Temperature ^{0}C	Humidity	P^H value
8kg	6kg	2kg	39	50%	6.4
8kg	6kg	2kg	38	56%	6.4
10kg	8kg	2kg	40	57%	6.4

Sample- 3

Water	Kitchen waste	Substrates	Temperature ^{0}C	Humidity	P^H value
8kg	6kg	2kg	37	60%	6.8
8kg	6kg	2kg	40	51%	6.8
10kg	8kg	2kg	43	50%	6.8

2.5 Anaerobic Digestion

Different containers of volumes to collect the wet waste, stale cooked food, waste milk products. The vegetables refuse like peels, rotten potatoes coriander leaves collected in bags. The digestion process occurring without (absence) oxygen is called anaerobic digestion which generates mixtures of gases. The gas produced which is mainly methane produces 5200-5800 KJ/m^3 which when burned at normal room temperature and presents a viable environmental friendly energy source to replace fossil fuels. Anaerobic digestion occurs inside the digester with certain bacterial fermentation. The entire process of digestion is completed in a sequence of stages like Hydrolysis, Acidogenesis, Actogensis, and Methanogenesis.

III. RESULT AND DISCUSSION

The slurry is being prepared with kitchen waste and water by different proportion and put into the digester for fermentation process. The volume of methane generated around 5kg by the fermentation of 20kg of biomass. The produced biogas may burn continuously 2hrs twice a day with double burner. The experimental analysis is made to calculate the pH value of the slurry, ambient temperature, biogas production rate, methane percentage, etc. The readings are taken in batch production and real time.

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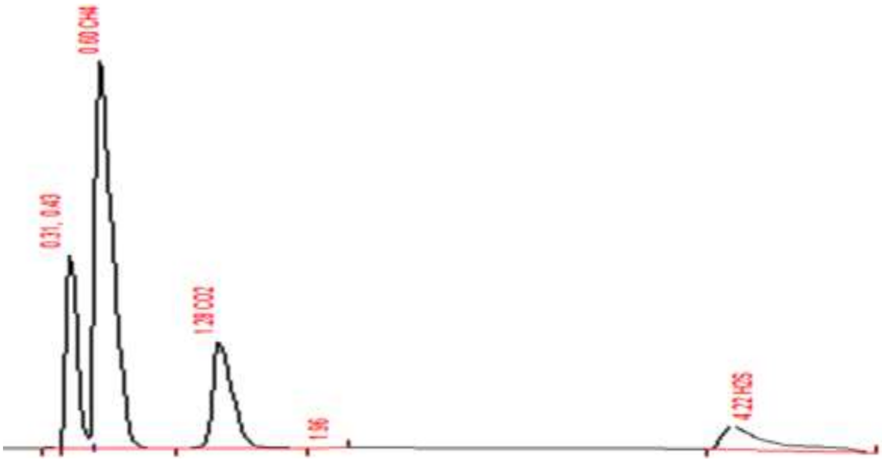
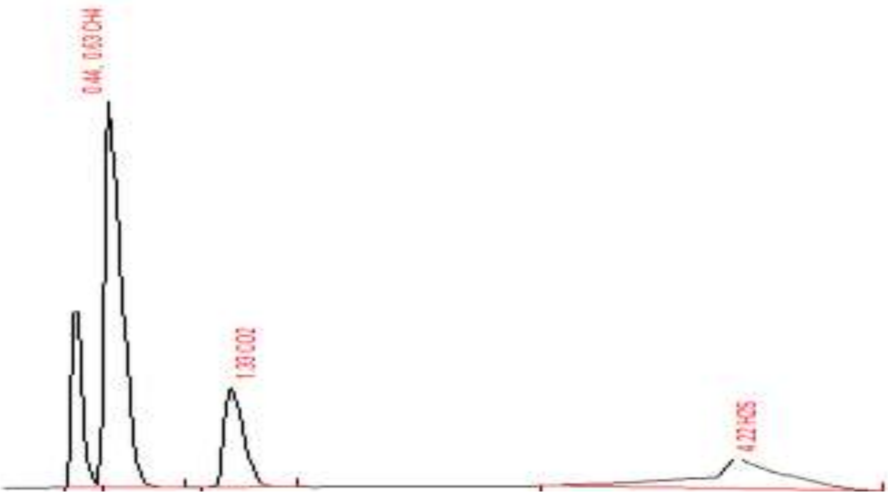
Table 3 Volume of different constituent gases in samples

Constituent	CH_4	CO_2	H_2S	Others
Sample 1	60	24	04	12
Sample 2	67	22	06	05
Sample 3	64	24	08	04

Different samples are taken subjected to different parametric conditions and the gases produced are reported as in Table3. The volume of methane generation is found highest of value 67% and lowest 60% by taking different the samples. The GC-MS test of different samples explained the production of methane in the digester.



Graph 3 Gas Chromatography of Sample 1



Graph 4 Gas Chromatography of Sample 2

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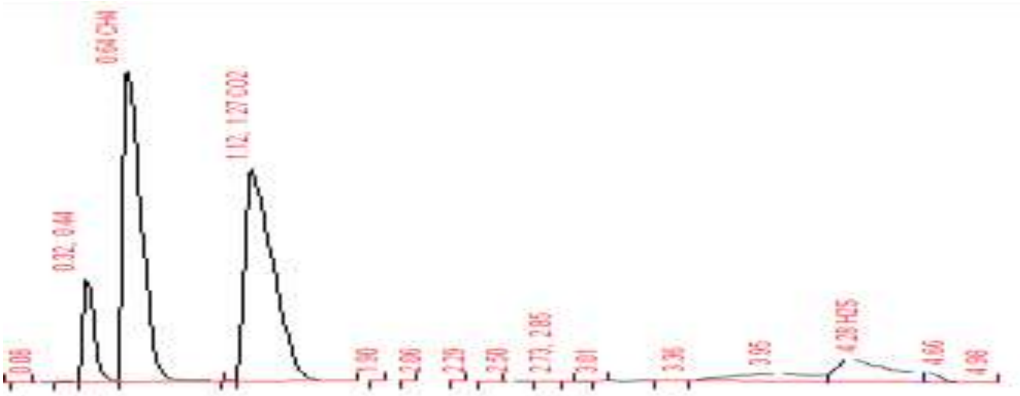
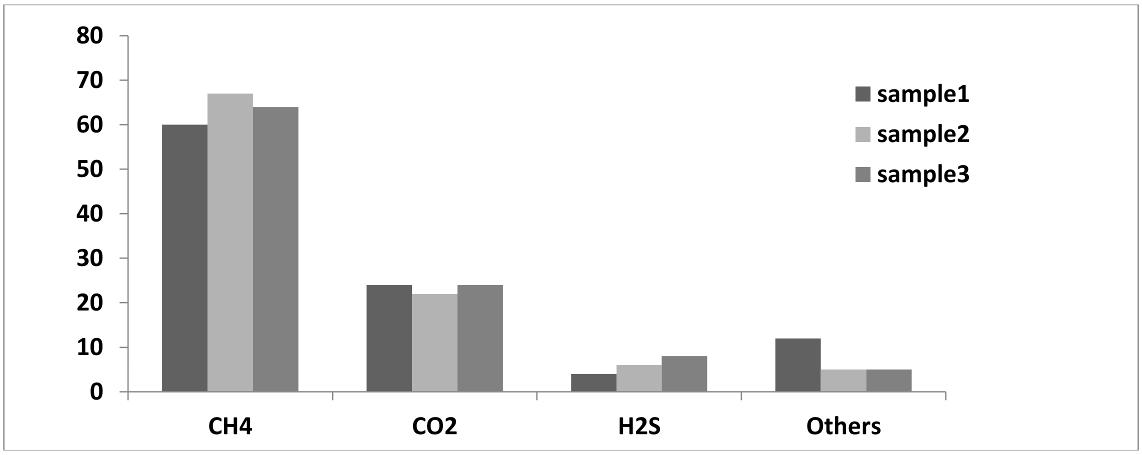


Graph 5 Gas Chromatography of Sample 3



Graph 6 Comparison of volume of Methane content in biogas

The residue left out from the digester is found rich in nitrogen, phosphorus, and potassium, and can be used as a organic fertilizer. Due to the anaerobic digestion of organic matters, these nutrient concentrations were easily taken up by plants. The effluent can be directly used as a fertilizer in farming. The dried effluent could also be used as an adsorbent to remove lead from industrial wastewater. Biogas slurry could be helpful in growing algae, water hyacinth, duck weed, and fish poly-aquaculture.

Table 4 Volume of N-P-K in the residue of samples (liquid)

Constituent	**%N**	**%P**	**%K**	**%Others**
Sample 1	0.384	0.321	0.28	0.015
Sample 2	0.41	0.284	0.24	0.066
Sample 3	0.39	0.32	0.22	0.07

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IV. CONCLUSION

The biogas technology is a promising method for extracting energy from Kitchen waste and the residue left out may further be used as Fertilizer for agriculture. The temperature of the slurry prepared to feed to digester and loading rate also influence for maximum biogas production. The temperature of the digester is significantly changing with ambient conditions. The homogeneity of the slurry is also important for maximizing the volume of gas production. The different samples taken in the floating drum digester and maintained different favorable conditions. The maximum gas production is visualized under suitable parameters.

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