[Nammi, 5(7): July 2018] ISSN 2348 – 8034
DOI- 10.5281/zenodo.1306659 Impact Factor- 5.070

GLOBAL JOURNAL OF ENGINEERING SCIENCE AND RESEARCHES

CO-DIGESTION OF KITCHEN WASTE AND COW DUNG BY ANAEROBIC DIGESTION

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ABSTRACT

In present days the studies on the kitchen waste become the good potential for generating biogas by anaerobic digestion due to the richness in the yield of methane gas through proper procedures. Emerging economic countries like India where kitchen waste is an important concern showcasing both positive as well as negative impact on environmental and especially addressing soil, water, air etc. Anaerobic digestion could become the possible solution to urban and rural environment in multiple folds by the reducing rising garbage problems and at the same time decreasing the input energy requirement. Due to the overpopulation the demand for refinery products like liquefied petroleum gas (LPG) is increasing day by day that leads to the risk of global warming and a shortage of fossil fuels. This stresses our resource system and demands a great development of sustainable and advanced plans for eco-friendly environment. The present paperaims to utilizethe kitchen waste in the GMRIT hostel and cow dung to produce biogas. Experiments were conducted in a 20 litre container with kitchen waste was varied with decreasing from 100% to 60% whereas cow dung was varied with increasing from 0% to 40%. For better digestion, the digester is maintained at room temperature to ensure mesophilic condition and digestion time was around 43200 seconds. Experimental results are finally optimized using MINI TAB software. The optimum value obtained for thekitchen waste was at 60 % and cow dung at 40 % for the maximum production of biogas and the digestion time was 28800 seconds. The optimum values obtained through MINI TAB are purely suitable for GMRIT environment and other premises where cow dung and kitchen waste are abundantly available. This method will best suits for biogas production and for the best utilization of kitchen waste.

Keywords: *Anaerobic digestion, Kitchen waste, Cow dung, Digestion time, Biogas.*

I. INTRODUCTION

Kitchen waste is a global issue according to the Food and Agriculture Organization (FAO, 2011) of the United Nation, nearly 103 billion tons of food is wasted per year globally. Whereas in India 40 % of food produced is wasted and this costs one lakhcrore rupees every year. Disposal of kitchen waste in open dumps causes public hazards (Wang et al. 2016) and diseases such as malaria, cholera, typhoid will be at dangerous spread. Alsoit will emit unpleasant odour and methane which is a major source of Green House Gas (Lee et al. 2010). The mechanism like incineration and pyrolysis are expensive and less capable of recovering energy from the kitchen wastes, due to the facts that the kitchen waste contains a large amount of moisture content (Zhang et al. 2012). Kitchen waste is one form of organic waste which includes not only uneaten food from the sources like canteens, restaurants, and weddings but also the leftover of subsequent material from the processing, storing, food preparation, and management (Almas et al. 2018, Zhang et al. 2007). Kitchen waste contains some typical characteristics such as moisture content 70-90%, volatile solids to total solids (VS/TS) of 82-92%, and carbon to nitrogen (C/N) 14.7-18.1(Zhang et al. 2007 , Zhang et al. 2012, Zhang et al. 2013). Anaerobic digestion enactment is based on the physical and chemical characteristics of organic waste because they rest on biogas production and process stability. The biodegradation of a feedstock is established by biogas and amount of solids that are reduced during anaerobic digestion (Kim et al. 2006, Sagar et al. 2008). However these wastes can be renewed into biogas. Generally organic waste material consists of adequate quantities of the nutrients crucial for growth and metabolism of the anaerobic bacteria in biogas production. Yet, the chemical composition and biological availability of the nutrients contained in these materials vary with species which influences the growth and age of the animal or plant (Cusheng et al. 2013). The anaerobic digestion will be an economical and viable option in solving these issues. The present study is to use the kitchen waste generated from the GMRIT hostels and the cow dung from the nearby farms for the production of the biogas. The optimum percentage for the maximum production of the biogas is determined by varying the percentages of kitchen waste and cow dung respectively.

II. EXPERIMENTATION

2.1 Kitchen waste collection and analysis
The kitchen waste generated from GMRIT hostel was used in this experimentation and for analysis. The waste contains the cooked rice, vegetables and non-used vegetable waste. Nearly 70% of the food waste is consisted of rotten rice, vegetables, eggs, fruits etc. were relatively low in mass. The biological substrates of kitchen waste were separated and converted into slurry using ordinary food processor. Cow dung was collected from a farm near the GMRIT boundaries.

2.2 Description of experimental set-up and Installation:
A 20 litre container is used as a digester which has a small opening acting as inlet. At the top of the bottle a 2 mm aperture is made which is acting as the gas outlet. A gas pipe of the same diameter is placed and sealed well so that the container is leak proof for the gas. The whole setup is used as a batch digester and after the completion of the experiment the contents are removed, cleaned and fresh contents are placed for the next experiment.

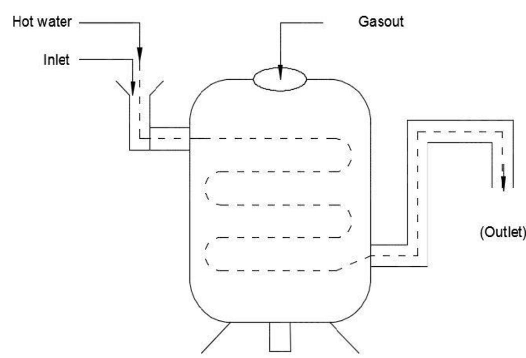

Fig. 1 Anaerobic Digester

2.3 Operating Conditions of the digester:
The digestion should anaerobic to prevent the inclusion of gases.Food waste should be grinded before taking into the digester. Only maximum 40% cow dung should be taken in mixture. Extra water should not be added because decrease in moisture content gives more gas production.

2.4 Start-up procedure of experimental digester (Anaerobic)
A 20 litres volume of container used as a digester of which 50% was effective working volume. Anaerobic digestion batch tests were conducted in a specific volume of kitchen wastes added into digester up to mark of effective volume. Before introducing into the digester the food mixture should be in homogeneous condition as well as least possible moisture content is maintained which decreases the digestion time and increases the gas production. Nearly 5 grams of yeast extract was added for every proportion of food waste and cow dung. Now both the food inlet and outlet valves are closed with the help of stopper also check and close the valve of gas outlet. For accurate outcomes digester should be kept at mesophilic temperature. The digestion time is around 43200 seconds and after the completion of digestion time open the valve of gas and place it in water and bubbles come which indicate the production of gas. Now again the same experiment is to be conducted to check whether the gas is combustible or not. After the completion of digestion, the gas pipe valve is opened and placed against burning wood. The height of flame increases which indicates that the gas is combustible. Till now experiments are conducted only using kitchen

waste in which carbohydrates are major composition. Generally compound waste (mixed) gives better results (in terms of biogas production) but it has taken extra time for digestion and increased reactor volume.Installation of the heating system is an important part of the anaerobic digester. Heating pipes in which warm water flow required to heat all substrate inflow into the digester at 35 C. Adding manure to the digester instantaneously while it is emitted from the animal(cow) will help reduce heating requirements. Various proportions of food waste and cow dung like 100:0%, 90:10%, 85:15%, 80:20%, 75:25%, 70:30%, 65:35%, and 60:40% respectively. The liberation of the gas bubbles indicate the presence of gas which is determined by the water test whereas the syringe method was used to analyze the amount of methane and carbon dioxide in the produced gas.

2.5 Estimation of gas composition:

The following tests were conducted to identify the presence of gases

Water test: Placed the outlet gas pipe in water after opening the valve. The liberation of gas bubbles indicates the presence of gas.

Syringe method: This test is used for the determination of amount of methane and carbon dioxide in the gas liberated.

A 100 ml diluted sodium hydroxide solution was prepared by dissolving granules of NaOH in about 100 ml of water. Take 20 to 30 ml of sample of biogas produced during experiment into the syringe and put end of the tube in NaOH solution then push out the excess gas to get a 10 ml gas sample. Now take 20 ml of solution and retain the end of the tube immersed in the NaoH solution shake the syringe for 30 seconds. Point it down and thrust the extra liquid out, so that syringe plunger level reaches 10ml. Now the read the volume of the liquid which should to be 3-4 ml indicating about 30-40% of gas absorbed which indicates 60 - 65% is methane. Repeat the experiment for 3-4 times consider the obtained results and calculate the average that gives the approximate composition of bio gas.

III. RESULTS AND DISCUSSIONS:

3.1 Performance evaluation for the change in the cow dung percentage:

Using the kitchen waste in the form of slurry the digester gave a constant performance whereas, by introducing the cow dung some changes occurred to enhance its performance. Table1 shows a description of the variation in the digestion time and ignition time with the change in the percentages of kitchen waste and cow dung samples. It can be observed that with the increase in the cow dung percentage the digestion time decreases and the ignition time increases due to the methane production. It can also be observed that the cow dung at 0 percentage has an ignition time of 6 seconds and digestion time of 39600 seconds. The ignition time increased to 11.4 seconds with increase in the cow dung percentage to 40% and the digestion time decreased to 28800 seconds. In all the cases it was observed that cow dung accelerates the rate of decomposition.

Figs. 2and 3 shows the variation of digestion time and ignition time with the change in the cow dung percentage. The digestion time gradually decreased and ignition time increased with increasing the cow dung percentage. A proportion 0% cow dung and 100% food waste sample took a maximum digestion time of 39600 seconds whereas the ignition time was 6 seconds. The digestion time was further decreased to 28800 seconds and ignition time increased to 11.4 seconds for the cow dung and kitchen waste proportion of 40:60%. So increasing the cow dung percentage there was a reduction in the digestion time. This is due to the fast rate of breakdown of organic matter gives more methane yield resulting reduce the digestion time in anaerobic digestion whereas ignition time was increased with the change in cow dung percentage is because of more degradation helps to methane generation.

Tab. 1Variation in co-digestion patterns for the change in the percentage of cow dung and kitchen waste.

Samples	Cow dung (%)	Kitchen waste (%)	Digestion time (seconds)	Ignition time (seconds)
Sample 1	0	100	39600	6
Sample 2	10	90	38520	6.9
Sample 3	15	85	36000	7.2
Sample 4	20	80	34920	8.5

Sample 5	25	75	34200	8.8
Sample 6	30	70	32400	9.2
Sample 7	35	65	28800	10
Sample 8	40	60	28800	11.4

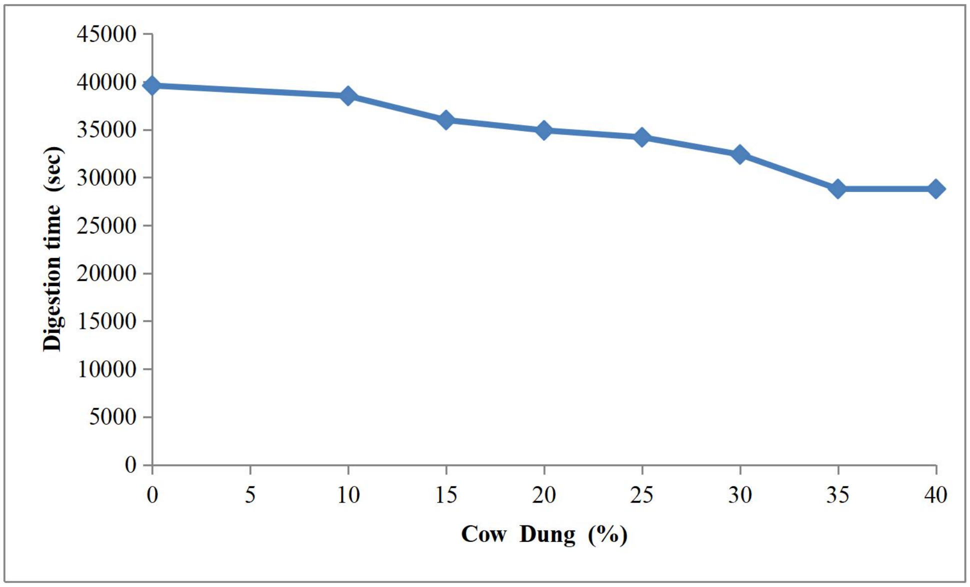

Fig. 2Variation of the digestion time with respect to change in the cow dung percentage

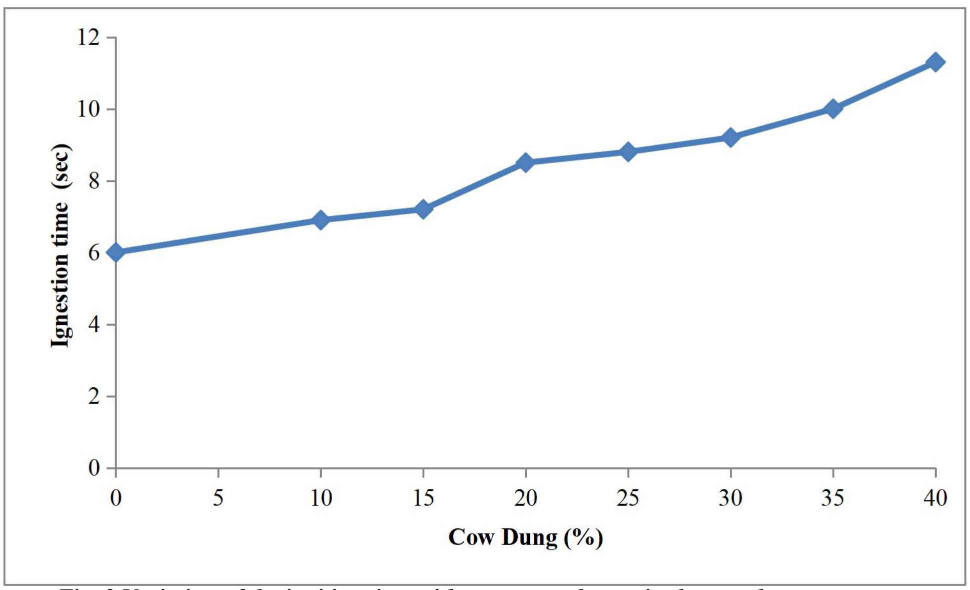

Fig. 3 Variation of the ignition time with respect to change in the cow dung percentage

3.2 Optimization analysis of experimental results using MINITAB

Table 2 shows the experimental values that are entered into MINITAB software by varying three variables such as kitchen waste and cow dung concentration and digestion time.

Fig. 4shows the variation of digestion time with increase in the cow dung and decrease in the kitchen waste percentage. It is confirmed that at digestion time of 37800 seconds maximum methane yield was produced. The most favourable condition to conduct the experiment was at a digestion time of 37800 seconds with appropriate samples consist of the desired percentage of cow dung and kitchen waste and maximum methane production

Fig. 5 shows the contour plots which are used to determine the pictorial representation of cow dung that effects the digestion time. The digestion time decreasing depends on increasing the cow dung percentage due to increase in the methane yield. It means fast reactions take place in an anaerobic digestion by adding Cow dung obtains methane within a small period of time. The methane production rate is comparatively low at 0 percentage cow dungand digestion time 37800 seconds. By increasing cow dung percentage digestion time isgradually decreasing at 25-40% cow dung the optimum digestion time in between 28000-38000sec. The plot proves that cow dung is the major component that affects the digestion time.

Table 2 Results generated by MINITAB software for given input conditions

S.no	Cow dung	Kitchen waste	Digestion time (Seconds)	Ignition time(seconds)
1.	0.25	1	37800	9.2
2.	0.25	0.75	37800	9.4
3.	0.25	0.75	37800	8.9
4.	0.1	0.9	37800	7.3
5.	0.25	0.75	43200	9.5
6.	0.4	0.6	37800	11.4
7.	0.25	0.75	32400	9.3
8.	0.25	0.75	37800	9.5
9.	0.4	0.6	37800	11.6
10.	0.25	0.75	32400	9.8
11.	0.1	0.9	37800	7.6
12.	0.5	0.5	32400	12.4
13.	0.1	0.9	37800	7.5
14.	0.4	0.6	32400	11.9
15.	0.25	0.75	43200	9.3
16.	0.25	0.75	46881	9.6
17.	0.1	0.9	37800	6.9
18.	0.25	0.75	43200	9.3
19.	0.4	0.6	28718	12.1
20.	0.4	0.6	43200	12.2

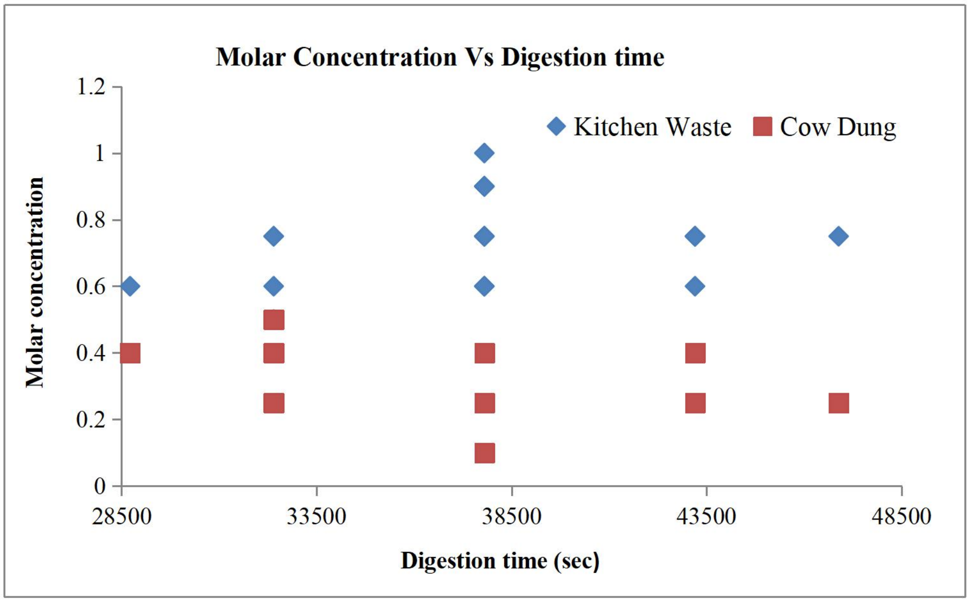

Fig. 4 Variation of digestion time with the change in the molar concentration

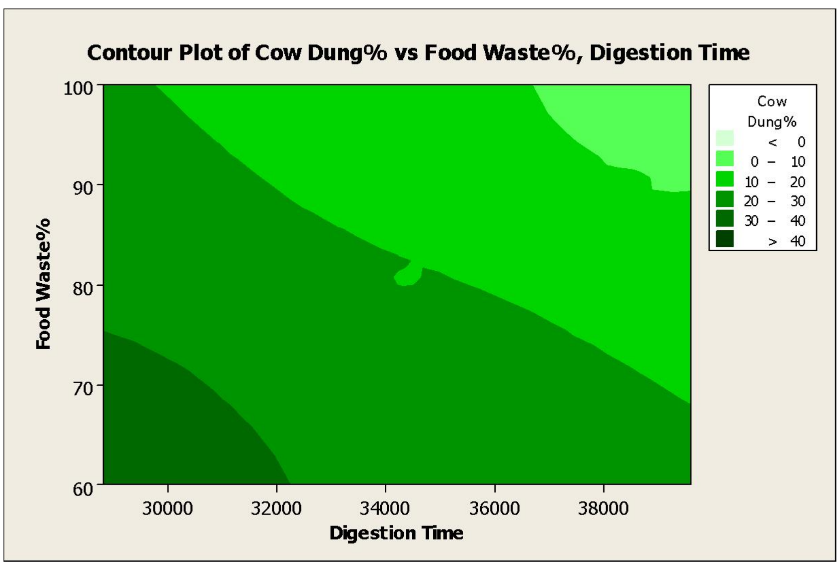

Fig. 5 Contour plot showing the variation of digestion time with respect to the food waste (%) and cow dung (%)

Tab. 3 Final Constituents of Bio-gas Observed are:

S.no	Composition of Bio-gas	Composition in percentage (%)
1	Methane	55-60
2	Carbon dioxide	30-40
3	Nitrogen	2-3
4	Water vapour	0.5

IV. CONCLUSIONS

The feasibility of an anaerobic co-digestion of the kitchen waste and cow dung could make sure the biogas output and methane production. It creates the energy from unwanted material and can reduce the GHG footsteps of kitchen waste by taking carbon-dioxide and methane onsite whereas provide external carbon source complete the generation of Non-traditional renewable energy. Conducting a series of experiments by varying percentages of cow dung ranging from 0 to 40. Results have favoured the ratio of 40: 60 cow dung and kitchen waste for optimum conversion and least possible digestion time. Syringe test results showed that on an average sample consists of 55-60% methane and 35-38% carbon dioxide. On daily basis 2 full capacity LPG cylinders are being used for hostel purpose. By developing the small gas plant with the capacity of 100 kg digester or multiple digesters, we can compensate the use of LPG cylinders.

V. ACKNOLODEGEMENTS

This work was carried out at Grandhi Mallikarjuna Rao Institute of Technology (GMRIT), Rajam Srikakulam, Andhra Pradesh. Boys hostel, we would like to express deep appreciation to our management and staff of GMRIT

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