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Evaluation of Biogas Potential of Students Hostel Kitchen Food Wastes

A. Krishnaveni*, C. Sivakumar, D. Shanmugapriya, S. Shobana, M. Siva and M. Pandiayan*

Agricultural College and Research Institute, Tamil Nadu Agricultural University, Vazhavachanur-606 753, Thiruvannamalai District, Tamil Nadu, India

**Corresponding author*

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A B S T R A C T

The production of biogas from the food wastes is important to recycle it an effective way to avoid mixing of odorous gas in to the atmosphere. The biogas production potential of food waste is higher due to high organic nutrients and starch contents. This researchpaper indicate that the potential of food waste for biogas production. The combinations of kitchen food waste with different ratios of cow dung were involved for the production of biogas production. The result indicated that the treatment containing 100% kitchen food waste alone produced maximum quantity of biogas2877.5 ml for about 60 days when compared to other treatments.

Introduction

The depletion of conventional resources like coal, petroleum, natural gases etc., are in rapid way due to over population and modern life style in urban areas in addition to its prize fluctuation in international market, which positioned us for the exploration of alternated energy sources in an economical way. The wastes are available in different sectors like house hold, hostels, and industries for the production of energy especially for in urban and rural areas. In the World, the alarming problem is pollution because of the different degradable and non degradable wastes from many sources. These wastes are generally managed through land filling orburing in land surface which affect the quality of atmospheric air and groundwater. The general concepts of Recycle, Reduce and Reuse have been generally employed for waste to wealth based on the chemical composition of waste. Peter Wieland (2010) reviewed that biochemical parameter in the feedstock influences the yield of biogas through activity of microbial conversion.

The greenhouse gases emission particularly carbon dioxide is an major issue for global warming, so effective management of waste is essential. In most of cities and rural areas, kitchen food waste is discarded without any treatment for decomposition or otherwise disposed as landfill, which ultimately leads to atmospheric pollution and also public health problems like asthma, diarrhoea, cholera, malaria, typhoid etc., due to inadequate management. The waste dumping sites are breeding place for disease causing microorganisms, flies, rats, mosquitoes and rats. The unbearable odorous gss emitted from the dumping sites leads to global warming.

Based on the need of the fuel cost, there is a demand for the production of energy from different waste for the future use. In our project, we focused on utilizing kitchen wastes for the production of useful biogas. So biogas can be used as an alternate fuel in the engines which cause no harmful emissions as that of other fossil fuels. There are many sources available for gas production, but highly degradable and odorous gas producing kitchen food wastes was taken for this study because the reaction time is faster and easily available. Kitchen waste is organic material having the high calorific value and nutritive value for the microbial reactions. The food wastes have the efficiency of biogas production, which was reported by different scientific workers in different organic wastes for the production of biogas. In India, approximate amount of 1.0 lakh metric tons of different solid wastes and also the per capita waste generation rate has increased from 0.44 kg per day in 2001 to 0.6 kg per day in 2011.

The biogas was different from other renewable energies through utilizing waste as input and also it can be converted into fertilizer in agricultural crop management. Biogas does not require any advanced technological system for its producing from the waste materials and also has no geographical limitations. The biofuels are having greater economic advantage of utilizing for transport rather than power production when compared with other fuel sources with regards to its effect on the environment, finical dependence, and functioning of the plant in Ireland. The optimum amount of feed stock with total solids is essential for biogas production. HilkiahIgoni (2008) reported that the concentration of Total Solids in the Solid Wastes has influenced the pH, temperature and activity of microorganisms during the decomposition process for the production of biogas in an anaerobic continuously stirred tank reactor. The Appropriate Rural Technology Of India (ARTI), developed by Anand Karve (2003) in Pune resulted that the starch and sugar containing food materials viz., spoiled grain flour rotten and over ripened fruits and vegetables, unutilized green leaves and rhizomes, house hold kitchen waste and food wastes etc. were utilized for the production of biogas in the compact system. In this system, two kg of food waste has produced 500 g within 24 hrs, whereas the conventional system of cow dung requires 40 kg for the same amount of gas with 40 days duration. Ravi *et al.*, (2013) compared different ratios of kitchen waste in different materials fabricated biogas plant and then concluded that black painted aluminum materials biogas plant was best for community level biogas production from kitchen waste. Cunsheng Zhang *et al.*, (2014**)** invented that the co-digestion of food waste with waste water enhanced the biodegradation of long chain fatty acids and resulted higher methane yield.

Microbial action during the anaerobic biogas production

During the biogas production the methanogens and acid-producing bacteria will act in the food materials in a symbiotic way through acid producing bacteria create an anaerobic conditions for methane producing to produce methane. In turn the methane producing microorganisms consume the intermediate compounds of the acid producing bacteria because intermediates create toxic to the acid-producing microorganisms Lissens *et al*., (2004) stated that the total biogas yield was increased from available biogas 50% to 90% in the continuously stirred tank reactor containing the waste material and then inoculated with bacteria *Fibrobacter succinogens* to produce the biogas. Kumar *et al.,* (2004) observed the methane emission from solid waste landfills. The review of Cunsheng Zhang *et al.,* (2014) stated that the anaerobic digestion of food waste can produce biogas. Abishek *et al.,* (2015) stated that the biogas from kitchen Waste can carried in anaerobic digester. The production of biogas from fruit and vegetable wastes mixed with different wastes was experimented by Leta Deressa (2015). The biogas quantity was increased with inoculating the microorganism and the anaerobic microorganisms for converting the kitchen food waste to biogas was done by Malakahmad *et al*., (2009). The biogas was produced from different food wastes by Sudha. andSatyanarayana (2012). Potivichayanon *et al.,* (2011) stated that the biogas can be obtained from bakery waste by *Pseudomonas aeruginosa*

Materials and Methods

The study was conducted in Agricultural College and Research Institute, TNAU, Vazhavachanur, Thiruvannamalai, Tamil Nadu during 2019. In this college, there are two hostelsfor both boys(Thenpennai) and girls (Gomuki). In this mess, there are around 300 students are dinning in breakfast, lunch and dinners constitutes vegetarian and non vegetarian items. The discarded vegetable and fruit skin, wasted food materials and other materials were utilized in this study. The treatment follows.

Treatment details

T_1	Cowdung alone 100%
T_2	Kitchen waste alone 100%
T_3	Kitchen waste 50% + Cowdung 50%
T_4	Kitchen waste 75% + Cowdung 25%
T_5	Kitchen waste 25% + Cowdung 75%

Treatment Details		Mixing ratio of different treatments
T_1	Cowdung alone 100%	500 g cow dung + 250 ml water
T_2	Kitchen waste alone 100%	500 g kitchen waste + 250 ml of water
T_3	Kitchen waste 50% + Cowdung 50%	250 g of cow dung + 250 gram kitchen wastes+ 250 ml of water
T_4	Kitchen waste 75% + Cowdung 25%	375 g of kitchen waste + 125 g of cowdung + 250 ml of water
T_5	Kitchen waste 25% + Cowdung 75%	375 g of cow dung + 125 g of kitchen waste + 125 ml of water

The kitchen wastes were collected from the breakfast, dinner and lunch for about 7 days. The collected food wastes were segregated and then dried in Hot airoven @ 120 ^{O}C to get optimum moisture content. The food waste sample was estimated for its pH, EC, Total Solids. The collected waste were mashed through wooden mortar and then filled in different bottles and then closed with rubber cork to create an anaerobic condition.

Estimation of chemical parameters of food wastes

pH

The food waste samples was mixed with distilled water in the ration of 2.5:1 and then fed in the pH meter and then recorded the meter reading

EC

The food waste samples was mixed with distilled water in the ration of 2.5:1 and then fed in the Conductivity Bridge and then recorded the meter reading

Total Solids (TS)

The total solid in the food waste was estimated by 10 gram food waste was taken in the container and heated at 105 ^{o} C and calculated based on the formula and expressed in percentage.

$$TS\ \% = (W1 - W2 / W3 - W2) \times 100$$

W1 –weight of the dried crucible + dried residue

W2-Weight of the crucible (gm)

W3- Initial weight of the wet sample (substrate) + crucible

Estimation of biogas

The biogas was estimated through water displacement method at different stages of anaerobic process. The initial reading was taken through placing the gas tube of anaerobic bottle in to known volume of water containing measuring cylinder. The displacement of water by biogas was observed and then noted the value.

Results and Discussion

The kitchen waste were continuously collected at different session's viz., Breakfast, Lunch and Dinner and presented in Table -1. The biodegradable wastes were collected and weighed (Table -2) .An amount of 162.5 kg of bio- degradable wastes are collected in the students hostel mess for one week. so, it was an excellent source for producing bio gas.

The composition of kitchen waste of then pennai and gomuti hostels was segregated and expressed in Fig -1

From results it has been seen that pH reduces as the process going on as the bacteria produces fatty acids. Here methanogens bacteria which utilize the fatty acids, is slow reaction compare to other so it is rate limiting step in reaction. In T2 which contains kitchen waste (100%) pH decreases highly means

Estimation of biogas

From the result it has been observed that in T_2 which contain 100 % kitchen waste alone produced more biogas @ 2877.5 ml when compare to other treatments. In T_2 with kitchen waste produces average 47 per cent more gas than T_1 (100% cow dung) of 931.5 and 76 per cent more gas than $T_3$683.5 and 77 per cent more gas than $T_4$with 885 ml and 81 per cent more gas than T5 (557.5 ml).

Table.1 Quantity of food wastes collected at different sessions in a week

Date	Day	Komuki girls hostel (kg)			Thenpennai boys hostel (kg)		
		Breakfast	Lunch	Dinner	Breakfast	Lunch	Dinner
23.1.19	Sunday	5	4	3	3.5	3	**3**
24.1.19	Monday	4	6	4.5	5	3.3	**2**
25.1.19	Tuesday	3.5	5	4.5	4	5	**3**
26.1.19	Wednesday	4	6	2	2.5	2	**3.5**
27.1.19	Thursday	5	2	2.5	4	2	**3.9**
28.1.19	Friday	3	7	4	5	2	**2.3**
29.1.19	Saturday	4	6	4.5	4	6	**5**
Total		**= 89.5 kg**			**= 73 Kg**		

Table.2 Quantity of biodegradable food wastes in different sessions in a week

Date	Day	Weight (kg) Gomuki girls hostel	Weight (kg) Thenpennai boys hostel
		Bio - degradable	Bio -degradable
23.1.19	Sunday	12	**9.5**
24.1.19	Monday	14.5	**10.3**
25.1.19	Tuesday	13	**12**
26.1.19	Wednesday	12	**8**
27.1.19	Thursday	9.5	**8.9**
28.1.19	Friday	14	**9.3**
29.1.19	**Saturday**	**14.5**	**15**

Table.3 Quantity of biogas in different inputs in the treatments

Treatment days	Quantity of biogas (ml)				
	T_1	T_2	T_3	T_4	T_5
Day -1	4	16	3	7	5
Day -2	5	22	3.5	7.5	6
Day -3	6.5	25	4	8	8.5
Day -4	6.5	27.5	4.5	8.5	9
Day -5	9	38	6	11	9.5
Day -6	10.5	38.5	8	12	11
Day -7	13	39	8.5	13	12
Day -8	15	40	14	14.5	13
Day -9	18	42.5	16	15	15
Day -10	20	43	16	16	15.5
Day -11	22	43	18	16	17
Day -12	25	44	18.5	17	17
Day -13	28	46	21	17.5	17
Day -14	30	46.5	24	18	18

Day -15	33	48	24	18	18.5
Day -16	34.5	49	24.5	18	19
Day -17	35	49	25	19	19
Day -18	35	50	25	19.5	19.5
Day -19	36	51.5	27	20	20
Day -20	39	52	27.5	22	23.5
Day -21	40	55.5	29	22	26
Day -22	42	58	35	23	28
Day -23	41	60	35	24	29
Day -24	39	61	36	27	29
Day -25	35	63.5	39.5	29	30
Day -26	33	64	33	29	27
Day -27	33	64.5	30	30	22
Day -28	31.5	65	28	32.5	20
Day -29	29.5	66	24	33	19
Day -30	29	66.5	20	35	19
Day -31	29	68	16	33	17
Day -32	24	69	13	31	14
Day -33	21	67.5	11	30	11
Day -34	19	66	7	27	9
Day -35	15	66	3.5	25	3
Day -36	14	65	2.5	23	3
Day -37	13.5	64.5	-	20	-
Day -38	11	64	-	20	-
Day -39	9	63	-	19	-
Day -40	3	63	-	18	-
Day -41	-	62	-	14	-
Day -42	-	60	-	12	-
Day -43	-	58	-	9	-
Day -44	-	57	-	8	-
Day -45	-	53	-	4	-
Day -46	-	51	-	3	-
Day -47	-	50	-	2	-
Day -48	-	49	-	2	-
Day -49	-	48.5	-	2	-
Day -50	-	48	-	1	-
Day -51	-	42.5	-	-	-
Day -52	-	42	-	-	-
Day -53	-	35	-	-	-
Day -54	-	31	-	-	-
Day -55	-	28.5	-	-	-
Day -56	-	23	-	-	-
Day -57	-	17	-	-	-
Day -58	-	15	-	-	-
Day -59	-	7	-	-	-
Day -60	-	4	-	-	-
Total	931.5	2877.5	683.5	885	557.5

T_1-Cowdung alone 100%,T_2-Kitchen waste alone 100%,T_3-Kitchen waste 50% + Cowdung 50%,T_4-Kitchen waste 75% + Cowdung 25%,T_5-Kitchen waste 25% + Cowdung 75%,

Table.4 Changes of parameters in T_2 treatment during anaerobic process

Parameters	Initial day	After a week
pH	7.3	6.1
EC (ds/m)	1.5	1.10
Total Solids (%)	11.9	10.3

Plate.1 Different Methodology involved in production of biogas

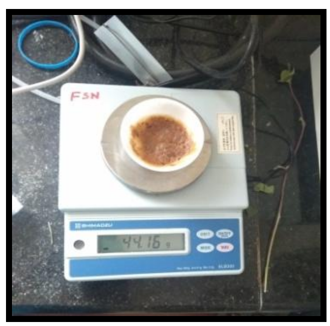
Step -I
Weighing of food wastes

Step - II
Grinding of food wastes

Step - III
Drying the food wastes in Hot air

Step - IV
Estimation of pH and EC

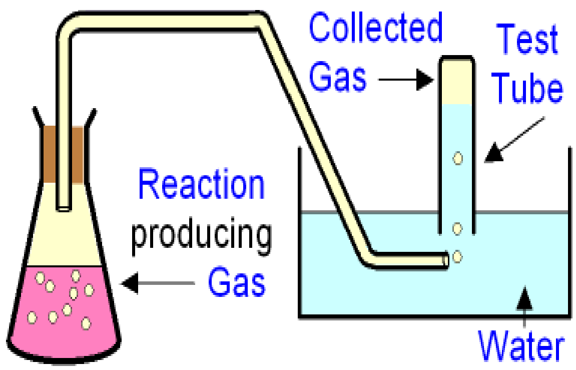
Step -V
Estimation of TS



Step -VI
Filling of food waste in the bottles

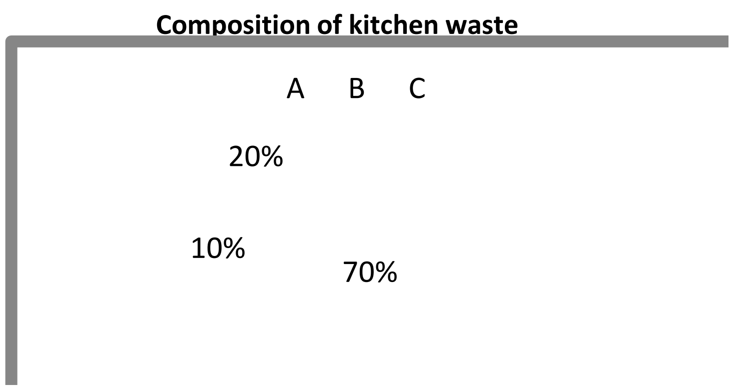
Experimental Set up for Food Solid waste for biogas production

Diagram of gas collection



Confirmation of biogas

Fig.1 Composition in the food wastes collected in the hostel mess at different sessions in a week



A	Cooked food waste
B	Egg shell
C	Rotten Fruits and vegetables

Composition of food waste A	Egg shell B	Composition of Rotten fruits & vegetables C
Pongal	Broken eggs	Rotten tomatoes
Poori	Boiled Egg Shell	Onion peel
Idli	Omlet Egg shell	Banana Peel
Dosa		Potato peel
Vada		Rotten chilly
Rice with sambar		Cabbage leaf waste
Chicken gravy waste		Rotten cucumber

Fig.2 Total quantity of biogas in different treatments

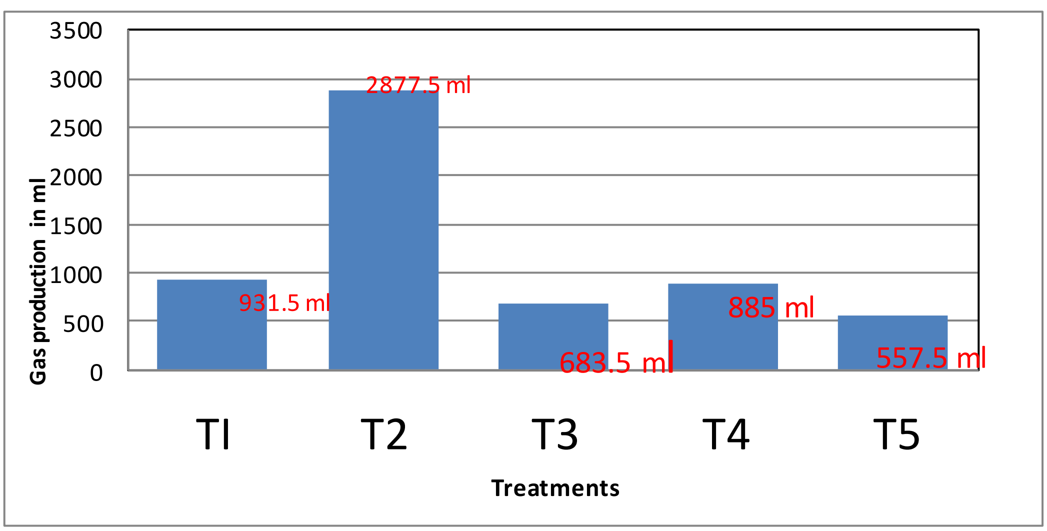
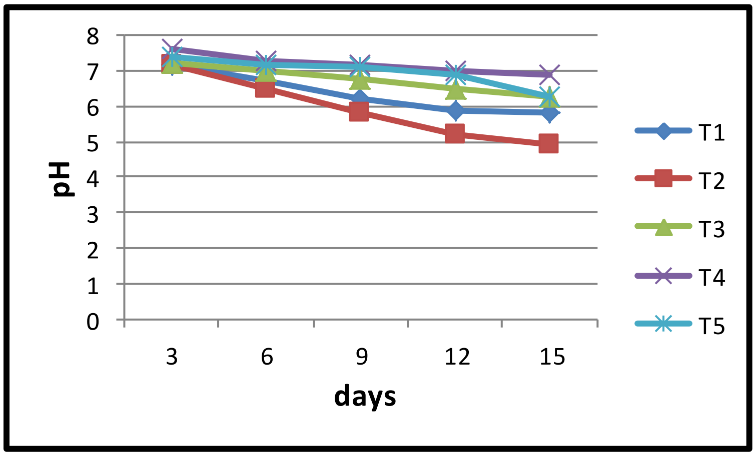


Fig.3 pH and EC variation in the treatments in different days



The kitchen waste produces more gas than cow dung because the kitchen waste contains more nutrients along with carbohydrate than cow dung. The kitchen waste released more biogas compared to other inputs (Table -3).

The finding was similar to that of Srinvasa Reddy *et al.,* (2017) stating that the bio gas was produced from kitchen and food wastes of residential community in Mumbai city suburbs through a fabricated anaerobic digester.

The total quantity of biogas in different treatments were expressed in Fig -2 and initial days up to 15 days for the production of biogas in different treatments were presented in Fig -3.

pH, EC and Total solids

The pH and EC starts decreasing as acid concentration increases in the bottles and pH decreases below 7 after 4-5 days. The addition of water diluted and then increased the pH. The gas production again starts increasing. Therefore, we can infer that acid concentration greatly affects the biogas production. The EC and total solids were start decreasing in the anaerobic process (Table 4).

In conclusion, the gap between demand and supply for energy sources can be minimised by converting bio degradable hostel kitchen waste into a biogas in an economical way.Among the different treatments, Treatment T_2 (100% kitchen waste) alone produced more amount of biogas. The biogas can be used for cooking food items instead of LPG and also used to operate generators instead of electricity. It is a source of renewable green energy. The left over sludge can be packed and used as a manure and compost for agriculture farming.

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