International Journal of Geology, Agriculture and Environmental Sciences
Volume – 2 Issue – 2 April 2014
Website: www.woarjournals.org/IJGAES *ISSN: 2348-0254*

Potential of biogas production from food waste in a uniquely designed reactor under lab conditions

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Abstract: ***An original digester design is adopted in building a lab scale 20 L biogas plant. The novelty is the digester has a recycling line apart from other inclusions (inlet, outlet, gasline etc.) including water seal. Initially cow dung (inoculum) was added. After initial gas production, cow dung in the digester was co digested with food waste. Main ingredients of the food waste included rice, vegetable peelings, cucumber, bitter gourd etc., This waste had slightly higher solids and volatile solids (9.3% and 94.9%) content compared to cow dung (8.5% and 93.1%).***

The biogas volume was determined by measuring the downward movement of the water line and calculating the volume of the water that was displaced by gas. The loading rate of the digester in terms of Total solids was 16.6 kg/ (m^3*day). The amount of biogas production starting from the 16^{th} to the 23^{rd} day was 6.7L. This biogas did not burn. The failure to burn was probably due to low methane and a high carbon dioxide concentration in the biogas. After the 23^{rd} day 650 mL biogas was ignited using a match stick. The total biogas yield recorded was 68.50L for a period of 60 days. The lab temperature was between 30- 34^0C. Maximum microbial counts of $6.21*10^4$ colonies / mL were observed during the peak of biogas production. The phosphate content was recorded 1.027 mg/100g (slurry content) on the 60^{th} day. The volatile solids finally reduced to 81.66% of total solids. This volatile solids reduction/destruction/ leads to conversion of biogas. The volume of biogas produced from the amount volatile solids destroyed calculated using the ideal gas law was 51Litres. In an Indian scenario, food waste can become a good feedstock for biogas production at Indian households instead of going to the dump yards or being burnt along with plastic/polythene cover. Of the different types of organic wastes available food waste holds highest potential of economic exploitation as it contains high amount of carbon in the volatile solids that can be converted into biogas. The widespread implementation of biogas digesters in urban areas would contribute to the solution of the problems of urban sanitation energy supply and mitigation of green house gases.

Keywords: design, food waste, ideal gas law, microbial count**,**

1. Introduction

Food waste is any food substance, raw or cooked, which is discarded, or intended or required to be discarded. Food wastes are the organic residues generated by the handling, storage, sale, preparation, cooking and serving of foods. Food waste is an untapped energy source that mostly ends up rotting in landfills, thereby releasing greenhouse gases into the atmosphere. Food waste is difficult to burn, treat or recycle since it contains high moisture content and is mixed with other wastes during collection. Major generators of food waste include households, hotels, restaurants, supermarkets, residential blocks, cafeterias, food processing industries, etc. The proportion of food waste in the municipal solid waste is gradually increasing. Hence, a proper food waste management strategy needs to be devised to ensure its eco-friendly and sustainable disposal. Food waste can be recycled via anaerobic digestion, composting and vermicomposting. Biomethanation systems already exist in India. However, a large part of these systems are related to farm scale biogas plants and industrial effluents. There is a little experience in the treatment of solid organic waste in an urban setting.

Biogas technology is a low cost fuel with production of a useful soil amendment, improved urban sanitation, and low gestation period, provision of quick benefits, participant friendliness and political acceptance. Biogas technology is a socially relevant, useful, economically viable and financially sound energy source that provides energy security to developing economies.

Biomass alone meets 57% of the national energy demand (Tata 1998) yet is rarely featured in any official statistics of energy use, given perhaps its scattered nature, and its low status as fuel.

Bangalore is one of the fastest growing cities not only in India, but in the world. The population is over 9 million and the surface area is about 800 sq km. The estimated municipal solid waste (MSW) generation projection of 2009, from all sources of Bruhat Bangalore Mahanagar Palike (BBMP) zones, is 3000 tons per day (tpd). Per capita waste generation is about 350 grams per day from domestic waste. Households contribute 54% of the total waste. Markets and function halls contribute 20%. Commercial establishments and institutions contribute 17% and others 9%. Segregation of waste at sources is 10%.

Nag et al (1985) discovered that there was a general tendency for householders to construct an oversized plant, even when the digester was only used for cooking purposes and not applied to wider energy demands. Too large a plant was found to lead to underfeeding, and eventually to failure to produce biogas.

Studies related to Biogas production from food waste

Cho & Park in 1995 determined the methane yields of different food wastes at 37^0C and 28 days of digestion time. They were 482, 294, 277 and 472 ml/g VS for cooked meat, boiled rice, fresh cabbage and mixed food waste.

According to Zhang et al 2007, food waste contains well balanced nutrients for anaerobic microorganisms. The methane yield was determined to be 348 and 435 ml/g VS, respectively, after 10 and 28 days of digestion. The studies show that anaerobic digestion is preferable to incineration in terms of global warming potential.

The pH of digester corresponds to the system defined by the concentration of volatile fatty acids, bicarbonate alkalinity of the system and the amount of CO_2 being produced (Chawla, 1986).

The main objective was to design a unique biogas digester that can be implemented in Indian households. In this study assessment of the performance of treating food wastes was considered. Food waste was the primary source of waste for biogas production in the continuously operated digester. Physico chemical parameters of fresh and digested slurry and microbial analysis (enumeration) at various stages of digestion were carried out.

2. Material and methods

In the lab scale digester used for this study, materials (food waste slurry) were added on one side and an equal amount of the slurry comes out of the digester from the other side.

2.1 Requirements and build-up of the unique biogas Digester

The digester (plastic can of 20 litre capacity) consists of CPVC (Chlorinated polyvinyl chloride) pipe (4 feet), elbows, tee, bucket, gas collection unit. Reducer, gum and M Seal, (blade, and knife) were utilized during the fabrication and depicted in figure 1.

Figure 1. Set up of the fittings of the digester and operational digester

2.2 Designing procedure of the digester

A plastic can of 20 litre capacity was used for the study. This can, acted as a digester. The physical parameters of the digester are tabulated in Table 1.

Table 1: Physical characteristics of the digester

Parameters	Values
Total capacity	20 litres
Digester height	40 cm
Side water depth (liquid height)	27 cm
Free board line (empty volume)	13 cm
Liquid slurry volume	13.5 liters

The study was based on the principle of continuous feeding into the digester. Thus the digester was designed in such a way so that the waste can be easily put inside it. Following sequential steps were taken for designing of the digester. Two holes were made at the top of the digester with a drill. The holes were made about one inch in diameter. Two more holes of the same size were made on the sides of the digester, one at a height of 27 Centimetres (cm) and 5 cm respectively. One of the above two holes were joined with the inlet chamber. The other one was fitted with a gas line. The side holes were joined with the over flow line and the outlet respectively. All the joining's were completely made air tight by M-seal.

2.2.1 Inlet System: A pipe of 8.5 cm in length was joined with one of the hole made on the top of the digester. This inlet pipe was connected by means of a joint and a union. A tee was connected and its free end was joined with a pipe of 5 cm to act as a vent. The vent was made to prevent siphon during feeding of the slurry. The feed pipe outlet immersed into the slurry.

2.2.2 Gas line: A pipe attached on the top of the digester carried the gas from the digester. Provision was given to connect pipe through the water seal by means of a tee. The gas was collected and measured by means of a water displacement method.

2.2.3 Over flow line: The over flow line was connected at the height of 27 cm of the digester. The CPVC pipe was then bent by means of an elbow and immersed into water can at the pipe outlet. This water-can was further connected to one more pipe at its top end. The function of the over flow line is to take the excess slurry out of the digester such that it can be easily recycled by mixing with the fresh food waste and then feeding it again to the digester.

2.2.4 Outlet: The outlet pipe was connected at the bottom of the digester. Its function was to take the digested slurry out of the digester.

Side water depth is the height of the digester up to which the slurry is present inside. Similarly free board line is the height above the slurry which is free.

2.2.5 Water seal: The pipe that carried the gas from the digester was given a provision to connect pipe through the water seal by means of a tee. Water seal is a trough of water. This is connected to take away the moisture of the gas. The other side of the tee was fitted with the plastic pipe of half an inch and was further fitted at the bottom of the graduated beaker which was filled with water and kept upside down.

2.3 Preparation of the inoculum: The inoculum was made on 15th March 2012. The cow dung that was used to inoculate was one day old. 3kg of cow dung was weighed and was put into a can. Three litres of tap water were added and homogenized nicely to make fine slurry. Thus the dilution factor was kept as 1:1. The six litre slurry was fed into the digester from the inlet. The inlet chamber was then closed by a lid and kept airtight. Care was taken to prevent any leaks.

2.4 Food waste collection and Preparation of the sample: Food waste was brought on 31 of March 2012 at 10 am in a plastic container from the hostel. The food waste was physically assessed and was found to consist of the following mixture: cooked rice, vegetable peelings, cucumber and bitter guard.

Fresh feed material (food waste) was collected every week and was stored at 4^{o}C. The preparation included homogenization in a kitchen blender, diluting with water and sampling for further analysis and feeding inside the digester. The food waste in the form of paste was taken and mixed with tap water; it was mixed to make fine slurry. Fresh sample was taken from the slurry for physicochemical and microbial analysis.

2.5 Loading rate: Loading rate is the amount of raw materials fed per unit volume of digester capacity per day. About 6 kg of dung per m^3 volume of digester is recommended in case of a cow dung plant Biogas Sector Partnership (BSP, 2003). If the plant is overfed, acids will accumulate and methane production will be inhibited. Similarly, if the plant is underfed, the gas production will also be low. In this study fresh food waste was brought every week and was kept and stored at 4^{o}C. Loading of the digester was done daily. Organic loading rate i.e. 100 gVSS/(Ld) of slurry consisting of 60 gVSS/(Ld) of waste and 40 gVSS/(Ld) of water was mixed well and then fed. Loading was done until 60 days. Thus, daily the loading rate was calculated by dividing 60 gVSS/(Ld) food waste + 40 gVSS/(Ld) water by 6 liters liquid slurry volume. A rundown of the feed has been indicated in Table 2. The loading rate in this experiment in terms of food waste (wet mass basis) was 16.6 kg/(m^3*day) (60 + 40/6 liters = 16.6 kg/(m^3*day) from 16 to 25th day).

Table : 2 Feeding of waste into the digester

Waste	Amount	Day
Cow dung	3000g/3kgs	1st day
Water	3000/3L	1st day
1st gas production on 16 day From 16- 60 day food waste addition		
100mL (60 food+ 40 water)	1000	16th day-25 day (10 days)
150mL (90 food +60 water)	1500	26th day – 35day (10 days)
150mL (90 food +60 water)	1500	36th day – 45 day (10 days)
250mL (150 +100 water)	2500	46th day – 55 day (10 days)
200mL (120+ 80)	1000	56th day – 60 day (5 days)
Volume of total waste in the digester on the 60th day	13,500	16-60 day

2.6 Measurement of the gas: The biogas was measured daily by the water displacement method. In this method the gas line from the digester was connected to the inverted glass beaker of one litre capacity at bottom. The glass beaker was graduated and the divisions of the beaker were used to measure the gas in millilitres. The beaker was completely filled with the water and kept upside down with a cap at its mouth. A hole was made in the cap for the pipe to get fitted into it. When the gas was produced it could easily displace the water and go inside the beaker. Provision was also given to collect the gas in a tire tube on holidays.

2.7 Shaking and temperature: The shaking was done manually twice a day. Inside and outside temperature was measured by a long thermometer. The temperature was not regulated. The experiment was carried out under mesophilic conditions between 25^{o}C - 40^{o}C.

2.8 Physicochemical analysis: The waste was done to assess the changes occurring in the waste during the digestion. The parameters were checked before the fresh slurry was put into the digester and at the end of the study analysis was carried out. Moisture content was measured as gravimetric method. Estimation of Organic Carbon was carried out by Volumetric method (Walkley and Black, 1934). Estimation of Phosphates by Olisen method. Estimation of pH and %Total solids and volatile solids by the Standard EPA method 2001.

2.9 Microbial Analysis: Was carried out at point of charging, point of flammability, at the peak of production and at the end of the retention time. Total Viable Count for the food waste slurries were done to determine microbial load using modified Miles and Misra method.

3 Results and Discussion

3.1 Biogas production:

The biogas production started on the 16th day from the start of the experiment. Soon after the gas production started waste was added to the digester in the ratio of 1:1 (50 mL food waste and 50 mL water). Shaking and mixing of the digester was carried out as it is very important because it prevents the solids to get settled at the bottom and maintains a uniform distribution of the nutrients for the microbes. Mixing also helps in preventing the crust formation.

On 23rd day the biogas (650ml) caught flame for the first time and it burned with a blue flame which continued for about 10 seconds**.** Initially the flame of matchstick extinguished when it was brought near the graduated beaker, containing gas. This indicated that the gas was not rich in methane and that the produced gas was probably rich in CO_2. During this period the amount of gas produced was 6700 ml /6.7litress.

The total amount of biogas produced for a study period of 60 days was 68.85litres (Figure 2). From the first day of biogas ignition to the end of the experiment (60 days), the average daily biogas production was 1.5 L/Ld. This corresponds to 68.8/13.5x60 =0.0849cum (cubic meter) of gas production per litre per day.

3.4 Results from physicochemical analysis of the waste before and after digestion:

The changes found in the pH, total solids, moisture content, VS, %C and phosphates of the waste have been represented in Table 3. The data given in the Table 2 is the mean of three measurements.

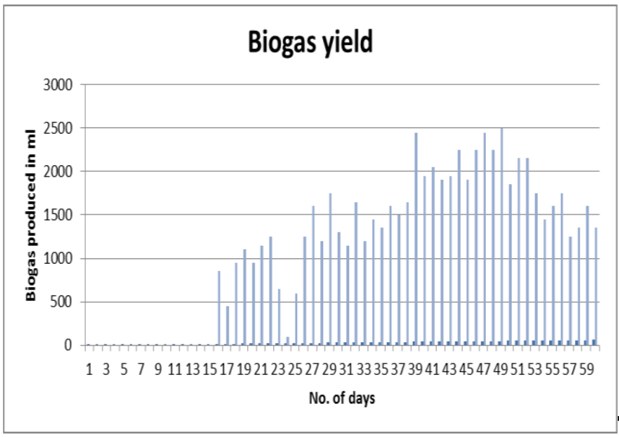

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Figure 2: Daily biogas production

3.3 Exposure

On 23rd day i.e. the digester showed a small opening on the top which was immediately sealed. Hence there was a decrease of biogas production recorded on these days.

Table 3: Results for physicochemical characteristics

SI. No.	Parameter	Fresh cow dung slurry	Fresh food waste slurry	Fresh cow dung + fresh food waste slurry	Digested slurry
1	pH	6.6	6.1	6.35	7.1
2	Total solids (%)	8.5	9.3	8.9	5.34
3	Moisture content (%)	91.5	90.7	91.1	94.66
4	Volatile solids (%)	93.1	94.9	93.7	81.66
5	Percent Carbon	2.4	3.14	2.77	0.18
6	Phosphate mg/100g	0.26	0.3062	0.28	1.027

3.4.1 %Total Solids (TS)

The total solids which were held at 8.9 % showed a decrease after the retention period of 60 days which were found to be only 5.34%. The total solid for various types of wastes is shown in Table 3. The total solids in the digester = TS x digester volume ie 5.34 x 13.5 = 72.09 (on the 60th day, for 13.5 litres slurry). Similarly initial TS in the digester was 53.4 ie 8.9% x 6 litres.

Day 1 showed, VS of 237 ml/g and dry mass 255ml/g for cowdung and for wet biomass 534ml/g and total volatile solids was 491ml/g for water and cow dung. On the 60th day TS at 5.34% the dry mass was 720ml/g and VS were 588ml/g. The accumulation or destruction of mass is equal to mass at the end minus mass at start with TS of 465.99ml/g and VS at 351.3g (Table 4).

Total solids are very important as far as anaerobic digestion is concerned. According to Abdulkarim et al (2010), at some point in the increase of the percent TS, no further rise in the volume of the biogas is obtained.
Igoni et al (2007) showed gas production increases with TS% concentrations up to a limiting value of TS% concentrations.

Table 4: Accumulating and destruction of total and volatile solids on the 1st day & 60th day.

Day 1	Cow dung	Total solids	Dry mass	Volatile solids	Volatil e solids
	gVSS/(Ld)	%	g	%	ml/g
	3000	8.5	255	93.1	237.405
	Food waste	Total solids	Dry mass	Volatile solids	Volatile solids
	gVSS/(Ld)	%	g	%	ml/g
	0	9.3	0	94.9	
	Water	Total solids			
	gVSS/(Ld)	%			
	3000	0	0		
	Total wet mass	Total solids	Total dry mass	Total VS	Total VS
	gVSS/(Ld)	%	g	%	ml/g
	6000	8.9	534		497.154
			6000*8.9/100 =		
End	OUT				
Day 60	Slurry	Total solids	Dry mass	Volatile solids	Volatile solids
	gVSS/(Ld)	%	g	%	ml/g
	13500	5.34	720.9	81.7	588.7
Accumulation or destruction = mass at end - mass at start					
Positive sign = accumulation. Negative sign = destruction.					Volatile solids ml/g
Mass at start		ml/g	255		237
Mass at end		ml/g	720.9		588.7
mass at end - mass at start		ml/g	465.9		351.3

Table 5: The overall mass balance for the mass wasted, mass fed, mass at the end and mass at the start is calculated

OVERALL MASS BALANCE		Accumulation or destruction = mass wasted - mass fed + mass in digester at end - mass in digester at start	
Positive sign = accumulation. Negative sign = destruction.			
		Total solids	**Volatile solids**
Mass wasted	ml/g	0	0
Mass fed	ml/g	419	397
Mass at end	ml/g	721	589
Mass at start	ml/g	255	237
Overall	ml/g	**47**	**-46**
Change in total solids fed	(%)	11	-11.6

Balsam (2002) and Zennaki *et al*. (1996) found that the optimum solid content obtained for biogas production is in the range 7- 9%. Furthermore, Baserja (1984) reported that the process was unstable below a total solids level of 7% (of manure) while a level of 10% caused an overloading of the digester. Itodo and Awulu (1999) showed that slurries of higher TS concentrations were more acidic than that of lower TS concentrations. The overall mass balance has been worked out in Table 5.

3.4.3 Volatile Solids (VS)

VS reduction occurred in the slurry during the digestion. The VS fed on an average basis into the digester were found to be 93.7%. The VS found after the digestion process was found to be 81.66%. Thus there was about 12% decrease in volatile solids. Volatile solids are the solids that are lost on ignition of the dry solids at 55°C centigrade. VS are responsible for biogas production. Since food waste contains 93.7% of volatile solids thus it has a great potential of biogas production and can be used easily and potentially as a raw material for biogas production.

As per Ideal gas law, volume of total gas predicted was 51L. The amount of biogas recorded in the experiment was 68.85 litres. In actual the values need to be almost similar. The difference between the predicted and experimental value might be due to incorrect assumptions about the carbon content of the volatile solids and temperature deviations from 32°C.

3.4.4 Percent Carbon

Percent carbon content in the feedstock was found to be 2.4 in cow dung slurry and 3.14 in the food waste slurry. The reduction of C by anaerobic processes was therefore probably limited to the production of organic acids, H_2 and CO_2 by facultative bacteria (Hobson *et al.*, 1981).Thus continuous process of feeding is also efficient in removing carbon content. The carbon compounds are converted to CH_4 and CO_2.

According to Richard (1996) and Wilkie (2005), anaerobic bacteria do not or very slowly degrade lignin and some other hydrocarbons. In other word, the higher lignin content will lower biodegradability of waste. As food waste was used, it contains enough carbohydrates and less cellulose and lignin content, thus the removal of carbon content was fast.

3.4.5 Moisture Content

The moisture content of the digestate increased from 91.1% to 94.66% thus there was an increase (Table 2). According to Sadaka and Engler (2003), water content is one of very important parameter affecting anaerobic digestion of solid wastes. There are two main reasons i.e., (a) Water makes possible the movement and growth of bacteria facilitating the dissolution and transport of nutrient and (b) water reduces the limitation of mass transfer of non-homogenous or particulate substrate. In general, the moisture content of the digestate increased with increase in the amount of VS and TS reduction. The moisture content to be maintained for the degradation depends upon the type of the waste. In the present study final moisture content was at 94.66%

3.4.6 Phosphate content

In this study the amount of phosphorous which was present at the start of the digestion was 0.28 mg/100 gram of the waste (wet mass basis). The phosphorous content was again analyzed at the end of the study period (60 days) and it was found to be 1.027. Thus the phosphorous content had increased during the digestion process. Increase in the quality of phosphate was recorded in the slurry; Table 2. Phosphorous a macronutrient is very important as far as plant growth is considered. It is present in every living cell. It is very important to enhance process stability and maintain a stable operation for anaerobic digestion of municipal solid waste (Kayhanian and Rich, 1995).

3.4.7 Microbial analysis at various stages

The result of the microbial total viable count (TVC) revealed the progression of the microbes that converted the wastes to biogas. The microbial load started lower, increased towards the peak of production and reduced towards the end of the retention period. At the time of gas production the number of microbes has increased under complete anaerobic process. Further due to the stabilization of the conditions inside the digester the number of microbes reached to maximum which can be seen in the results (Table 8 and Figure 3). At the same time gas production was highest and flame was strong with blue color.

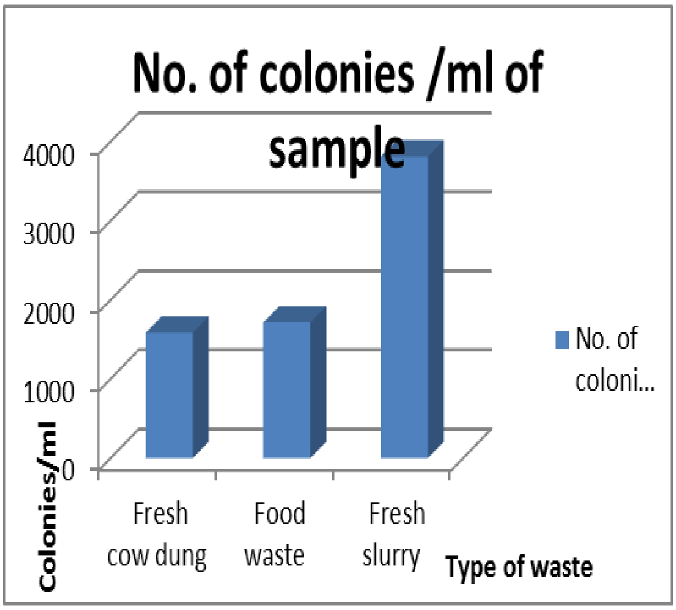

Figure 3: Number of colonies/mL of sample for fresh cow dung, fresh food waste, (cow dung& food waste together and digested slurry).

Table 8: Microbial analysis of slurry.

Slurry (cow dung +food waste)	
Period	**No. of colonies per ml**
At the time of charging	3.811×10^3 (3811)
At the time of flammability (after 23days)	3.9435×10^4 (39435)
At the time of peak production of gas	6.2111×10^4 (62111)
Towards the end of the retention Period	4.6221×10^4 (46221)

According to Eze J.I. et al (2010) total viable count (TVC) increases and the coliforms decrease due to the fact that the conditions are favourable for anaerobes to develop and unfavourable for the coliforms.

3.4.8 Temperature variation

Ambient temperature and the temperature inside the biodigester are shown in the Figure 5. The temperature inside the digester changed in response to changes in the ambient temperature. The average temperature found inside and outside the digester was about (33°C) and (30°C) respectively. Further the highest and lowest temperatures found inside and outside the digester were 35°C and 33°C, and, 30°C and 28°C respectively.
The mean outside temperature remained 30°C. The mean inside temperature remained at 33°C (Figure 5). Inside the reactor, temperature was always more than the outside; this is because microbial degradation of the waste raised the temperature of the waste slurry. Temperature is an important parameter for biogas production and generally at higher temperatures the biodegradation process is high and thus the biogas yield is also more.

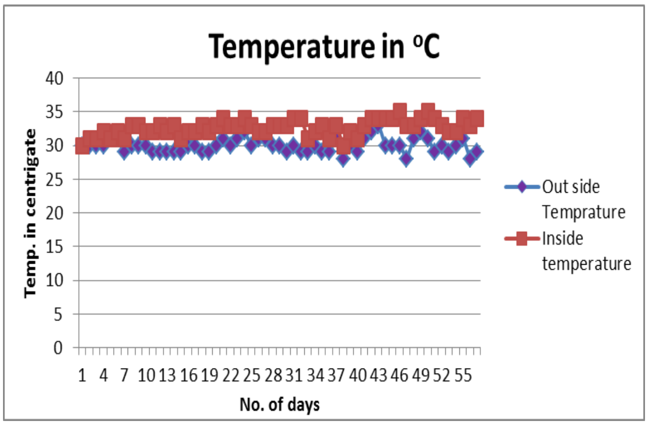

Figure 5: Graphical comparisons of inside & outside temperature

3.4.9 pH change

The pH during the process was found between 6.2 – 7.5. pH analysis was carried out every 15 days. The food waste loaded had a pH of 6.2 and the final slurry had a pH of 7.5. After 30 days the pH had dropped to 7.2 and was found to be 7.5 at the end of sixty days (Table 9).

3.5 Over flow or the Recycle line

Due to scarcity of water in some area's the water can be recycled once more. The slurry coming out of the digester into the water can, was further connected to one more pipe at its top end. The function of the over flow line is to take the excess slurry out of the digester which can be easily recycled by mixing with the fresh food waste and then feeding it again to the digester. This also returns some of the biogas producing bacteria to the digester.
In this paper the design aspect of this model is similar to a setup of a UASB digester. New inclusions are a recycle line and a water seal. In a UASB digester the feed liquid enters from the bottom of the reactor and biogas is produced while liquid flows up through the sludge blanket (FAO, 1996).

Table 9: pH analysis

Time period	**pH**
Loading	6.2
After 15 days	7.4
After 30 days	7.2
After 45 days	7.1
After 60 days	7.5

The observed pH stabilization indicates that a syntrophic relationship between acid producing and methane producing bacteria was established in the digester.

3.6 Water seal: The pipe that carried the gas from the digester was given a provision to connect pipe through the water seal by means of a tee. This is connected to take away the moisture of the gas. The other side of the tee was fitted with the plastic pipe of half an inch and was further fitted at the bottom of the graduated beaker which was filled with water and kept upside down.

4. Conclusion

The study evaluates biogas production from food (rice, vegetable peelings, cucumber) waste through an anaerobic digestion of 20L capacity designed and built in the lab. In the duration of 60 days, biogas production started from the 16th day. The total amount of gas production recorded up to 60 days was about 68.85litres. From the 16th day onward, biogas production and the digester pH were stable. The loading rate during this period was 16 kg VSS/(Ld) wet mass per m^3 liquid in the digester per day. This result demonstrates that the design can be used to construct small digesters (< 1 m^3 volume) that can be implemented in Indian households.
Food waste getting converted into biogas not only becomes an alternative source of energy but also burning the biogas helps in reducing the methane production from organic waste which is one of the green house gases. From our study it is evident that food waste can become a good feedstock for the biogas production. Food waste contains more biodegradable solids (9.3%), with higher volatile solids (94.9%) than cow dung. Increase in moisture content of the digestate was 3.56%. 12% decrease in VS was observed after 60 days. Since food waste contains 93.7% VS, it thus has a great potential of biogas production and can be used easily and potentially as a raw material for biogas production. The volatile solids finally reduced to 81.66%.
As food waste is used, it contains enough carbohydrates and less cellulose and lignin content. Thus the removal of carbon content was fast. The phosphorous content decreased during the digestion process from 0.28 to 1.027mg. The phosphate content was recorded 1.027 mg/100g on the 60th day.
At the time of gas production the number of microbes had increased. Maximum microbial counts were observed during peak of biogas production of 6.21×10^4 colonies / mL.
The lab temperature was between 33- 35°C. The mean inside temperature remained at 32.6°C. pH during the process was found between 6.2-7.5. Hence food waste from households can be used for biogas production instead of going to the dump yards in Indian scenario, where it is left or burnt along with polythene cover. Of the different types of organic wastes available, food waste holds highest potential of economic exploitation as it contains high amount of carbon and volatile solids that can be converted into biogas.
Continuous feeding helps in daily biogas production and managing food waste to produce biogas which can be used for domestic purpose. The biogas technology not only provides the

energy but also gives final digested slurry which can be used in composting/vermicomposting and later used in the soil as a nutrient supplement.

Further by designing continuous digester the waste can be daily added and removed and thus the digester can become very economical. The slurry can be recycled back into the digester mixed with fresh waste. A water seal would be good enough to remove the moisture content in the biogas. Thus biogas from food waste can help in achieving sustainability due to rise in LPG prices in India. The process needs a lot of care with respect to the physical and biochemical changes like pH, temperature, and proper anaerobic conditions.

5. Acknowledgements

We are grateful to Mark McCormick (Industrial Bioenergy Systems Laboratory, University of Applied Sciences, Yverdon-les-Bains, Switzerland) for giving us very useful suggestions.

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