Biogas production to mitigate Green House Gas Emission

Rinku Verma, Mark McCormick, Jean-Bernard Michel

***Abstract*— This paper provides an overview of methodology used for biogas production (i.e. anaerobically digested in a batch fed bioreactor/biodigester), in a laboratory scale set up. The amount of gas produced was recorded over a period of 134/101 days in each experimental set up, one being fresh buffalo dung waste and the other being partially degrading food/vegetable waste by earthworm (*Eudrilus eugenia / Eisenia foetida*). The efficacy of gas production was observed for both buffalo dung and food/vegetable waste separately. The research findings help to correlate the greenhouse gas (GHG) emission from unused buffalo dung and food/vegetable waste if not allowed to biodegrade completely or in the right manner. There by making this technology of biogas production more environmental friendly at household level and by mitigating percentage of GHG into the atmosphere on individual basis and ground.**

***Index Terms*— Green house Gas, Buffalo dung, Food waste, Bio gas and biogas digester**

I. INTRODUCTION

As the global energy consumptions are growing day by day, biogas an alternative to fossil fuel has a great use as a renewable resource. Biomass energy technologies are being worked in various stages. This is an important technology with regard to climate change; hence its improvements in research are necessary. Combustion of fossil fuels, is biggest source Green House Gas (GHG) emission, hence substituting by using this renewable energy would be a very important topic to help sustain our Earth's climate. Clean Development Mechanism established under the Kyoto Protocol accords waste to energy projects (CDM Rulebook, 2008**)** with displacing fossil fuel electricity generation and eliminating methane gas production in landfills. Hence we recognise waste to energy as a renewable energy source, taking this research forward in clean usage to mankind and reduction of GHG emissions from wastes. Nearly two-third of renewable energy sources in the European Union stem from the biomass, including waste (European Commission, 2011). Biogas is the biological breakdown of organic matter in the absence of oxygen, which is the result of hydrocarbon chains' oxygen free disintegration, (literally called as fermentation). This occurs in nature almost everywhere, where there is not enough oxygen for the break down of organic material (Barta, 2007). Biogas production is an advantageous solution for the disposal of biological wastes from the economic and environmental point of view. Of the two anaerobic digestion and aerobic composting process, the latter process generates carbon dioxide (CO_2) which is a GHG (Gabor et al., 2009) while anaerobic digestion also generates methane that can be used as fuel. From significant reductions in emissions associated with the combustion of fossil fuel, such as SO_2, nitrogen dioxide (NO_2), carbon monoxide (CO), total suspended particles (TSP's) and poly-aromatic hydrocarbon (PAH's), are possible with the large-scale introduction of biogas technology.

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Related Work: Characteristics

According to Milono et al., 1981, cow dung gas has 55-65% methane, 35-45% carbon dioxide, 0-3% nitrogen 0-1% hydrogen, and hydrogen sulfide (0-1%). According to Vindis et al., 2008, the methane bacteria can only work and reproduce if the substrate is sufficiently bloated with water (at least 50%). Indian Agricultural Research Data Book 2004, gives details related to high moisture and organic content in wastes which can be utilized in biological treatment like anaerobic digestion techniques. The low C/N weight ratio (15:1) in the digested substrate indicates that it can be utilised as biofertilizer or soil conditioner (Rao and Singh 2004). Gas production per kg cattle (cow and buffaloes) is 0.023- 0.040 cubic meter. A kg of volatile solids in cow dung would produce 0.25 m^3 biogas (Sathianathan, 1975).

Biogas production and Climate Change

In the Pacific islands region, the reported methane emissions from solid waste disposal from dump account for 1.7% of the total emissions from the region (Hay and Sem 2000).

Climate change has accelerated the need to find measures to reduce and manage the waste. Reduction and reuse of waste will help reduce pressure of the planet's natural resource while potentially reducing emission of greenhouse gases created through mass production and burning of fossil fuels. Recovery value from the waste offsets the GHG emissions (SPREP 2009).

Methane emissions during manure storage are reduced and the fertiliser quality of the digestate is high. Each year some 590 -880 tons of methane are released worldwide into the atmosphere through microbial activity. However, if biogas is not recovered properly, it will contribute to a GHG effect 20 times worse than if methane is simply combusted. Therefore, there is a real incentive to transfer biogas combustion energy into heat and electricity. The calorific value of biogas is about 6 kWh/m^3 – this corresponds to about half a litre of diesel oil. Biogas use, replaces conventional fuels including firewood, allows for the conservation of environment, thus saving forests (ICAR report).

Methane is the valuable component under the aspect of using biogas as fuel. $1m^3$ biogas (approximately 6k Wh/m^3) is equivalent to: Cow dung (approximately 5 kWh/kg dry matter) 1.2 kg and Plant residues (approximately 4.5 kWh/kg d.m.) 1.3 kg. Seven cubic feet of methane gas can be generated from one pound of dry leaves but only one cubic foot of gas will come from one pound of cow dung.

Estimating an average per capita consumption of 3 kg of wood per day for energy in rural areas, the daily per capita demand of energy equals about 13 kWh which could be covered by about 2 m^3 of biogas. A biogas plant therefore directly saves forest.

A recent study by Winrock, Nepal and others found that each biogas plant can mitigate about 5 tons of CO_2 equivalent per year. A single biogas system with a volume of 100 cubic feet ($2.8m^3$) can save as much as 0.3 acres (0.12ha) of forest (woodland) each year.

Methane is not only the second most important GHG (it contributes with 20% to the effect while CO_2 causes 62%, it has also a 25 times higher global warming potential compared with CO_2 in a time horizon of 100 years (ICAR report) and 72 times GWP on a time horizon of 20 years. The reduction of 1 kg methane is equivalent to the reduction of 25 kg-72 kg CO_2 depending on the time horizon (IPCC). The reduction of greenhouse gases with a high GHG potential can be more efficient compared with the reduction of CO_2 (ICAR report).

This study was undertaken to find out the amount of gas produced and reduction in GHG by biogas production from buffalo dung and partially degrading food/ vegetable wastes under lab scale set up and correlating if let unattended or untreated.

II. Materials and Methods

Two bio digesters units were used. Design details of this small lab scale biogas unit are described in subsequent section. Experiment conducted in each of the biodigester unit is mentioned below.

Unit 1: 50g of fresh buffalo dung was taken, mixed with tap water in the ratio 1:3.4 and made into a slurry.

Unit 2: 50g of partially degraded food/vegetable waste, 2 g of buffalo dung were taken, mixed with tap water in the ratio 1:3.4 and made into a slurry. The partially degraded food waste comprised of cooked rice and vegetable waste (mainly beetroot and cabbage) and was acted upon by earthworms *Eudrilus eugenia* and *Eisenia foetida* for about 10 days prior to its introduction into the biogas digester. It was not required to mash the food/ vegetable waste as it was already partially degraded by earthworms.

Design of small lab scale biogas unit

A big trough (dimension 42 cm * 30 cm * 13 cm) was filled with water. A 250 ml conical flask was taken and was placed outside the trough. The conical flask (250 ml) had a normal opening on the top, as well as a small protrusion with an opening at the side; (at 4 cms from the mouth of the conical flask) the length of protrusion was 1.5 cms. This side opening was connected with a rubber tube which fitted well, such that no escape of gas would take place. The mouth of the conical flask was sealed with mseal. The rubber tube coming out of the conical flask was dipped in the trough containing water. A measuring cylinder was taken and was completely filled with water. The mouth of the cylinder was sealed and a small opening was made to facilitate entry of the rubber tube. The cylinder was inverted and placed inside the trough. Figure 1 shows the diagrammatic representation of the setup. Care was taken to ensure that the setup was airtight.

The conical flask would function as a bio digester in the lab experiment (as Unit1 and Unit2) and the trough/cylinder would facilitate measurement and collection of gas generated. Gas was collected in the graduated cylinder by downward displacement of water. The gas yield was recorded in ml on a weekly basis. The total biogas yield obtained was calculated for the entire 134/101 day detention period for both the set ups. The volume of gas production was recorded and calculated. The total biogas yield in ml has hence been converted and calculated in cubic foot and cubic meters, respectively correlating to its energy characteristics. Conversion to grams i.e. gram wise requirement obtained at various time intervals has been indicated.

Both the lab experiments were conducted at room temperature with the max temperature ranging from 26^0C - 36^0C (mesophilic conditions) during the month of November till May. The conical flask was stirred adequately on a daily basis during weekdays whereas was left untouched on weekends.

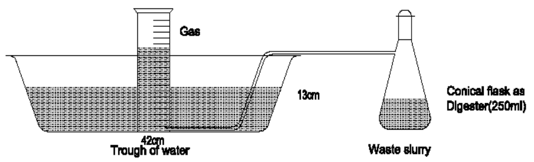

Figure 1. Schematic diagram of experimental laboratory set up

Physico chemical analysis/microbial analysis (CFU) was done on the initial slurry and the final digested slurry. Both were tested for Moisture content, %Total solids, Volatile solids: determined by Standard EPA method 2001, Percent phosphorous: by Stannous chloride method, Ash content: by standard AOAC (1985) method, % Carbon content: by Walkey and Black method. Total nitrogen: Kjeldhal Nitrogen Method and Microbial analysis by Miles and Misra method and pH value.

III. RESULTS AND DISCUSSION

Efficacy of the first experimental biogas set up form fresh buffalo dung.

Daily biogas production was observed and readings were recorded on weekly basis. At later stage the readings were noted on daily basis. The onset of flammability took place at different lag periods. After an interval of 15th, 12th, 11th, 9th, 12th , 7th , 14th, 8th, 15th, 11th, and 20th days the gas was burnt completely with good flammability. Flammability was hence resumed on these days, after collection of the gas in the graduated cylinder as shown in Table 1. Initially the flame was yellow blue finally pure blue flame was achieved. The blue flame indicates complete methane being burnt out.

Amount of gas collected for the whole detention period of 59 days is reported to be 785 ml = 0.027722 ft³ / 785 ml = 0.000785 m³. The biogas has been expressed in litres, (1.256 litres) as indicated in Table 1.

The amount of biogas from fresh buffalo dung under lab conditions under a 134 day period was 1367 mL and commencement of biogas production started from the 11th day from the initial start. The flammable biogas production resumed and burning took place 11 times, when lit with a match stick, at various time intervals. It was observed that the gas production with which the flame burnt was very characteristic. The biogas burnt with different flames showed, (on the 15 day) gas burnt with completely blue flame, followed by red flame on the 27th day, then with yellow flame on the 38th day and subsequently on the 47th and 59th day with a total retention period of 69 days respectively. The biogas showed flames of gas similar to that of a normal Liquid Propane Gas (LPG) cylinder would show when lighted up for cooking purpose. Later the biogas showed blue flame till the last burning (134th days).

Table 1. Biogas collection and its burning at different time intervals form buffalo dung

<table>
<tr><th>Serial No</th><th>Experimental set up</th><th>15th day (gas burnt with flame)</th><th>27th day (gas burnt with flame)</th><th>38th day (gas burnt flame)</th><th>47th day (gas burnt flame)</th><th>5 9th (gas burnt flame)</th><th>66th day</th><th>80th day</th><th>88th day</th><th>103rd day</th><th>114th day</th><th>134th day</th><th>Total</th></tr>
<tr><td>1</td><td>Number of readings</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>Total volume of gas</td></tr>
<tr><td>2</td><td>In days</td><td>15 day</td><td>12 day</td><td>11day</td><td>9 day</td><td>12day</td><td>7day</td><td>14 day</td><td>8 day</td><td>15 Day</td><td>11 day</td><td>20</td><td>1367 mL</td></tr>
<tr><td rowspan="5">3</td><td rowspan="5">fresh Buffalo dung</td><td>200 ml</td><td>145 ml</td><td>200ml</td><td>120ml</td><td>120ml</td><td rowspan="2">142 ml</td><td rowspan="2">202 ml</td><td rowspan="2">42 ml</td><td rowspan="3">85 mL</td><td rowspan="3">50 mL</td><td rowspan="4">61 mL</td><td rowspan="5">785ml
1171 ml
1306 mL
1367 mL</td></tr>
<tr><td colspan="5">785ml</td></tr>
<tr><td colspan="8">1171 ml</td></tr>
<tr><td colspan="10">1306 mL</td></tr>
<tr><td colspan="11">1367 mL</td></tr>
<tr><td>4</td><td>In cubic meter</td><td>0.0002 m³</td><td>0.000145 m³</td><td>0.0002 m³</td><td>0.00012 m³</td><td>0.00012 m³</td><td>0.00014 2 m³</td><td>0.00020 2 m³</td><td>0.000 042 m³</td><td>0.000 085 m³</td><td>0.00005 m³</td><td>0.00006 1 m³</td><td>0.00078 5 m³</td></tr>
<tr><td>5</td><td>In cubic feet</td><td>0.00706 2 ft³</td><td>0.005120 ft³</td><td>0.007062 ft³</td><td>0.004237 ft³</td><td>0.00423 7 ft³</td><td>0.00501 4 ft³</td><td>0.00713 3 ft³</td><td>0.001 483 ft³</td><td>0.003 001 ft³</td><td>0.00176 5 ft³</td><td>0.00215 4 ft³</td><td>0.02772 2 ft³</td></tr>
<tr><td>6</td><td>In litres</td><td>0.2 litres</td><td>0.145 litres</td><td>0.2 litres</td><td>0.12 litres</td><td>0.12 litres</td><td>0.142 Litres</td><td>0.202 litres</td><td>0.042 litres</td><td>0.085 litres</td><td>0.05 litres</td><td>0.061 litres</td><td>1.367 litres</td></tr>
</table>

According to Habmigern 2003, about one cubic foot of gas may be generated from one pound of cow manure at around 28°C. The gas is enough to cook a day's meals for 4-6 people in India. Keeping 1 cubic foot i.e. nearly 6 kgs is required for supporting the family for a day's meal. According to our study, biogas collection from buffalo sung for 169 days is 0.001422 m^3. Similarly for 128 days 0.00219 m^3 of biogas was produced from food waste,

Table 2 shows the biogas production every 24 days. The maximum biogas with respect to buffalo dung was produced on the 2nd, 24th day, (i.e. 48 days) monitoring with about 365 mL and that of the 3rd 24th day with another 365 ml gas, respectively. The biogas production from day 1 (i.e. 11th day onwards) up to 21 weeks (134 days) is plotted showing, a clear rise in gas production with 50 g of waste observed (Fig, 2). The quantity of gas production per week, is indicated in Figure 3. In the 2nd week maximum biogas production was with 144 mL, while 145.6 mL and 133.86 mL was shown on 6th and 9th week respectively. The first week and the thirteen week showed lowest biogas production, the former being 49 mL and the latter being 15 mL, and this complete study was carried out for a period of 21 weeks (five months).

The production of biogas for every 15 days period showed highest production peak appearing between 60 -75 days with 273.6 mL and the other being on the first 30-45 days with 238.7 mL. Finally there was a sudden drop in the biogas production

Table 2. Biogas production form buffalo dung for every 24 days

Si No	**Biogas production 1st 24 days**	**Biogas production**	**Biogas production**	**Biogas production**	**Biogas productio n**	**Biogas productio n**	**Total biogas productio n**
		2nd 24 days	**3rd 24 days**	**4th 24 days**	**5th 24 days**	**6th 24 days**	
	Considered from the day of start of experimentation 24 day (i.e. day one)	**48 day**	**72 day**	**96 day**	**120 day**	**144 day**	**From the start 169 days till cease**
1	300 mL	365 mL	365 mL	180 mL	113 mL	44 mL	55 mL
2 Total gas production	300 mL	665 mL	1030 mL	1210 mL	1323 mL	1367 mL	1422 mL
3 Conversion to metric cube	0.0003 m³	0.000365 m³ 0.000665 m³	0.000365 m³ 0.00103 m³	0.000386 m³ 0.001210 m³	0.000113 m³ 0.001323 m³	0.000044 m³ 0.001367 m³	0.000055 m³ 0.001422 m³
4 Conversion from ml to ft³	0.010594 ft³	0.012889 ft³ 0.023484 ft³	0.012889 ft³ 0.036374 ft³	0.013631 ft³ 0.042730 ft³	0.0039905 ft³ 0.0467213 ft³	0.0015538 ft³ 0.0482751 ft³	0.050217ft³ 0.001942 ft³
5 Conversion to litre	0.3 L	0.365 L 0.665 L	0.365 L 1.03 L	0.180 L 1.210L	0.113 L 1.323 L	0.044 L 1.367 L	0.055 L 1.422 L
6. Equivalent in grams	0.3 g 0.3 g	0.365 g 0.665 g	0.365 g 1.03 g	0.180 g 1.21 g	0.113 g 1.32 g	0.044 g 1.36 g	0.055 g 1.42 g

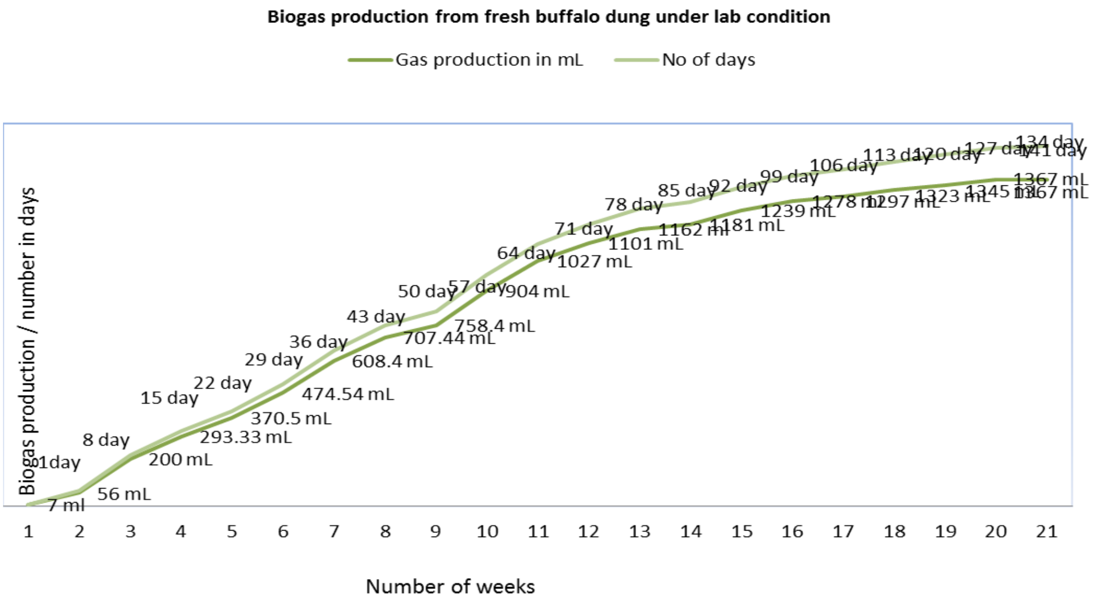

Figure 2. Quality of gas production on weekly basis from buffalo dung under partial degradation.

3.2 Efficacy of the second experimental biogas set up from partially degrading vegetable/food waste

Degradation of organic food/vegetable waste of 15 days had a lot of odour in it, as minimum amount of starter culture was used. The amount of biogas produced by this waste was about 365 mL on the 24th day, while the amount of biogas produced from fresh buffalo dung was only 300 mL. This indicates more gas production from food/vegetable waste which was

On the day of setting up of the experiment for partially degrading food/vegetable waste, the observation seen during setting the graduated cylinder with water connecting the pipe, making all the fittings air tight for no gas escape, it was observed that the whole cylinder was displaced by gas in 5 minutes, pushing all the water below. Immediately a burning matchstick was placed below lifting the graduated cylinder above water, the match stick put off flame indicating the complete gas to be carbon dioxide (CO_2). Thus showing gas reactions had already started. Including this the total gas production was 2071 mL from degrading food waste.

The cumulative biogas production from partially degraded organic waste was greater than buffalo dung. The cumulative biogas yield, biogas flammability and effective retention periods of 101 days has been indicated by 2071 mL of gas production (Table 3). There was enough gas production even at times when the digester could not be mixed; therefore this did not affect the gas production as the amount of waste taken was only 50 g. According to Hobson et al., 1981, a batch digester is a smaller experimental system may be suitable as the digester has only to be loaded once and may not even need to be stirred. This was convenient for this study as amount of GHG being liberated otherwise would be noted by carrying out the experiment systematically.

The biogas yield from Buffalo dung was 0.0284 litres/gram wet dung and 0.316 litres/gram dry dung.

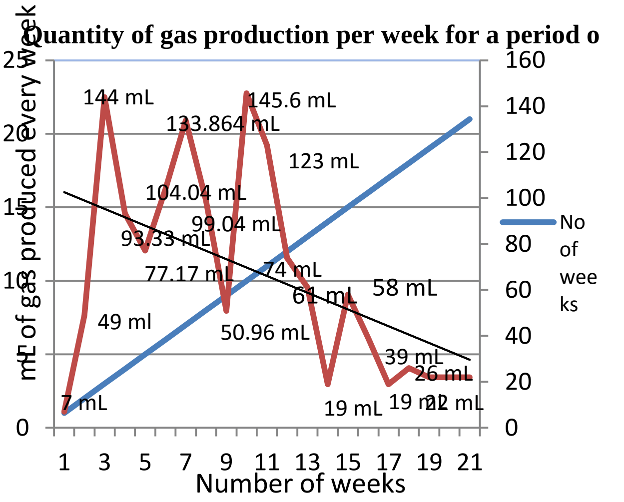

Figure 3. Biogas collection from partially degraded food/vegetable waste and its burning at different time intervals food/vegetable waste and its burning at different time

Table 3: Biogas collection from partially degraded intervals

Serial No Experimental set up	**2 day and conversion to meter cube**	**4 day and conversion to meter cube**	**6 day and conversion to meter cube**	**23day and conversion to meter cube**	**24 day and conversion to meter cube**	**31 days**	**45 days**	**53 days**	**65 days**	**77 days**	**86 days**	**101 days**	**Total of Days 128**
Biogas production in mL Partially degrading food waste	50 mL	75 mL	100 mL	350 mL	365 mL	655 mL	1047mL	1324 mL	1479mL	1734 mL	2009 mL	2071 mL	+120ml= 2191 mL
Conversion to m³	0.000050 m³	0.000075 m³	0.0001 m³	0.00035 m³	0.000365 m³	0.000655 m³	0.001047 m³	0.001324 m³	0.001479 m³	0.001734 m³	0.002009 m³	0.002071 m³	0.002191 m³
Conversion to ft³	0.001765 ft³	0.002648 ft³	0.003531 ft³	0.012360 ft³	0.012889 ft³	0.023131 ft³	0.036974 ft³	0.046756 ft³	0.0522 ft³	0.061236 ft³	0.0709 ft³	0.0731 ft³	0.077374
In liters (L)	0.05	0.07	0.1L	0.35 L	0.365 L	0.655 L	1.047 L	1.324 L	1.479 L	1.734 L	2.009 L	2.071 L	2.191 L

Table 4. Biogas production from 50g of different kinds of waste understudy

Si No	**Total Biogas production form 50 g of waste, under lab conditions in the ratio of** 1:3.4	**Buffalo Dung**	**Food Waste Hostel food/vegetable waste (partially degrading by earthworms)**	**From vermicomposting (farm yard waste) (composted by both *E. eugenia* and *E. foetida* spp)**
1	In g	1.42	2.191	0.075
2	In m³	0.00142	0.002191	0.000075
3	In L	1.42	2.19	0.075

It has been reported that 20% of GHG emissions in the US are from the landfills. Linear trend was obtained for fresh buffalo dung up to 758.4 mL (57days) and similar trend continued for upto 1226 mL of gas production i.e. upto 100 days. Organic waste diversion has been largely accepted worldwide as a means to reduce GHG emissions from landfills. The European Commission's Landfill Directive requires member states to divert 65% of organic waste (relative to 1995 levels) from landfills by 2016 (CECD 2003). In 2009, the Chicago Climate Exchange formulated the protocol for evaluating organic waste diversion programs and began assigning GHG emission offset credits (Levis et al., 2010). Fresh vermicompost showed 0.075g biogas production, and the biogas production of buffalo dung and food waste was 1.42g and 2.19g, respectively (Table 4)

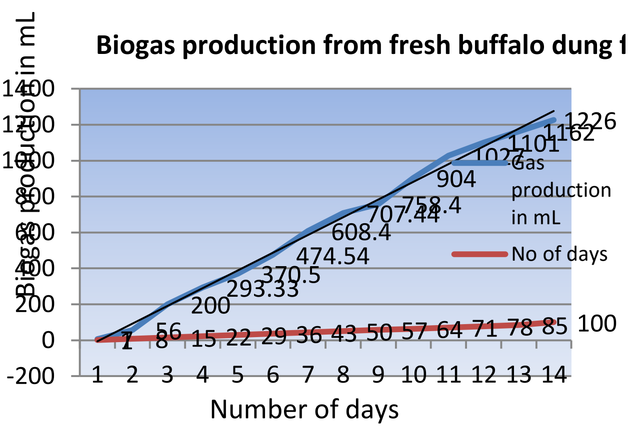

Figure 4. Biogas production from buffalo dung

For biogas production from partially degrading food and vegetable waste upto 1324 mL the biogas showed an exponential curve after which the curve obtained was liner (i.e after commencement of reduction in gas production). In case of buffalo dung linear curve was observed (indicated in figures 4 and 5), as well as biogas in fresh buffalo dung and degrading food waste)

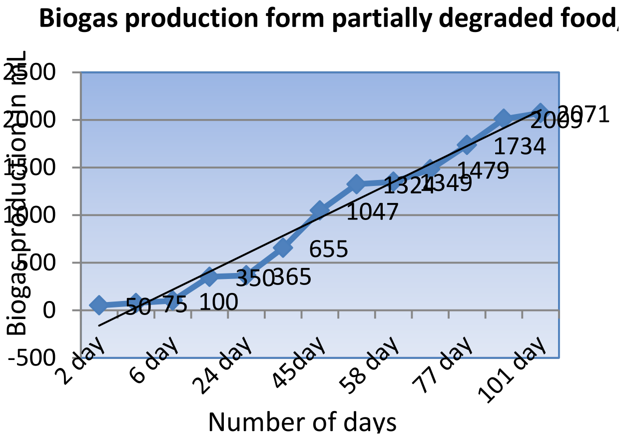

Fig 5. Biogas production from partially degrading food/vegetable waste

Initial waste slurry and the digested slurry: Initial constituents and final constituents of the wastes were analyzed for the following parameters, which have been indicated in Table 5a. Increase in moisture content, 96% and 97%, pH by 7.5 and 7.1 and phosphorous with an increase at 1.25 and 0.58 were recorded. The carbon content recorded being 0.88% and 0.21%, total solids of 4% and 3%, and volatile solids of 76.8% and 66.66% showed decreasing trend after biogas production (Table 5a). An increase in microbial count was observed as indicated in Table 5b.

Table 5a. Physico chemical properties of wastes for fresh buffalo dung and partially degraded food waste

	Physico chemical properties of wastes	For fresh buffalo dung	For fresh food waste	For digested buffalo dung	For partially degrading digested food waste
1	Moisture (%)	91.5	89	96	97
2	Carbon content (%)	16.46	3.19	0.88	0.2125
3	Total solids (TS) (%)	8.5	11	4	3
4	Volatile solids (VS) (%)	93.1	94.904	76.86	66.66
5	pH (at charging) & digested slurry	6.6	6.1	7.5	7.1
6	Total phosphorous mg/100g	0.26	0.3062	1.2566	0.5853

Table 5b. Microbial count of fresh buffalo dung and partially degrading food waste

	Microbial count	For fresh buffalo dung	For fresh food waste	For digested buffalo dung	For partially degrading digested food waste
1	**Total Viable Count**	1.584 x 10^3 (1584)	1.7127 x 10^3 (1712)	$2.47*10^4$ (2470)	$3.46*10^4$ (3460)

Amount of bio gas produced

Biogas production recorded from 11th and 15th day for both the sets of experiments; up to 24th day was 265mL for buffalo dung and 365 ml for partially degrading food/vegetable waste, indicating the latter to have higher degree of biogas production from the initial start. Carrying out biogas production from fresh buffalo dung and partially degrading food / vegetable waste by earthworm reported gas production from organic waste with 0.001324 m³ while that of buffalo dung with 0.000785 m³ in 53 days and 0.002090 m³ in 86 days for food/vegetable waste and 0.001047 m^3 for buffalo dung for 88 days. The observations shown and recorded

indicate partially degrading food/vegetable waste giving 1.5 times more biogas production in comparison to buffalo dung both calculated for a period of 53 days respectively.

Biogas production from buffalo dung shows 300 mL of gas production in the 1st 24 day, followed by 365 mL in the next 24 days, and 44 to 55 mL in 144 days. This shows maximum gas production during the second phase than compared to the 1st 24 day and the last 24th day respectively (Table 2). Good flammability was achieved all through.

50 g of buffalo dung liberated 1.367 L of biogas in 134 days, if the same was not used in the biogas digester the gas would escape into the atmosphere accounting for liberation of the gas leading to GHG emissions, major component of the gas escaping would be methane though initially there would be some amount of CO_2.

Another 50 g of partially decomposed food and vegetable waste liberated 2.071 L of biogas in 101 days indicating more gas production from food and vegetable waste. With anaerobic digestion, a renewable source of energy is captured, which has an important climatic twin effect one being use of renewable energy reduces the CO_2 emissions through a reduction of the demand for fossil fuels. Secondly at the same time, by capturing uncontrolled methane emissions, the second most important GHG is reduced. There by reducing emissions of GHG considerably.

The percentage of biogas in a partially degraded food / vegetable waste 15 day old produced more biogas with 2.071L in 101 days. If waste was decomposed rightly the gas production let to the atmosphere would have been reduced. This study indicates that fresh vermicompost in the ratio of 1: 3.4 (vermicompost and water) gave CO_2 production recorded to about 0.000084 m^3 (Table 4). The biogas production for 159 day old digester (from day of start i.e. 169 days) was about 1422 mL. In the other case of no biodegradation and just dump would lead to more gas release to the atmosphere especially when in contact with water under strict anaerobic conditions. If one were to trap energy and use it for better amount of energy production then anaerobic digestion would be the best as it has maximum potential for utilization.

From this study it is suggested that organic food / vegetable waste give a quicker gas production when they are partially degraded and put inside the bio digester after making proper slurry with addition of distilled water, which was used in the experimental set up. According to Biogas production (Habmigern 2003) most vegetable matter has a much higher carbon - nitrogen ratio than dung has, so some nitrogen (preferably organic) must generally be added to the vegetable matter, especially when batch digestion is used.

The cumulative biogas yield for the fresh buffalo dung with a retention period of 134 days was 0.001367 m^3 lesser in comparison with the cumulative biogas yield 0.002191 m^3 of the partially degrading food waste under a total of 128 day retention period with the same amount of waste being considered (50g). Partially degrading food and vegetable waste showed slow abruption in gas production while buffalo dung showed gradual reduction in gas production. 2071 mL of biogas production was recorded for partially degrading food and vegetable waste with an addition of 120 mL in the last stages (128 days) i.e. a total of 2191 mL with the last gas collection and 1367 mL of biogas production was recorded for buffalo dung under lab environment/conditions with an addition of 55 mL being recorded (over 159 days) i.e. 1422mL, after this biogas production completely stopped.

In this study the complete biogas production for 50g waste in (1:3.4) ratio went up to 25 weeks with a total of 1422 mL/1.422 litres of biogas production. Maximum gas production happened in the first 3 to 4 weeks.

According to ICAR and Winrock International, 1 m^3 cattle manure = 22.5 m^3 biogas = 146kWh gross = 36 kg CO_2 emission. If calculated with respect to our study for 50 g of buffalo dung taken the expected values to be obtained would nearly be 0.00112m^3 of biogas. As this study has maintained complete anaerobic conditions, carried out under lab scale and the experiments was terminated till the complete reactions took place i.e. biogas production/ completely digested. The results showed 0.00142 m^3 of biogas production from buffalo dung from that of 0.00112 indicating the difference to be 0.00030 m^3. That is complete gas utilization has been made use by burning the biogas obtained from buffalo dung equivalent to 0.05g of CO_2 emission and 0.93g of CH_4 all pertaining to buffalo dung in this study.

Veziroglu (1991) gives 0.45-0.65 m^3 gas produced per kg food waste with a methane content of 60-65 %. In case of food/ vegetable waste it would be nearly 0.0225 m^3 for 50 grams of food waste. The results obtained from our food waste experiment was about 0.002191 m^3 and the difference being 0.0203 m^3

When food is disposed in a landfill it quickly rots and becomes a significant source of methane, a potent greenhouse gas with 21 times the global warming potential of carbon dioxide (EPA, 2012).

According to ICAR and Winrock International 1 m^3 biogas (up to 655 CH_4) = 0.51 fuel oil = 1.6 kg CO_2 and 1m^3 biogas = 5.5 kg fire wood = 11 kg CO_2. This study correlates to nearly 1422 mL i.e. 0.00142m^3 biogas would give up to 0.93g of GHG which could have been liberated into the environment if anaerobic conditions were maintained with reference to buffalo dung. Thus reducing biogas production in such environments would reduce GHG and combating climate change to a great percent.

With reference to 1 m^3 biogas (up to 655 CH_4) = 0.51 fuel oil = 1.6 kg CO_2, our study shows 0.002191m^3 of biogas from food waste will be responsible for 1.435g of CH_4 and 0.00350g of CO_2 from food waste while biogas generated from buffalo dung would be responsible for 0.93g of CH_4 and 0.00227g of CO_2 from buffalo dung.

IV. Conclusions

Results of the study have seemed to be very useful in production of biogas from just 50 g of waste under laboratory conditions (29-35^{0}C) correlating towards the tapping potential of waste resource and reducing liberation of GHG's into the atmosphere which is happening around the globe when waste is not treated in the right way and disposed of inefficiently.

Findings clearly report that partially degrading food/ vegetable waste has higher biogas collection anaerobically as compared to biogas from buffalo dung though the buffalo dung was taken fresh and organic food waste was partially degrading.

Maximum biogas production is observed in the first 45 days. Amount of biogas produced with characteristic blue flame by fresh 50g buffalo dung and 50g partially degrading food/vegetable waste is able to produce 0.00142 m^3 and 0.00219 m^3 of biogas production for duration of 21/25 weeks under laboratory conditions with a ratio maintained at 1:3.4 (waste to water). Complete gas utilization has been made use by burning the biogas obtained from buffalo dung equivalent to 0.0018g of CO_2 emission (in general for biogas, 0.092 % of CH_4 and 0.00227g of CO_2) from buffalo dung all with respect to calculated amount of biogas of buffalo dung from this study.

It shows that 0.002191m^3 of biogas from food waste will be responsible for 1.435g of CH_4 and 0.00350g of CO_2.

In case of food/ vegetable waste it would be nearly 0.0225 m^3 for 50 grams of food waste. These experiments were carried out in the lab.

During 21 week the biogas production from food/ vegetable waste was 2071 mL and for buffalo dung 1367 mL biogas production respectively. Biogas production was checked for another 2 and a half weeks and the total gas production was 1422 mL and 2191 mL for buffalo dung and degrading food / vegetable waste.

By sustainable biogas technology the research findings show reduction in escape of gases and contribution towards the minimization of the GHG which would have otherwise accounted for a direct release of 1.412 L of biogas form buffalo dung and 2.191 L of biogas release form partially degrading food/vegetable waste directly into the atmosphere when providing favorable anaerobic conditions.

This would otherwise get into the atmosphere from various sources like improper waste management practices, landfill, waste not decomposed properly or not allowed to decompose in the right manner, thus contributing to the liberation of GHG.

From this study biogas digester on a lab scale set up for buffalo dung and food/vegetable waste shows reduction in the amount of methane directly released into the atmosphere, by trapping it and utilizing the energy for beneficial purposes there by reducing GHG emission on large scale with recycling energy in a way leading to energy conservation. There is a need for conservation of energy and its utilization as landfills contribute to 21% of GHG. Small contribution from us can mitigate GHG's to a greater extent.

Fulfilling the main objective by showing the amount of GHG's which could be avoided getting into the atmosphere. Thus, indicating percentage of reduction of GHG's gas emissions into the atmosphere from these sources (using 50g waste in this laboratory set up as energy).

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