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Effects of Substrate Variation on Methane and Carbon-Dioxide Production in a Biogas Plant

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ABSTRACT

The study has attempted to observe three models of biogas system using twenty liter plastic containers as digesters with Cow Dung (CD) and Poultry Droppings (PYD) organic wastes. The cow dung and poultry dropping were mixed separately with water in a ratio of 1:1 (v/v) and the slurry was properly stirred. Thereafter Treatments A, B, C, D and E were prepared using previously made slurry with the following specific proportions as (100% CD + 0% PYD), (75% CD + 25% PYD), (50% CD + 50% PYD), (25% CD + 75% PYD) and (0% CD + 100% CD). Three replicates were carried out for each sample. The plant consists of the fermentation chamber, the inlet and outlet pipe, the gas pipe and the stirrer. The samples were tested for methane and carbon dioxide productions along with pH and Temperature for 31days. Treatment D which is a mixture of (25% cow dung and 75% poultry droppings) produced more methane than the rest of the treatments. 96.08%. The cumulative methane yields of treatments D, A, C, E and B were 96.08%, 83.16%, 72.3%, 46.9% and 36.04% respectively. The order of both methane and carbon dioxide productions production was 25% CD + 75% PYD > 100% CD + 0% PYD > 50% CD + 50% PYD > 0% CD + 100% PYD > 75% CD + 25% PYD. The study revealed further that the mixture of Cow Dung and Poultry Droppings as waste was great potentials for generation of biogas and its use should be encourage due to its early retention time and high volume of biogas yields than other organic waste. Also in this study, it was found that temperature variation, pH and some of the factors that affected the volume yield of biogas production. The main objectives of this study were to evaluate the variation of methane and carbon-dioxide production from Cow Dung and Poultry Droppings both individually and combined as substrates and also to find out the suitable substrates composition for biogas production.

1. Introduction

The use of electricity as advanced forms of energy, has improved the quality of human lives around the world. However, the majority of the people in developing countries do not easily access such forms of energy and, therefore, they entirely depend on solid fuel forms like wood and liquid fuel forms like Kerosene, Petrol etc. to meet their basic needs such as cooking and lighting. A study by GTZ (2007) revealed that about 90% of all household energy consumption is used for cooking purposes in developing countries [1]. To meet the basic needs such as cooking and lighting, the demand of Biogas is increasing day by day in developing countries especially in Bangladesh because of increasing cattle and poultry firms. An anaerobic digestion method produces Biogas as a clean renewable energy from organic wastes. Biogas when further refined burns as well as liquefied gas, but does not add to global warming like liquefied natural gas [2]

Usually 50-65% methane, 35-50% carbon dioxide are involved in Biogas [3]. A study by Lawbury, 2001, disclosed that approximately 60% methane (CH4) and 40% carbon dioxide is produced with traces of other gases such as hydrogen, nitrogen and hydrogen Sulphide [4]

In 2009, an experimental with mixing of Pig and Cow Dung were used by individually 100% cow dung (A), 100% pig dung (B) each substrates and mixture of 50% cow dung and 50% pig dung (C), 25% cow dung and 75% pig dung (D), 75% cow dung and 25% pig dung (E) and this study revealed that the 100% pig manure produced more gas per unit weight as compared to the 100% cow dung [5]. Treatment A, B, C, D and E showed that pH for the initial slurry varied within the range of 6.5 and 6.6 while the final ranged between 5.7 and 6.8 [5].

In 2011, Ezekoye, V. A., Ezekoye, B.A., and Offor P.O. observed the effect of retention time on biogas production from poultry droppings and cassava peels, and finally disclosed it from experiment data that an initial increase in biogas production during the first 5 days to 15 days, then it showed somewhat constant rate for the next 20 days to 30 days and a final (almost exponential) decline [6].

In 2012, an experiment for observing comparative study of biogas production with cow dung, cow pea and cassava peeling using 45 litres biogas digester were done and revealed

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it that Cow dung yield showed the highest biogas with methane content of 67.9%, Cow pea yielded 56.2% methane content and lowest methane content was produced by cassava peelings with 51.4% [7]

In 2013, Chrish, K. observed the variation of methane and carbon dioxide yield in a biogas plant by using cow dung and pig dung and revealed that the mixture of 50% cow dung and 50% pig dung produced more highest methane yield by volume was 61.2% [8].

Livestock population in Bangladesh is currently estimated to comprise 25.7 million cattle, 0.83 million buffaloes, 14.8 million goats, 1.9 million sheep, 118.7 million chicken and 34.1 million ducks [9]. In Bangladesh, 83.9 percent of total households own livestock (animals or poultry or both). About 45.9 percent households possess bovine stack, and 76.3 percent possess poultry. On average, each household owns 1.52 bovine animals, 0.9 goat and sheep and 6.8 chicken and ducks. [9].

About 40 liters (0.04 m3) gas can be obtained from one kg of cow dung and 60 liters (0.06 m3) gas can be obtained from one kg of poultry droppings per day. Based on this calculation, it is possible to get 3.0 × 109 m3 of gas which is equivalent to 1.7×106 tons of kerosene or 3.25 ×106 tons of coal. Beside this, a noticeable amount of biogas can be produced from the excrement of man, goat, ram etc. and waste, water-hyacinth or aquatic plant. Cow dung has high nitrogen content and because of pre-fermentation in the stomach of ruminant, and has been also revealed to be most compatible material for high yield of biogas through the study made over the years [10].

The objective of this study was to investigate the biogas production capacity along with effects of pH, temperature and also antagonistic and synergistic effects of Cow dung, and Poultry droppings by preparing three models with (100% CD + 0% PYD), (75% CD + 25% PYD), (50% CD + 50% PYD), (25% CD + 75% PYD) and (0% CD + 100% CD).

2. Materials and Methods

The study has attempted to observe three models of biogas system with different mixing ratios by Cow Dung and Poultry Droppings. The models of biogas systems were conducted in the laboratory using twenty liter plastic containers as digesters, which were durable and potable for waste management. Three replicates were carried out for each sample. The mean results from three models are used to observe the performance of different substrates or treatments.

2.1 Substrate Preparation

The study was carried out at Bangladesh Rural Development Academy (RDA), Bogra, Bangladesh. Substrates utilized in this research were cow dung (CD) and poultry droppings (PYD). The fresh cow dung and poultry droppings were collected from RDA Farms and then taken immediately to RDA Laboratories, for substrate analysis. The substrates (cow dung and poultry droppings) were checked for stones or other unnecessary materials before mixing with water. The cow dung and poultry dropping were mixed separately with water in a ratio of 1:1 (v/v) and the slurry was properly stirred. The amount of 50% water was fixed after determining the moisture content of both cow dung and poultry dropping. Thereafter Treatments A, B, C, D and E were prepared using previously made slurry with the following specific proportions as shown in Table 1.

Table 1. Proportions for Different Treatments

Mixture Proportions / Substrates composition	Treatment
100% cow dung	A
75% cow dung and 25% poultry droppings	B
50% cow dung and 50% poultry droppings	C
25% cow dung and 75% poultry droppings	D
100% poultry droppings	E

2.2 Experimental Procedure

The experiments were conducted in the laboratory using twenty liter plastic containers as digesters, which were durable and potable for waste management.

Fig 1. Experimental set up for Treatments A, B, C, D and E.

The plant consists of the fermentation chamber, the inlet and outlet pipe, the gas pipe and the stirrer. The performance of digester monitored for 31 days. The anaerobic fermentation chamber involving the degrading of the organic wastes (cow dung and poultry dropping) by the action of various microbes of different sizes and functions, leading to the production of biogas in the absence of oxygen was achieved and the organic wastes were also allowed to stabilize. The prevailing temperature range was 26 to 31°C during the period of study.

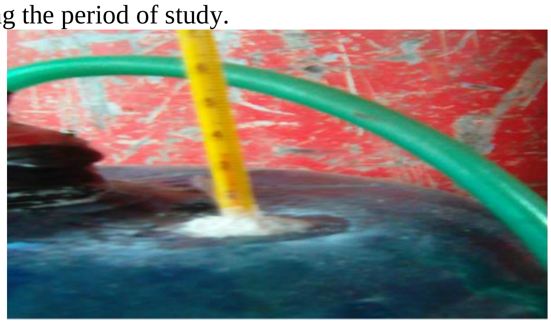


Fig 2. Included Thermometer in the Container

The pH of the mixtures was measured with a digital pH meter. There was a thermometer in each container to monitor temperature variations shown in figure 2.An exit pipe with inlet and outlet valves was provided at the top of the smaller cylindrical portion of the containers for biogas collection and measurement shown in figure1.Produced gases were collected in a tube and the percentage of Methane (CH_4), percentage of Carbon Di-oxide (CO_2) gas were measured by using gas analyzer (GAP 2008T) till 31observation days shown in figure 3.

Fig 3. GAP 2008T Gas Analyzer Used in the Experimental Works

The GA200plus Gas analyzer was switched off by a long press on the on/off button for about 15 seconds after taking each reading due to carry out clean air purge.

3. Results and Discussions

In this study, mainly we focused the variation of methane and carbon-dioxide production from Cow Dung and Poultry Droppings both individually and combined as substrates and also observed the suitable substrates composition for biogas production. The mean results of the three replicates for each sample are presented in Tables 2 and 3.

According to Lund, A, 1996,satisfactory gas production took place in the mesophilic range which is between 25^0 C to 35^0 C [11] but the observed temperatures in the digester were within ranged between 26^0C and 30^0C, which greatly reduced the production of methane since the optimum temperature (35^0 C) was not reached.

The optimum range of pH for optimum biogas production is between 6 and 7 [12].The initial and final pH of A, B, C, D and E treatments are shown in Table 3.

Table 2. Mean Values of Methane (%) and Carbon Di-oxide (%) and Temperature with Time for Treatments A, B, C, D and E.

Subs trates	A (100% Cow dung)			B (75% Cow dung & 25%Poultry droppings)			C (50% Cow dung & 50% Poultry droppings)			D (25% Cow dung & 75% Poultry droppings)			E (100% Poultry droppings)		
Time (Days)	CH_4 (%)	CO_2 (%)	Tem 0^0C	CH_4 (%)	CO_2 (%)	Tem 0^0C	CH_4 (%)	CO_2 (%)	Tem 0^0C	CH_4 (%)	CO_2 (%)	Tem 0^0C	CH_4 (%)	CO_2 (%)	Tem 0^0C
1	0.0	0.0	26.5	0.0	0.0	26.2	7.83	0	26.2	0.0	0.0	26.3	0	0	26.2
2	0.0	0.0	27.3	8.0	6.8	27.2	11.9	7.86	27.1	8.1	5.2	27.0	12.2	8.4	27.7
3	3.1	10.5	27.2	8.4	7.8	27.1	12.8	8.23	27.0	7.0	7.5	26.7	41.9	31.5	27.2
4	20.2	20.1	27.4	8.6	6.5	27.8	16.06	13.5	27.6	13.5	11.3	27.0	52.3	33.5	27.3
5	30.03	19.4	28.13	8.10	7.06	27.9	9.71	8.9	27.3	22.6	18.2	27.7	41.9	30.1	27.9
6	31.8	21.4	27.7	8.8	8.3	27.8	18.5	14.96	27.7	17.9	14.6	27.7	24.9	17.5	27.9
7	30.33	18.83	26.43	8.26	6.1	26.7	19.76	15.76	26.8	24.7	18.0	26.4	18.1	14.7	26.7
8	30.9	20.6	27.5	11.5	8.3	27.5	20.6	14.93	27.3	21.7	17.0	27.3	16.0	13.9	27.0
9	39.10	28.43	28.1	16.03	11.23	28.1	22.3	14.8	27.7	21.8	16.1	28.2	16.8	14.8	27.7
10	45.8	27.6	29.1	14.26	10.53	29.0	24.9	13.8	21.1	19.5	14.6	28.5	19.2	16.4	28.5
11	50.43	32.23	29.5	12.26	7.8	29.2	28.9	15.6	29	14.63	11.5	29.5	20.1	18.0	29.0
12	52.2	39.0	29.3	16.23	11.3	29.1	15.9	9.97	29.1	27.93	18.1	29.0	21.8	18.1	29.3
13	23.23	17.23	28.47	21.3	16.7	28.3	16.10	12.33	28.5	13.23	9.17	28.5	12.2	8.11	28.3
14	27.2	18.5	28.4	14.2	10.0	28.8	18.83	13.03	28.9	35.8	28.2	28.4	12.1	8.16	28.0

Subs trates	A (100% Cow dung)			B (75% Cow dung & 25% Poultry droppings)			C (50% Cow dung & 50% Poultry droppings)			D (25% Cow dung & 75% Poultry droppings)			E (100% Poultry droppings)		
Time (Days)	CH_4 (%)	CO_2 (%)	Tem 0^0C	CH_4 (%)	CO_2 (%)	Tem 0^0C	CH_4 (%)	CO_2 (%)	Tem 0^0C	CH_4 (%)	CO_2 (%)	Tem 0^0C	CH_4 (%)	CO_2 (%)	Tem 0^0C
15	26.4	26.4	28.0	13.5	9.4	28.0	25.5	20.4	28.0	43.1	33.0	28.0	13.1	9.2	28.0
16	28.2	28.2	29.0	13.5	9.8	29.0	24.2	20.1	29.0	11.8	8.6	29.0	13.4	9.9	29.0
17	24.2	20.2	29.5	12.2	8.2	29.4	33.3	23.2	29.2	34.2	24.2	29.5	13.7	10.8	29.5
18	30.6	24.4	30.0	11.9	8.1	30.0	55.8	39.7	30.0	22.3	17.2	30.0	11.3	8.2	30.0
19	29.1	23.8	29.5	10.2	8.2	29.5	30.2	22.2	20.3	21.2	14.4	29.5	9.2	8.8	29.3
20	27.4	22.3	28.0	9.5	9.0	28.0	29.2	21.5	28.4	30.1	22.0	28.5	8.2	9.9	28.6
21	29.7	23.8	28.5	8.2	10.2	28.5	28.3	20.2	28.5	44.2	28.5	28.5	8.0	9.0	28.5
22	34.1	28.2	29.0	18.2	16.2	29.0	32.7	23.0	29.0	50.6	40.2	29.2	7.5	8.5	29.0
23	40.1	31.8	29.5	13.4	9.3	29.5	31.9	22.5	29.5	48.2	35.2	29.0	7.0	7.5	29.0
24	35.7	30.2	28.0	14.3	10.2	28.5	33.6	24.3	28.0	44.8	31.5	28.0	6.6	6.5	28.5
25	34.2	27.2	28.5	13.6	9.8	28.5	34.7	22.3	28.5	41.8	30.3	28.5	6.5	6.0	28.0
26	31.8	24.0	27.5	12.2	9.3	27.5	32.2	21.2	28.0	40.4	28.0	28.0	6.2	6.0	28.5
27	25.6	17.8	29.0	12.1	8.3	29.0	12.1	8.3	29.0	47.9	38.5	29.0	6.0	6.5	29.0
28	16.6	11.8	28.5	11.2	8.2	28.5	21.4	12.5	28.5	55.6	41.2	28.5	5.5	5.0	28.5
29	11.5	8.2	30.0	10.2	7.2	30.0	17.8	7.5	30.0	61.3	38.2	30.0	5.0	5.5	29.5
30	11.3	8.1	29	9.8	7.3	29	17.2	7.8	29	58.5	37.8	29	5.5	5.0	28.5
31	10.8	8.2	29.5	9.7	7.4	29.5	16.8	7.8	29.5	56.5	37.5	29.5	5.0	4.0	29.0

Table 3. pH for the Different Treatments.

Treatment	Initial (pH)	Final (pH)
A(100% Cow dung)	6.7 ,6.9,6.6 Average pH The optimum range of pH for optimum biogas production is between 6 and 7 [12].The initial and final pH of A, B, C, D and E treatments are shown in Table 3. = 6.73	6.5, 6.8, 6.6 Average pH= 6.63
B (75% Cow dung & 25% Poultry droppings)	6.8, 6.9, 6.7 Average pH= 6.8	6.3, 6.5, 6.2 Average pH= 6.33
C (50% Cow dung & 50% Poultry droppings	6.4, 6.5,6.5 Average pH= 6.47	5.8, 6.1, 5.9 Average pH= 5.93
D (25% Cow dung & 75% Poultry droppings)	7.4, 6.9, 7.2 Average pH= 7.16	7.1, 6.5, 6.8 Average pH= 6.8
E (100% Poultry droppings)	7.5, 7.1, 7.4 Average pH= 7.33	5.9, 6.1, 6.2 Average pH= 6.06

In this study, pH for the initial slurry varied within the range of 6.73 and 7.33, the final ranged between 5.93 and 6.8 (Table 3). Thus, the experiment was conducted within the optimum pH range for optimum methane production except Treatment C because of showing final pH below 6. Since the final pH of Treatment C was 5.93 and it was closed to 6 therefore the effect of pH in Methane production on Treatment C was not significance. A study by Jain et al. (1998) revealed that the efficiency of methane production was more than 75% when the substrate slurry pH was above 5.0 [13]. Furthermore, it had also observed that biogas production was only significantly affected when the pH of the slurry decreased to below 5.0. [5]

3.1 Digester Performance and Biogas Production Capacity of Different Treatments

Treatment A

100% cow dung and 0% poultry droppings was used in Treatment A. Methane gas production on the first day was 0% and highest was 52.2% on 12th day. Methane production of sample A gradually increased till pick value within 12 days and then rapidly falls within 13 days, after 13 days Methane production gradually increase till 23 days except 17th day and then falls rapidly till last observation day (31th day). Methane production on 31th day was 10.8%.The corresponding temperatures (^{0}C) on 12th, 13th and 31th days were 28.47, 29.3 and 29.5 respectively and the variation in temperature for whole experimental days was very low.

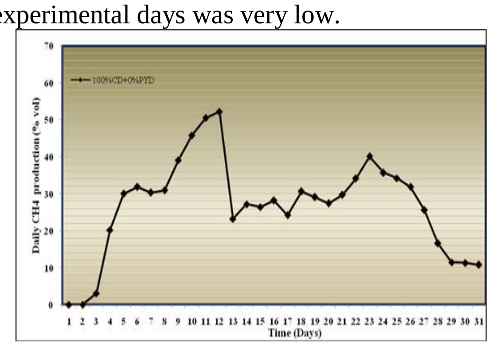


Fig 4(a). Methane Gas Production with Time for Treatment A

Treatment B

Treatment B was prepared with 75% cow dung and 25% poultry droppings. Methane gas production on the first day was 0% same as treatment A and highest was 21.3% on 13th day. Methane production for Treatment B had no significance variation till 31 observations days and Methane production was comparatively very low. Methane production on 31th day was 9.7%. The variation in temperature for whole experimental days was low. The maximum and minimum temperatures (^{0}C) were 30 and 26.2 respectively. This study revealed that Treatment B will not be economical for Methane production because of very low production capacity and also disclosed it that the Methane production capacity of cow dung is reduced because of adding about 25% of poultry dropping with cow dung.

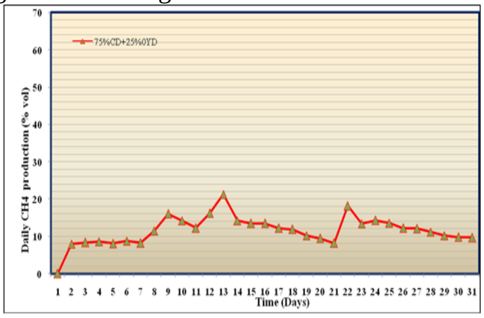


Fig 4(b). Methane Gas Production with Time for Treatment B

Treatment C

50% cow dung and 50% poultry droppings was used in Treatment C. Methane gas production on the first day was 7.83% where Treatment A and B showed zero and highest was 55.8% on 18th day. Methane production of sample C showed lowest variation till 17 days, after 17 days pick value was observed within 1 day and then rapidly falls within next 1 day.

Methane production of sample C both rises and also falls after 18 days and till last observation day (31th day). Methane production on 31th day was 16.8%.

This study revealed that Treatment C will be economical comparatively than Treatment A, B and E for Methane production because of comparatively good production capacity and also disclosed it that the Methane production capacity of cow dung is increased due to increasing amount of poultry dropping about 50% by reducing of amount of cow dung.

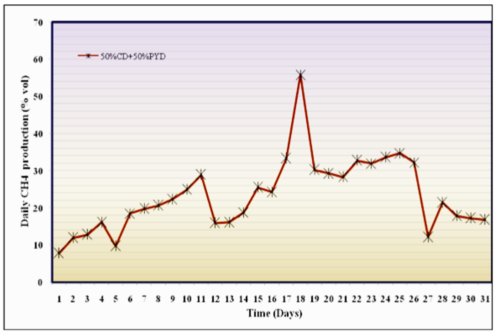


Fig 4(c). Methane Gas Production with Time for Treatment C

Treatment D

In Treatment D, 25% cow dung and 75% poultry droppings was used. Methane gas production on the first day was also zero same as Treatment A and B and highest was 61.3% on 29th day. Methane production of sample D gradually increased till almost whole observation period with rise and fall in some days.

Methane production on each day for Treatment D was largest than Treatment A, B, C and E outside of few days. This study disclosed that Treatment D will be more economical than

Treatment A, B, C and E for Methane production because of good production capacity and also disclosed it that the Methane production capacity of cow dung is increased due to increasing amount of poultry dropping about 75% by reducing of amount of cow dung.

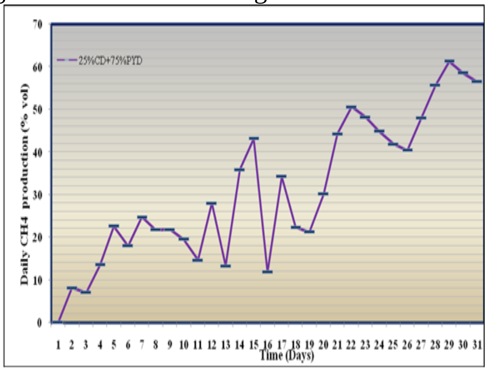


Fig 4(d). Methane Gas Production with Time for Treatment C

Treatment E

Treatment E was prepared with 0% cow dung and 100% poultry droppings. Methane gas production on the first day was zero same as Treatment A, B and D and highest was 52.3% on 4th day.

Methane production of sample E rapidly increased till pick value within 4 days and then rapidly falls within 7 days, after 7 days Methane production decreases gradually. Methane production on 31th day was 5.0%. Methane production capacity of Treatment E showed comparatively lowest value on each observation day than others all Treatment outside of 3th, 4th and 5th observation days.

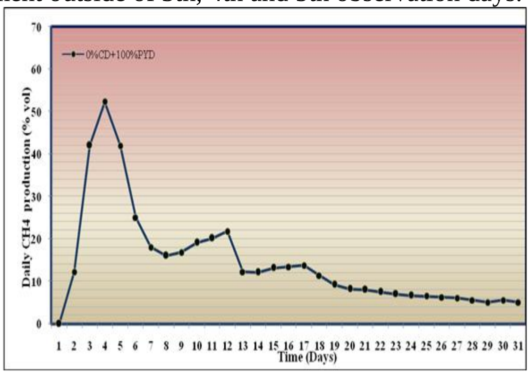


Fig 4(e). Methane Gas Production with Time for Treatment C

3.2 Relative Variation in Methane (CH_4) Production.

Figure 5 showed the relative variation in methane production. From Figure 5(a), Treatment E (0.0% CD + 100% PYD) digester showed the highest methane yield 52.3% till 4 days, where Treatment E (100% CD + 0.0% PYD) digester showed methane yield 2.33% due to slower degradation than Cow dung. After 4 days, the Methane gas production of Treatment A was greater than Treatment B. This outcome also agrees well with Marchaim (1992). According to study outcome of Marchaim that poultry waste degrades faster than cow dung [14]. However, on the 12th day, Treatment A showed the highest methane yield 52.2%, where Treatment E showed methane yield 21.8%. The cumulative yields on 31[th] day of Treatment A and E were 83.16% and 38.13% respectively.

Therefore, the ability of cow dung to produce more biogas than poultry droppings and variation in gas production between them was also high with respect to time.

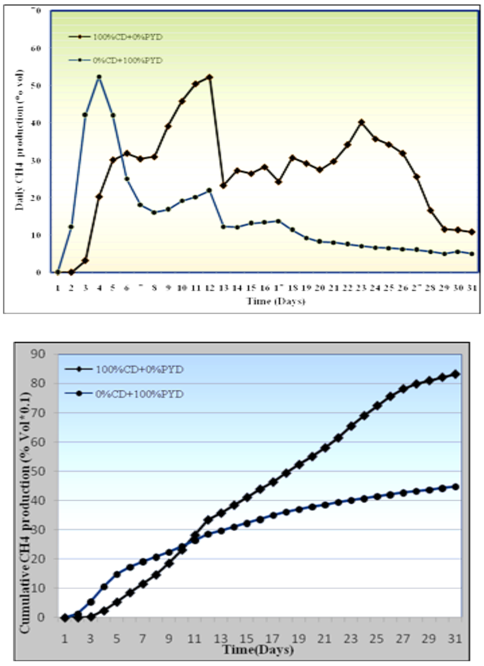


Fig 5(a). Showing Relative Variation of Methane Production Daily and Cumulative with Time for Treatments A and E

From Figure 5 (b), Treatment A (100% CD + 0% PYD) digester showed highest methane yield 52.2% till 12 days, where Treatment D (25% CD + 75% PYD) digester showed methane yield 27.93%. After 20days, the Methane gas production of Treatment D was greater than Treatment A. However, on the 29th day, the Treatment D showed highest methane yield 61.3%, where Treatment A showed methane yield 11.5%. At the interim, Treatment A and D showed low variation.

The cumulative yields on 31[th] day of Treatment A and D were 83.16% and 96.08% respectively but Treatment A showed higher cumulative yield than Treatment D till 28 days.

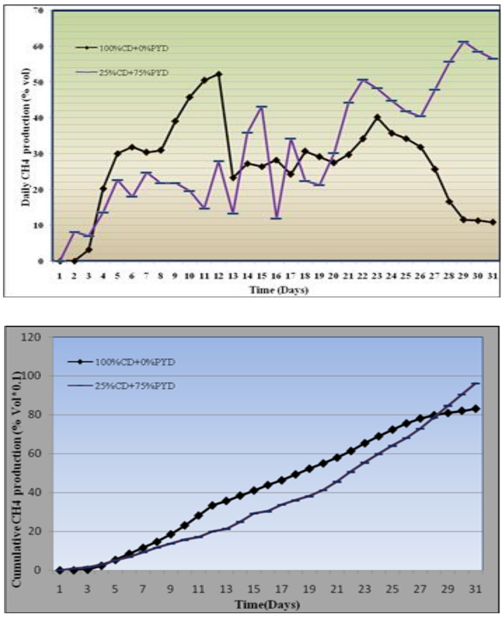


Fig 5(b). Showing Relative Variation of Methane Production Daily and Cumulative with Time for Treatments A and D

The relative variation of Methane production daily and cumulative with time for Treatments A and C was shown in figure 5 (c). Except 5 to 11 and 18[th] days, the relative variation between Treatment A and E was very low.

The cumulative yields on 31th day of Treatment A and E were 83.16% and 72.1% respectively. It was also observed that the variation in cumulative Methane gas production between them was comparatively lowest.

Therefore, ability of cumulative biogas productions capacity comparatively low for increasing the amount of PYD till 50% by decreasing the amount of CD

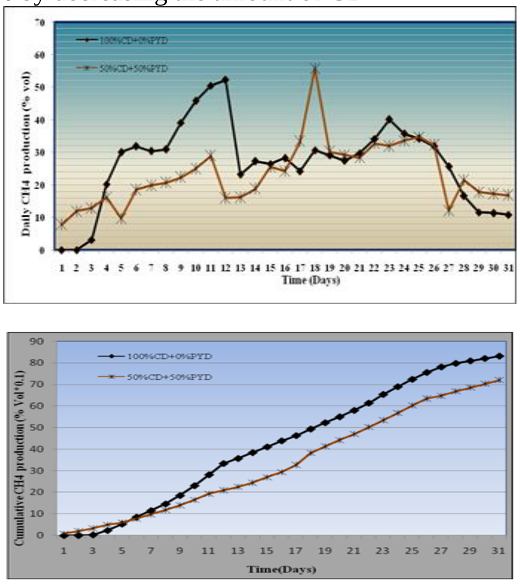


Fig 5(c). Showing Relative Variation of Methane Production Daily and Cumulative with Time for Treatments A and E

From Figure 5 (d), it may be observed that the Treatment B (75% CD + 25% PYD) digester showed the highest methane yield 21.3%, where Treatment D (25% CD + 75% PYD) digester showed methane yield 13.23%. Except 13th and 16th days, Treatment D showed higher Methane gas production capacity than Treatment B and the variation was very high.

The cumulative yields on 31th day of Treatment B and D were 36.04% and 96.08% respectively. It was also observed that the Treatment B digester failed to produce significance gas in some days during the experiment.

Therefore, ability of biogas productions capacity comparatively very low for increasing the amount of CD till 75% by decreasing the amount of PYD

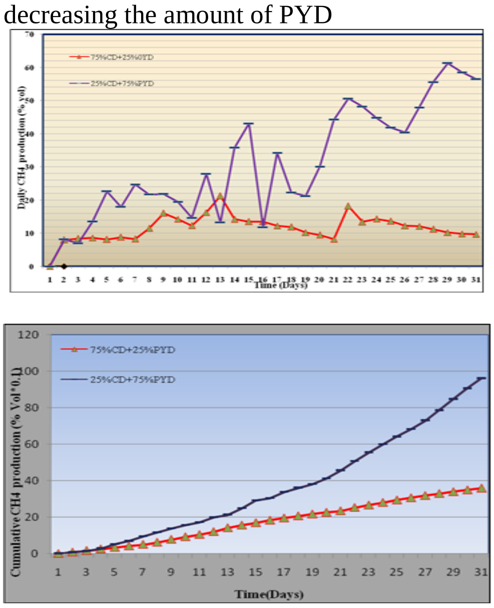


Fig 5(d). Showing Relative Variation of Methane Production Daily and Cumulative with Time for Treatments B and D

This section summarized the Methane gas production capacity both daily and cumulative and also variation among all Treatments by taking facilitation from figure 6.

Treatment D with 25% cow dung and 75% poultry droppings produced more methane than the rest of the treatments on the 29th day of digestion. The highest methane production from sample A, B, C, D and E were 52.2% on 12th day, 21.3% on 13th day, 55.8% on 18th day, 61.3% on 29th day and 52.3% on 4th day respectively.

Treatment D produced more cumulative Methane gas than the rest of the treatments and its highest cumulative Methane yield by volume was 96.08%. This was followed by treatments A, C, E and B and these were obtained with cumulative methane yields of 83.16%, 72.3%, 46.9% and 36.04% respectively.

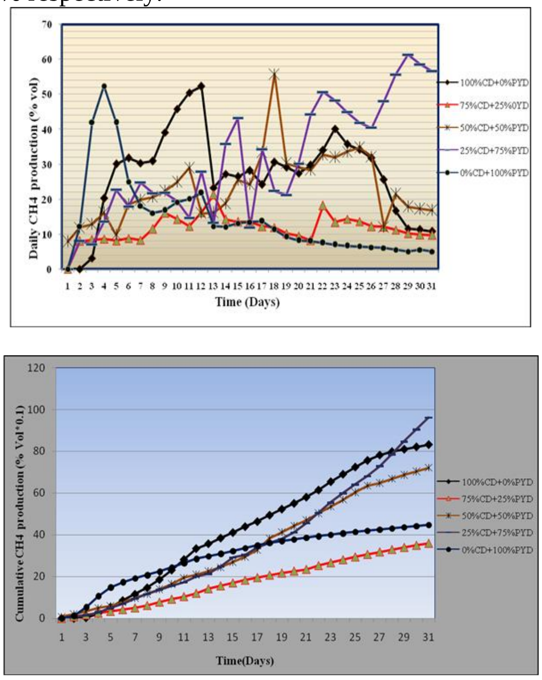


Fig 6. Showing Variation of Methane Production Daily and Cumulative with Time for Different Treatments

Ultimately, this study disclosed that the order of Methane gas production is 25% CD + 75% PYD > 100% CD + 0% PYD > 50% CD + 50% PYD > 0% CD + 100% PYD > 75% CD + 25% PYD.

Although, treatment D (25% CD + 75% PYD) provided maximum cumulative yield, but treatment A (100% cow dung and 0% poultry droppings) provided maximum cumulative yields from 11 days to 28 days.

Therefore, Biogas yield was significantly influenced by co-digestion of the substrates and unit any substance either cow dung or poultry dropping don't have best capacity to produce more gas.

3.3 Co-digestion Performance along with Antagonistic and Synergistic Effects

Table 4 illustrates the synergistic and antagonistic effect of co-digestion of cow dung with poultry droppings. The co-digestion improved the treatment efficiencies with higher cumulative biogas production for 50% CD + 50% PYD and 25% CD + 75% PYD mixtures, however the 75% CD + 25% PYD digestion mixture was less than both cow dung and poultry droppings single substrate digestion, this could be as a result of antagonistic effects. The synergistic mixture effects of the substrates is pronounced in the 50% CD+50% PYD digestion mixture; there was 8.16% improvement in biogas production in the 50% CD+50% PYD digester compared to the baseline digesters.

There was also 41.75% increase in gas production for the 25% CD + 75% PYD mixtures which represent the optimum digestion mixture. However, the positive mixture effect of the substrates marked by increase in gas production in this research work is observed with increase in poultry droppings in the digestion mixtures. This showed that co-digestion significantly improved the biogas yield in this research work

Table 4. Antagonistic and Synergistic Effects of Co-digestion of Cow Dung and Poultry Droppings

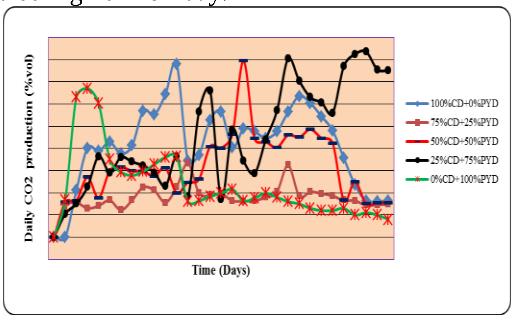
Digesters (CD:PYD)	Co-digestion %	Biogas Performance			
		CD (%)	PYD (%)	Increase (%)	Remarks
100:0	-	83.16	-	-	
75:25	36.04	62.37	11.18	-37.51	
50:50	72.1	41.58	22.36	8.16	
25:75	96.08	20.79	33.54	41.75	Highest gas yield
0:100	-	-	44.72	-	

3.4 Relative Variation of Carbon Di-oxide (CO_2) Gas Production with Time.

This section discussed the carbon dioxide gas production capacity both daily and cumulative and also variation among all Treatments by taking facilitation from figure 7

Treatment D with 25% cow dung and 75% poultry droppings produced more carbon dioxide (41.8%) than the rest of the treatments on the 29th day of digestion.

It was followed by Treatment A with 39.0% which was observed on the 12th day of digestion, Treatment C with 39.0% which was observed on the 12th day of digestion and E was with 33.5% which was observed on the 4th day. The lowest (CO_2) production was 16.7% on the 13th day of digestion for treatment B with 75% cow dung and 25% poultry droppings. The Methane gas production for Treatment D was also high on 29th day.



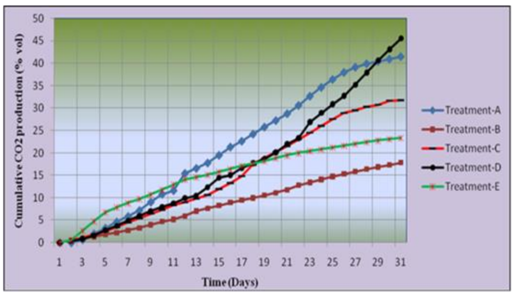


Fig 7. Showing Variation of Carbon di-oxide Gas Production Daily and Cumulative with Time for Different Treatments

Ultimately, this study disclosed that the order of carbon dioxide gas production is 25% CD + 75% PYD > 100% CD + 0% PYD > 50% CD + 50% PYD > 0% CD + 100% PYD > 75% CD + 25% PYD and this order was also similar for Methane gas production.

4. Conclusions

This study may be revealed that there was a strong possibility to enhance the biogas production under field conditions. It appears from the study that substrates ratio, hydraulic retention time, p^H value and temperature could be effective for biogas production in biogas plant.

The major conclusions may be summarized as follows:

i) The maximum (Cumulative) biogas production potential for the cow dung and poultry dropping mixture was in the order of 25% CD + 75% PYD > 100% CD + 00% PYD > 50% CD + 50% PYD > 00% CD + 100% PYD > 75% CD + 25% PYD and in shortly (D>A>C>E>B).

ii) A good productivity of methane for mixture of 25% cow dung and 75% poultry droppings was found to be 61.3% by volume within the period of study.

iii) Treatment D with 25% cow dung and 75% poultry droppings showed maximum methane production than the rest of the treatments on the 29th day of digestion. The average maximum methane production from sample A, B, C, D and E were 52.2%, 21.3%, 55.8%, 61.3% and 52.3% with respectively was 12th,13th ,18th,29th and 4th days.

iv) The study revealed further that cow dung and poultry droppings as waste was great potentials for generation of biogas and its use should be encourage due to its early retention time and high volume of biogas yields. Also in this study, it was found that temperature variation, pH and some of the factors that affected the volume yield of biogas production.

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