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Analysis of Production of $CH_4$and $CO_2$from Food Waste (MSW) by Anaerobic Digestion (Dry System) Under Mesophilic Condition

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Abstract - The aim of this study to understand the usability of organic portion of municipal solid waste (MSW) mainly residential waste (food waste) to find the amount of methane gas that can be produced from the residential waste and the process by which methane gas can be produced as a biogas is anaerobic digestion, soothe objective is to find the amount of biogas (methane gas) produced from food waste which is considered as residential waste and is a part of municipal solid waste. Although the gas obtained from anaerobic digestion are many but the mainly component parts of gas consists of methane (55%) and carbon dioxide (45%) and traces of sulphur dioxide [1]. In the study we considered dry systems based upon percentage of dry matter present in total solid content. Wet system contains dry matter 10-15% whereas the amount of dry matter present in dry system is 20-40%. For the experiment, intended for the analysis five sets of digesters are considered for the dry system. The ranges for the percentage of dry matter taken were 25%, 28%, 31%, 34%, and 37%.

Keyword - Anaerobic digestion, MSW, Food Waste, Dry System, methane.

1. INTRODUCTION

Anaerobic digestion (AD) is historically one of the oldest processing technologies used by mankind. Until the 1970s, it was commonly used only in the wastewater treatment plants waste management [1]. The amount of generated solid waste continuously increases and due to the large environmental impacts of its improper treatment, its management has become an environmental and social concern. Rapid biodegradation of the organic fraction of the MSW is of key importance to identify environmental more responsible way to process it rather than land filling or composting it. Anaerobic digestion has the advantage of biogas production and can lead to efficient resource recovery and contribution to the conservation of non-renewable energy sources. Furthermore, anaerobic digestion is closed and controlled process and based on fugitive emissions is more preferable than land filling and aerobic composting [2].

Food waste is one of the single largest categories of municipal solid waste (MSW). It comprises 12.4 % of the total municipal solid waste (MSW) [3]. Diverting a portion of food waste from landfills can provide a significant contribution toward achieving EPA, and local mandated solid waste diversion goals. In addition, diverting food waste from landfills prevents uncontrolled emissions of its breakdown products, including methane—a potent greenhouse gas [4-7]. Currently the principal technology for recycling the food waste is composting. While composting provides an alternative to landfill disposal of food waste, it requires large areas of land; produces volatile organic compounds (smog precursors), which are released into the atmosphere; and consumes energy [8]. Consequently, better recycling alternatives to composting food waste should be explored. Anaerobic digestion has been successfully used for many years to stabilize municipal organic solid wastes, and to provide beneficial end products, i.e., methane gas and fertilizer [9-11]. The digesters used in anaerobic digestion could provide an opportunity to recycle post-consumer food waste while producing renewable energy and reducing greenhouse gas emissions. In most cases if the purpose of the digestion is to produce biogas i.e. methane gas then the slurry (mixture of waste and water) used in the digesters are pig dropping, cattle waste chicken dropping etc. In this study we have considered organic portion of MSW as the raw material for Anaerobic Digestion. Although the experiment is imprecise and may yield only a small quantity of methane, it will familiarise us with the digestion process and, possibly, encourage us to investigate the construction of larger-scale generators that will produce usable quantities of gas [12-15].

2. METHODOLOGY

In this study, the organic fraction of Municipal solid wastes was segregated for biological treatment by anaerobic digestion process as a part of solid waste management strategies. The research is conducted on production of methane gas from MSW and to compare the rate of change of production of methane gas for both wet as well as dry system and also to observe the variation in production of methane gas for different percentages of total solid content for both the cases. The wastes for the feedstock were collected from residential waste mainly food waste. After collecting the wastes, the manual separation of the readily degradable organic fractions was carried out. The segregated wastes were then made into smaller fraction of uniform size with hand. The experiment was carried out at room temperature conditions (mesophilic conditions) thereby the complete digestion process requires a larger time then thermophilic process. The details of research methodology are described in the following steps [16, 17].

2.1. Water displacement method

The process of displacing water with gas can be considered as one the methods that can be used in the water displacement technology to measure gas, and that is what we have considered for our project of measuring methane gas [18].

2.2. Tools and instruments used

The instruments and tools that are used for the process can be listed as:

- Drums of small sizes which are used as digester vessel
- Beakers to hold the test tubes
- Test tubes to collect the produced gas
- Rubber pipes for leak proof passage of gas from digester to gas collector.

2.3. Organic waste source

Organic waste considered for the experiment is residential waste mainly food waste.

Fig. 1.organic waste taken for experiment

3. Set Up For Dry System

As we know that for dry system the amount of dry matter ranges from 20%-40% of total matter (solid waste and water) available for the digestion so for dry system we setup five sets of digester each with variable total solid content as shown below.

Table (1) Dry Weight Measurement for Dry System

Dry system			
Set no.	Total weight (dry matter + M.C)	Weight of dry matter	Dry weight %
Set 1	2340 gm	585 gm	25%
Set2	2554 gm	715 gm	28%
Set 3	2725 gm	845 gm	31%
Set 4	2868 gm	975 gm	34%
Set 5	2986 gm	1105 gm	37%

Table (2) M.c measurement for dry system

Dry system			
Set no.	Total weight (dry matter + M.C)	Weight of moisture content given externally	Total M.C% in the digester
Set 1	2340 gm	1440 gm	75%
Set2	2545 gm	1445 gm	72%
Set 3	2725 gm	1425 gm	69%
Set 4	2868 gm	1305 gm	66%
Set 5	2986 gm	1286 gm	63%

4. Result and Discussion

The digesters are considered to be operated near mesophilic range of temperature and the key parameters investigated included are:

4.1. Comparison of Increase in the production of CH_4 for every vs. total days.

Comparison of production of CH_4& CO_2 on day wise basis:

For the first three case as it can be shown from graphs (fig. no. 4.1to 4.3) that production of CH_4 is almost same for digesters containing dry matter percentage ranging from 25-30%, but for setups containing dry matter ranging between 30% and above there is been an increasing trend in the production of CH_4. So it can be depicted that for dry system, setups containing dry matter percentages ranging 30% and above may give best CH_4 production. Similarly we can do the same analysis for wet system setups also on day wise basis.

Day wise production of CH_4 dry system

For 2nd January

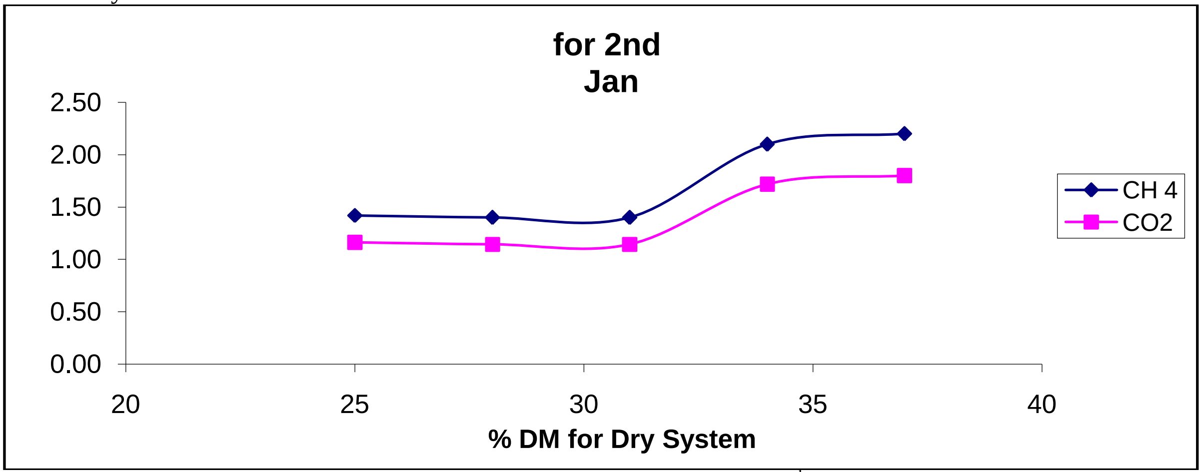

Fig. 3.variation of CH_4& CO_2 for dry system for 2nd January 2011

Table (3) production of CH_4& CO_2 for dry system setups on 2nd Jan 2011

% DM	CH_4,ml	CO_2,ml
25	1.42	1.16
28	1.40	1.15
31	1.40	1.15
34	2.10	1.72
37	2.20	1.80

For 9th January

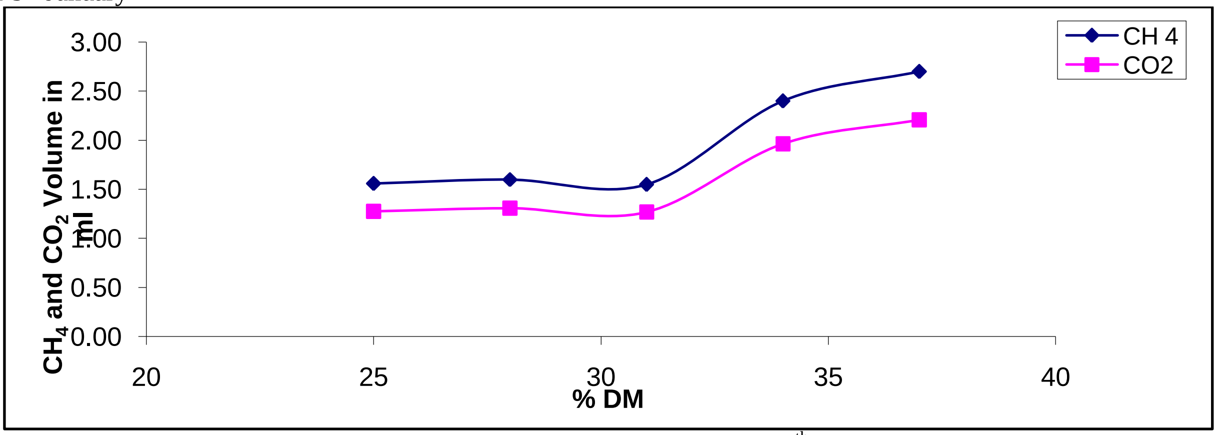

Fig. 4.variation of CH_4& CO_2 for dry system for 9th January 2011

Table(4) production of CH_4& CO_2 for dry system setups on 9th Jan 2011

% DM	CH_4,ml	CO_2,ml
25	1.56	1.28
28	1.60	1.31
31	1.55	1.27
34	2.40	1.96
37	2.70	2.21

For 17th January

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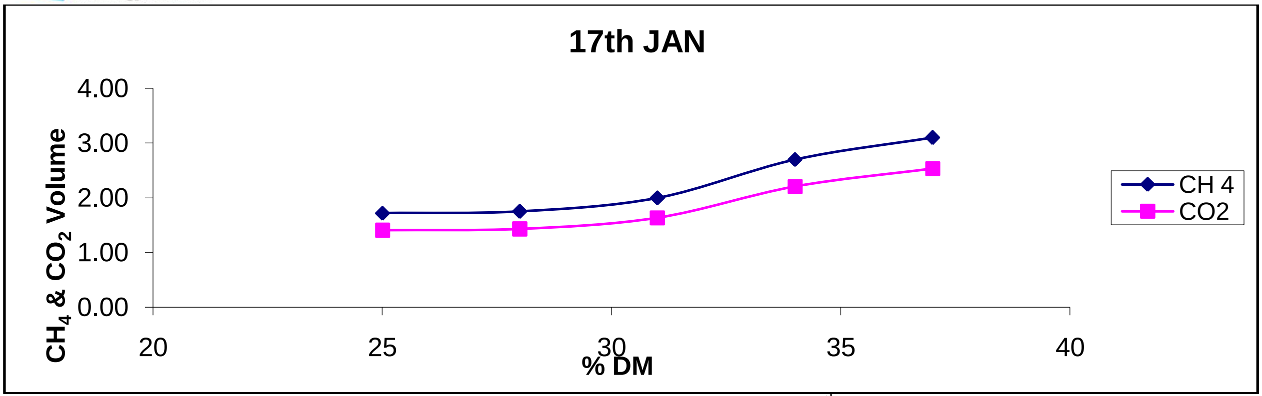

Fig. 5.variation of CH_4& CO_2 for dry system for 17th January 2011

Table (5) production of CH_4& CO_2 for dry system setups on 17th Jan 2011

% DM	CH_4,ml	CO_2,ml
25	1.72	1.41
28	1.75	1.43
31	2.00	1.64
34	2.70	2.21
37	3.10	2.54

4.2. Comparison of production of CH_4& CO_2on monthly basis.

As seen from the graph it can be depicted that in case of month's wise analysis the general trend is that for Wet system, production of gas is highest for the digester having dry matter percentage of 14% whereas the production of digester having dry matter 5% is generally low compared to other setups, And in case of Dry system also the digester having the highest amount of dry matter is producing the most amount of gas but it can be observed that at some points the production curves for 25% and 31% crosses each other means that cumulative production of gas is almost same for 25% and 31%. But at the end of production it was observed that net production of gas is higher for 31% digester compared to 25%.

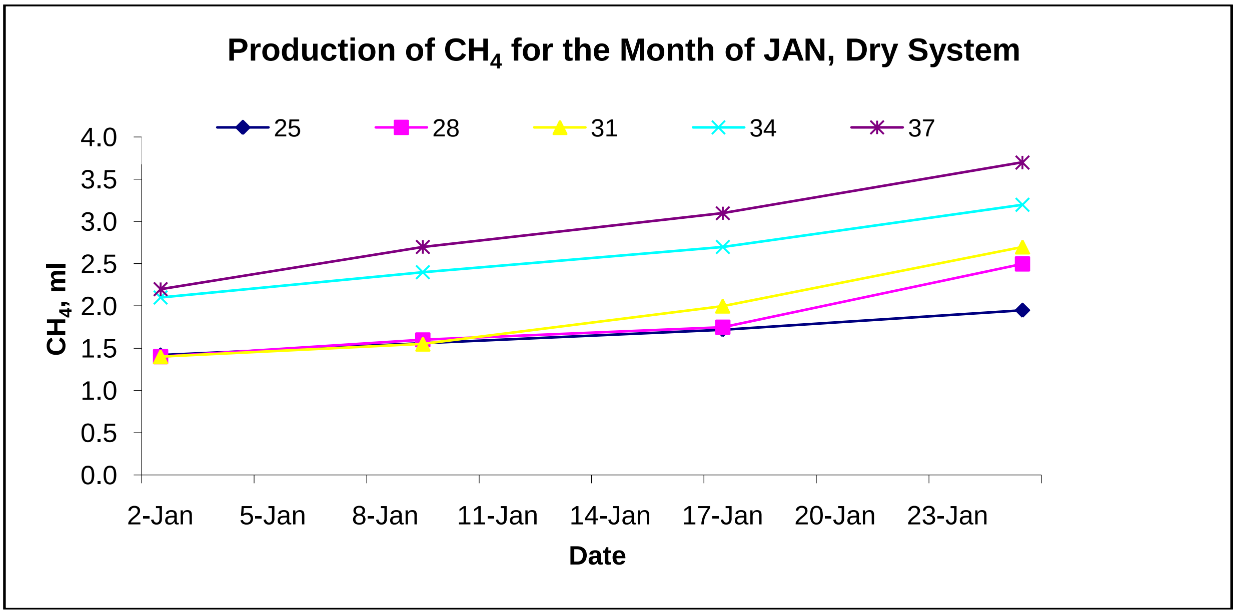

Fig. 6.variation of CH_4 production for the month of January in case of dry system

Table (6) CH_4 production for the month of January in case of wet system

DATE %DM	25	28	31	34	37
2-Jan	1.4	1.4	1.4	2.1	2.2
9-Jan	1.6	1.6	1.6	2.4	2.7
17-Jan	1.7	1.8	2.0	2.7	3.1
25-Jan	1.9	2.5	2.7	3.2	3.7

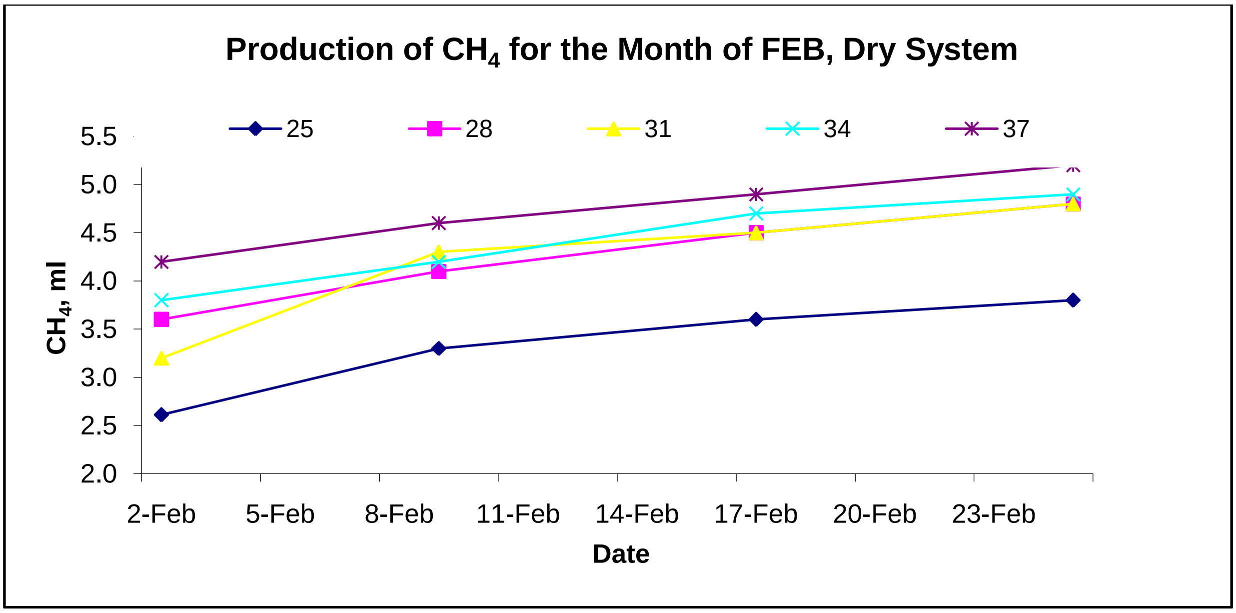

Fig. 7.variation of CH_4 production for the month of February in case of dry system

Table (7) CH_4 production for the month of February in case of dry system

DATE %DM	25	28	31	34	37
2-Feb	2.6	3.6	3.2	3.8	4.2
9-Feb	2.7	4.1	4.3	4.2	4.6
17-Feb	3.2	4.3	4.3	4.7	5.1
25-Feb	4.0	4.5	4.5	4.9	5.7

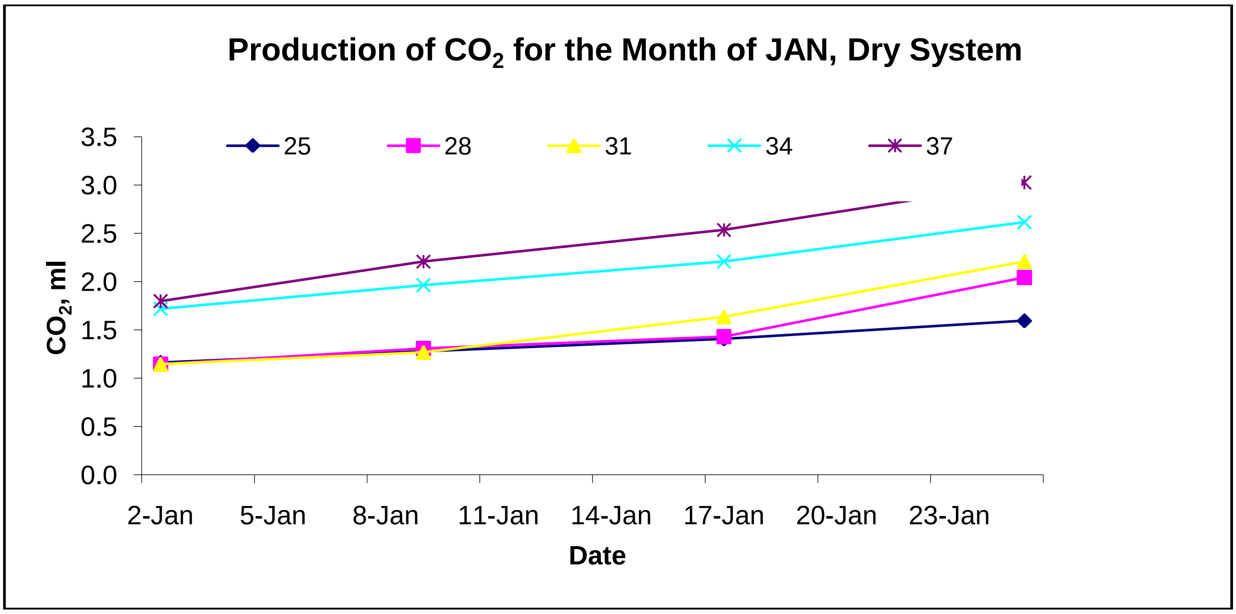

Fig. 8.variation of CO_2 production for the month of January in case of dry system

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Table (8) CO_2 production for the month of January in case of dry system

DATE %DM	25	28	31	34	37
2-Jan	1.2	1.1	1.1	1.7	1.8
9-Jan	1.3	1.3	1.3	2.0	2.2
17-Jan	1.4	1.4	1.6	2.2	2.5
25-Jan	1.6	2.0	2.2	2.6	3.0

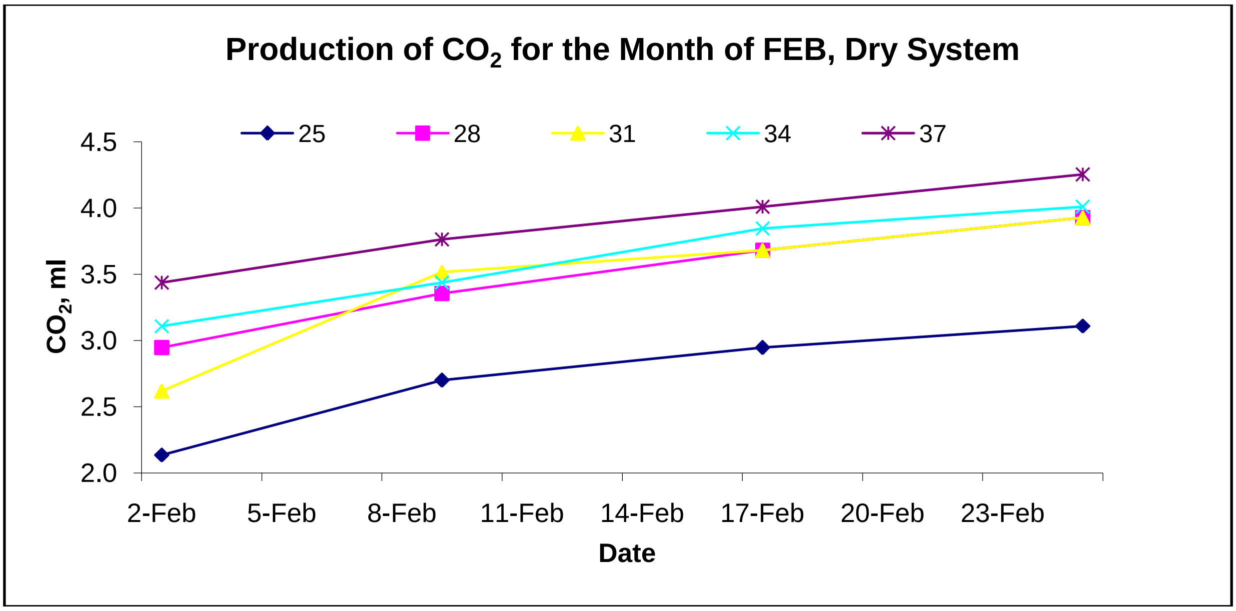

Fig. 9.variation of CO_2 production for the month of February in case of dry system

Table (9) CO_2 production for the month of February in case of dry system

DATE %DM	25	28	31	34	37
2-Feb	2.1	2.9	2.6	3.1	3.4
9-Feb	2.7	3.4	3.5	3.4	3.8
17-Feb	2.9	3.7	3.7	3.8	4.0
25-Feb	3.1	3.9	3.9	4.0	4.3

5. Conclusion

Owing to migration of more peoples from rural to city or town, the population is unban area is increasing continuously. With the increase in population, the quantity of MSW is also increasing day-by-day. MSW has a high amount of organic component. Considering the organic portion of MSW mainly food waste was the main objective of this study. Dry system method was considered for the analysis .The results shows that the system of setup contain high amount of organic matter. The system containing five setups each to compare the production of gases for each setup. Moreover analysis for the production is done on day wise basis.

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