Analysis of production of CH_4 & CO_2 by using dry and wet systems of anaerobic digestion under mesophilic conditions

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ABSTRACT

Municipal solid waste (MSW) has a high amount of organic component that could be converted into methane gas if digested anaerobically. Hence one should make use of the energy associated with MSW by converting it into methane gas. Generally anaerobic digestion is always being carried under mechanically operated digesters which requires large number of investments which are intended for commercial production of methane gas, so the objective of this work was the production of methane gas from simple man-made digesters which are very easy to construct and operate and the main point of importance is to study the production trend of methane gas. Secondly anaerobic digestion requires certain degree of temperature preferably 20°C and more, so it wasworthwhile to know the effect in the gas production if the temperature falls below 20°C. So, the topic of the analysis was selected by keeping in mind the season of the year which was mainly winter, i.e. December to April.Although the gas obtained from anaerobic digestion are many but the main component parts of gas consist of methane (approx. 55%) and carbon dioxide (approx. =45%) and traces of sulfur dioxide [1]. In this study, production of gas was checkedbased upon percentage of dry matter present in total solid content, and for two systems, namely wet system and dry system. Wet system contains dry matter 10-15% whereas the amount of dry matter present in dry system is 20-40% [2]. For the experimental analysis, five sets of digesters are considered for both wet as well as the dry system. For the dry system, the range for the percentage of dry matter taken were 25%, 28%, 31%, 34%, and 37%, whereas the range of dry matter taken for wet system were 5%, 7%, 10%, 12%, 14%. Analysis revealed that gas

production was higher for dry system and at the same time maximum gas production was obtained at higher temperature values.

Keywords: Dry system, Wet system, MSW, Food waste, Anaerobic Digestion, CH_4 and CO_2

List of Notations

AD	Anaerobic Digestion
BVS	Biodegradable volatile solids
C/N	Carbon to Nitrogen ratio
C_2H_5COOH	Propionic acid
C_2H_5OH	Ethanol
$C_6H_{12}O_6$	Glucose
CH_3COOH	Acetic acid
CH_4	Methane
CO_2	Carbon dioxide
DM	Dry matter
H_2	Hydrogen
HS-OFMSW	Hand Sorted Organic Fraction of MSW
LOI	Loss on Ignition
MC	Moisture Content
MSW	Municipal Solid Waste
N_2	Nitrogen
NH_3	Ammonia
OFMSW	Organic Fraction of Municipal Solid Waste
OLR	Organic Loading Rate
RT	Retention Time
RVS	Refractory Volatile Solid
SSO	Source separated organics
TS	Total Solids
VS	Volatile Solid

1. Introduction

1.1.Loss on Ignition (LOI)

Loss on ignition represents the amount of carbon in the sample and the remaining ash in the after ignition. LOI consists of carbon from the following sources: organic carbon (including biodegradable carbon, and carbon from non or slowly bio-degradable organic compounds such as plastics), inorganic carbonates, and elemental carbon. As an absolute measure of biodegradable carbon. It provides an excellent measure of biological decomposition in anaerobic digestion process. Only the biodegradable components of the waste are converted to CH_4& CO_2 during the digestion process [3]. Thus there is a relationship between the LOI of the waste after digestion with the LOI of the raw waste, and this concept is being assumed in the experiment so that the actual amount of organic content which is being used up during the process of anaerobic digestion is equivalent to the theoretical organic content value which is obtained from experimental calculation from the digestate available after digestion [4].

1.2.Municipal Solid Waste

Rapid industrialization and population explosion in India has led to the migration of people from villages to cities, which generate thousands of tons wastes which pollutes the water bodies and MSW on a daily basis. There are several techniques available to treat wastewater, like use of adsorption technique [5-18]. On the other hand, MSW amount is expected to increase significantly in the near future as the country strives to attain an industrialized nation status by the year [19]. Poor collection and inadequate transportation are responsible for the accumulation of MSW at every nook and corner. The management of MSW is going through a critical phase, due to the unavailability of suitable facilities to treat and dispose of the larger amount of MSW generated daily in metropolitan cities [20-23].

Municipal solid waste (MSW) is the waste generated in a community with the exception of industrial and agricultural wastes [24]. Hence MSW includes residential waste (e.g., households), commercial (e.g., from stores, markets, shops, hotels etc), and institutional waste (e.g., schools, hospitals etc). Paper, paperboard, garden and food waste can be classified in a broad category known as organic or biodegradable waste. The quantity of MSW generated depends on a number of factors such as food habits, standard of living, degree of commercial activities and seasons.The organic compound fraction of MSW represents 70% of the waste composition and consists of paper, garden waste, food waste and other organic waste including plastics. The biodegradable fraction (paper, garden and food waste) accounts for 53% of waste composition [25-26]. Therefore, treatment of these wastes is an important component of an integrated solid waste management strategy and reduces both the toxicity and volume of the MSW requiring final disposal in a landfill. This study explores the anaerobic digestion technology (AD), i.e. in the absence of oxygen, as one of the main options for processing the biodegradable organic materials in MSW [27-28]. The anaerobic decomposition of organic materials yields principally methane (CH_4 approx = 55%), carbon dioxide (CO_2 approx = 45%), traces of sulphur dioxide and a solid compost material that can be used as soil conditioner [29].

1.3.Types and sources of MSW

There are many categories of MSW such as food waste, rubbish, commercial waste, institutional waste, street sweeping waste, industrial waste, construction and demolition waste, and sanitation waste. MSW contains recyclables (paper, plastic, glass, metals, etc.), toxic substances (paints, pesticides, used batteries, medicines), compostable organic matter (fruit and vegetable peels, food waste) and soiled waste (blood stained cotton, sanitary napkins, disposable syringes) [30]. The quantity of MSW generated depends on a number of factors such as food habits, standard of living, degree of commercial activities and seasons. The sources and types of solid wastes according to WHO [31] are summarized in table 1.

Table 1. Sources and types of solid waste

Sources	Facility	Types of Wastes

Domestic	Single family dwelling, multifamily dwelling, low, medium and high-rise apartments.	Food, paper, packing, glass, Metals, ashes bulky household waste, hazardous household waste.
Commercial	Shops, Restaurants, market, office buildings, hotels and institutions.	Food, paper, packing, glass, Metals, ashes bulky household waste, hazardous household waste.
Industrial	Fabrication and heavy manufacturing, Refineries, chemical plants, mining, power generation.	Industrial process wastes, Metals, Lumber, Plastics, Oils, Hazardous waste.
Construction and demolition	Construction site like as Bridges, dam, Industry, Airport railway etc.	Soil, Concrete, Timber, Steel, Plastics, Glass, Vegetation.

1.4.Anaerobic digestion

The use of microbes in the absence of oxygen for the stabilization of organic material by conversion to methane, carbon dioxide, new biomass and inorganic products is called anaerobic digestion. Anaerobic biodegradation of organic material proceeds in the absence of oxygen and the presence of anaerobic microorganisms. AD is the consequence of a series of metabolic interactions among various groups of microorganisms. It occurs in four stages, hydrolysis/liquefaction, Acedogenesis, acetogenesis and Methanogenesis (figure 1). The first group of microorganism secretes enzymes, which hydrolyses polymeric materials to monomers such as glucose and amino acids. These are subsequently acted upon by second group i.e., acedogenic bacteria to break the monomeric molecules obtained in the first stage into simpler molecules. The third stage is where the hydrogen sulphides, ammonia and carbon dioxide are broken down to higher volatile fatty acids, H_2 and acetic acid. Finally, the fourth group of bacteria, methanogenic, converts H_2, CO_2, and acetate, to CH_4. These stages are described later. The AD is carried out in large digesters that are maintained at temperatures ranging from 20°C - 65°C [21].
A biological process, in which, decomposition of organic matter occurs without oxygen. Two processes occur during anaerobic decomposition. First, facultative acid forming bacteria use organic matter as a food source and produce volatile (organic) acids, gases such as carbon dioxide and hydrogen sulfide, stable solids and more facultative organisms [32]. Second, anaerobic methane formers use the volatile acids as a food source and produce methane gas, stable solids and more anaerobic methane formers. The methane gas produced by the process is usable as a fuel. The methane former works slower than the acid former, therefore the pH has to stay constant consistently, slightly basic, to optimize the creation of methane. We need to constantly feed it sodium bicarbonate to keep it basic [33]. A typical Path of anaerobic digestion process is shown using figure 2.Generally, methane production under anaerobic digestion is well supported under high temperature. So, use of anaerobic digestion process for the production of methane gas under low temperature (mesophilic condition) is worth studying which serves as the motivation and novelty for this work.

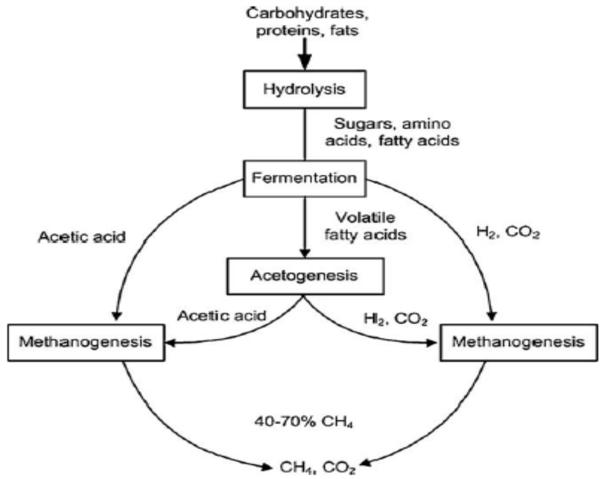

Fig.1. Stages of Anaerobic Digestion

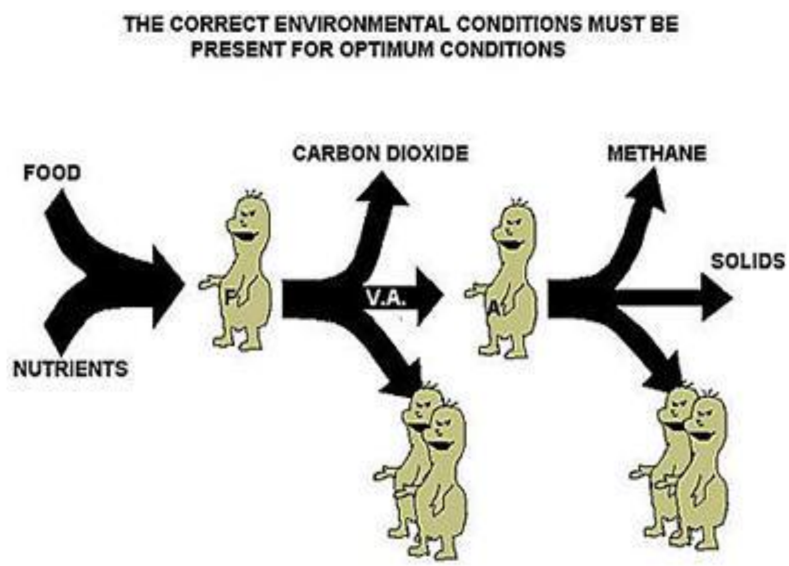

Fig. 2.Path of anaerobic digestion

2. Methodology

In this study, the organic fraction of Municipal solid waste (MSW) 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.

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 is being considered for the analysis of measuring methane gas.

2.1.1 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 (figure 3).
- 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.

2.1.2 Organic waste source

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

3. Experimental setup and procedure

For the digestion process the slurry (mixture of solid waste and water) was fed into 10 drums, all of which are identical in sizes. Now for the experiment, both ‘Dry system’ and ‘Wet system’ cases were studied. Again, for both the cases different ranges of total solid content were taken. Since the experimental setup which is being indented was in the in the room temperature and also in the winter season (Dec to April) so the temperature range was under mesophilic range (20°C- 40°C) and to be more precise was in the low range.

In the analysis the experimental setup is such that when there will be production of methane gas then the gas produced during the digestion process will be transported through the pipes and will be collected in the test tubes in inverted position, filled with water in the first place, and marked for measuring the volume of gas that will be collected (assuming CH_4, approx=55% & CO_2, approx=45%)[34-35] In due course of time as the digestion process will took place, and the collection of the gas will be through the water displacement phenomena where water will get displaced with lighter substance like gas. The experimental setup can be shown in fig 3 (a) & (b).

Fig. 3.(a) Experimental setup for ten sets of digesters, **(b)**Detailed arrangement shown for beaker and test tubes

3.1 Setup for Wet system

The amount of dry matter for wet system ranges up to 15% or below 15% of total matter in the system, and thus five sets of digesterswere made with total variable solid content and the same is presented using table 2.1 and table 2.2.

Table 2.1Dry weight measurement for wet system

Wet system			
Set no.	**Total weight (dry matter + M.C)**	**Weight of dry matter**	**Dry weight %**
Set 1	5600 gm	280 gm	5%
Set2	4643 gm	325 gm	7%
Set 3	3570 gm	357 gm	10%
Set 4	3517 gm	422 gm	12%
Set 5	3479 gm	487 gm	14%

Table 2.2 Moisture content measurement for wet system

Wet system			
Set no.	**Total weight (dry matter + M.C)**	**Weight of moisture content given externally**	**Total M.C% in the digester**
Set 1	5600 gm	5170 gm	95%
Set2	4643 gm	4135 gm	93%
Set 3	3570 gm	3220 gm	90%
Set 4	3517 gm	2802 gm	88%
Set 5	3479 gm	2727 gm	86%

3.2 Set up for Dry system

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 digesters each with variable total solid content as shown in the table 3.1 and table 3.2.

Table 3.1 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%

The tabular representation of moisture content (M.C) can be shown as:

Table 3.2 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 production of CH_4& CO_2 on monthly basis.
4.2 Comparison of Increase in the production of CH_4 for every vs. total days for both wet and dry system.
4.3 Rise in Temperature Vs Total Days
4.4 Increase in CH_4 for every Month for Wet System and dry system.

4.1.Comparison of production of CH_4& CO_2 on monthly basis.

Experimental analysis revealed that in case of month's wise analysis, the general trend is that for Wet system, production of gas (CH_4& CO_2) 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%. Results for 4.1 are presented using figure 4 to figure 15 and Table 4 to table 15.

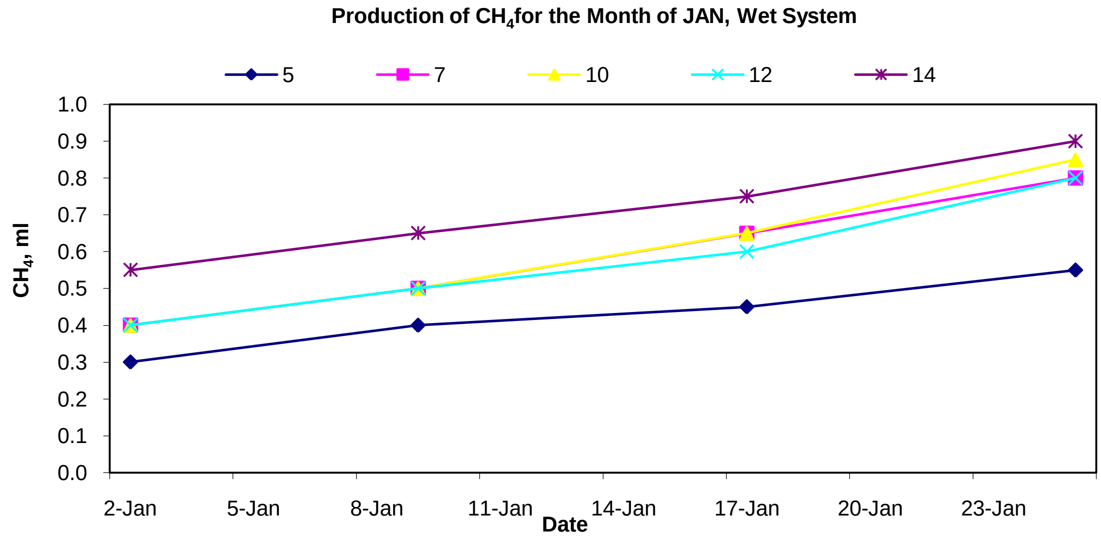

Fig. 4. variation of CH_4 production for the month of January in case of wet system

Table 4. CH_4 production (in mL)for the month of January in case of wet system

Date %DM	5	7	10	12	14
2-Jan	0.3	0.4	0.4	0.4	0.6
9-Jan	0.4	0.5	0.5	0.5	0.7
17-Jan	0.5	0.7	0.7	0.6	0.8
25-Jan	0.6	0.8	0.9	0.8	0.9

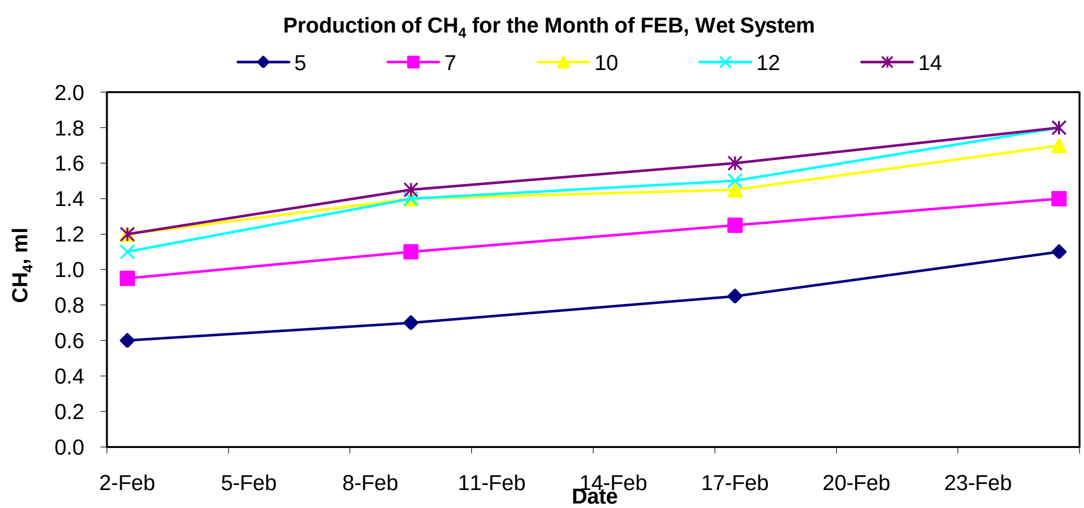

Fig.5.variation of CH_4 production for the month of February in case of wet system

Table 5. CH_4 production (in mL) for the month of February in case of wet system

Date %DM	5	7	10	12	14
2-Feb	0.6	1.0	1.2	1.1	1.2

9-Feb	0.7	1.1	1.4	1.4	1.5
17-Feb	0.9	1.3	1.5	1.5	1.6
25-Feb	1.1	1.4	1.8	1.8	1.8

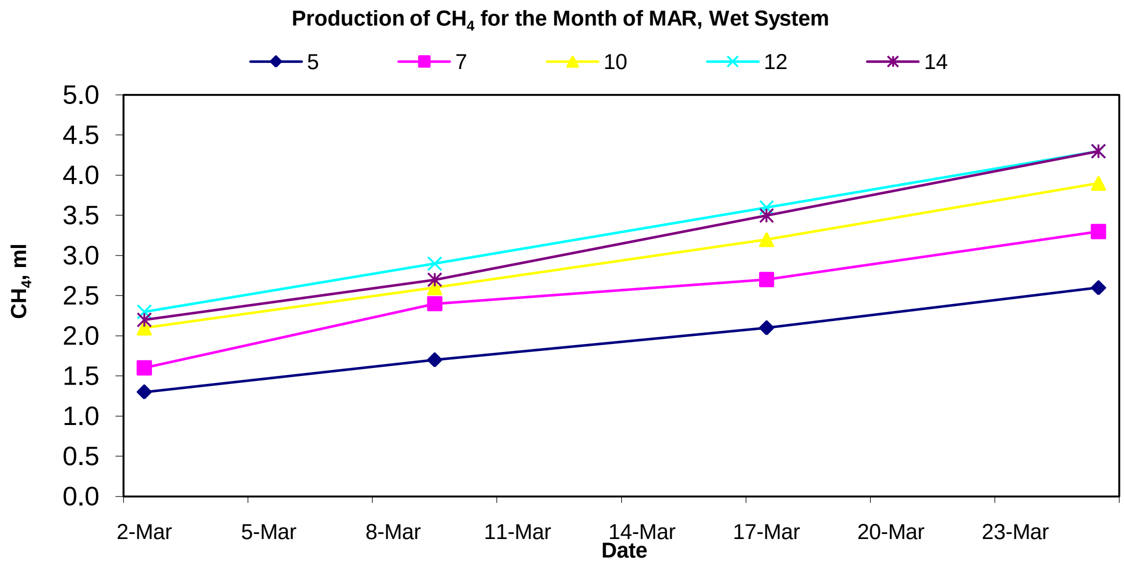

Fig. 6.variation of CH_4 production for the month of March in case of wet system

Table 6.CH_4 production (in mL)for the month of March in case of wet system

%DMDate	5	7	10	12	14
2-Mar	1.3	1.6	2.1	2.3	2.2
9-Mar	1.7	2.4	2.6	2.9	2.7
17-Mar	2.1	2.7	3.2	3.6	3.5
25-Mar	2.6	3.3	3.9	4.3	4.3

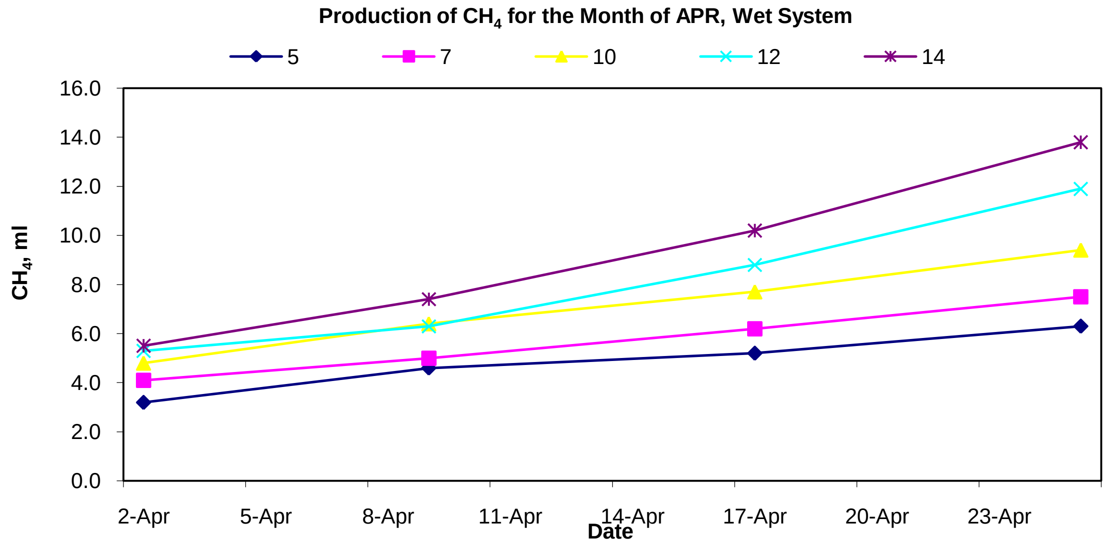

Fig. 7.variation of CH_4 production for the month of April in case of wet system

Table 7. CH_4 production (in mL)for the month of April in case wet system

DATE %DM	5	7	10	12	14
2-Apr	3.2	4.1	4.8	5.3	5.5
9-Apr	4.6	5.0	6.4	6.3	7.4
17-Apr	5.2	6.2	7.7	8.8	10.2
25-Apr	6.3	7.5	9.4	11.9	13.8

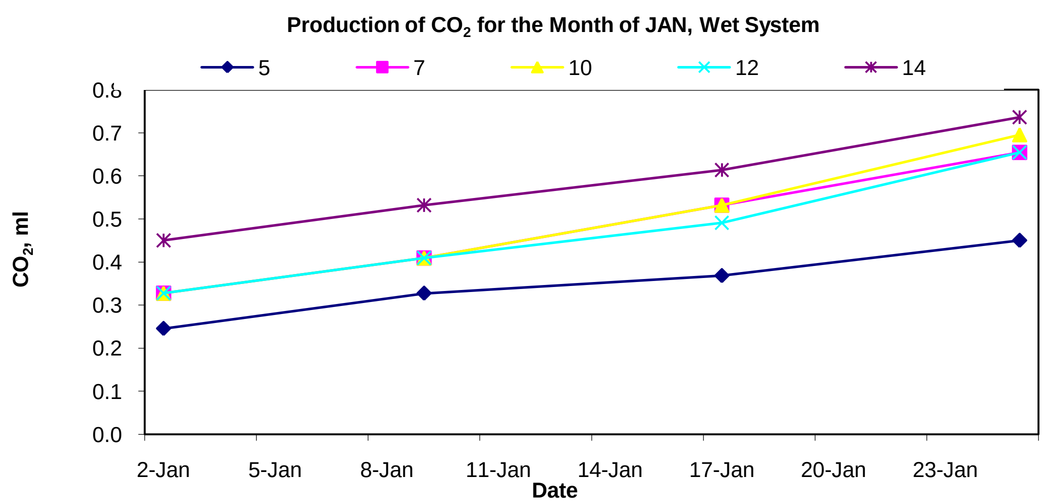

Fig. 8. variation of CO_2 production for the month of January in case of wet system

Table 8. CO_2 production for the month of January in case of wet system

DATE %DM	5	7	10	12	14
2-Jan	0.2	0.3	0.3	0.3	0.5
9-Jan	0.3	0.4	0.4	0.4	0.5
17-Jan	0.3	0.4	0.5	0.5	0.6
25-Jan	0.4	0.5	0.7	0.7	0.7

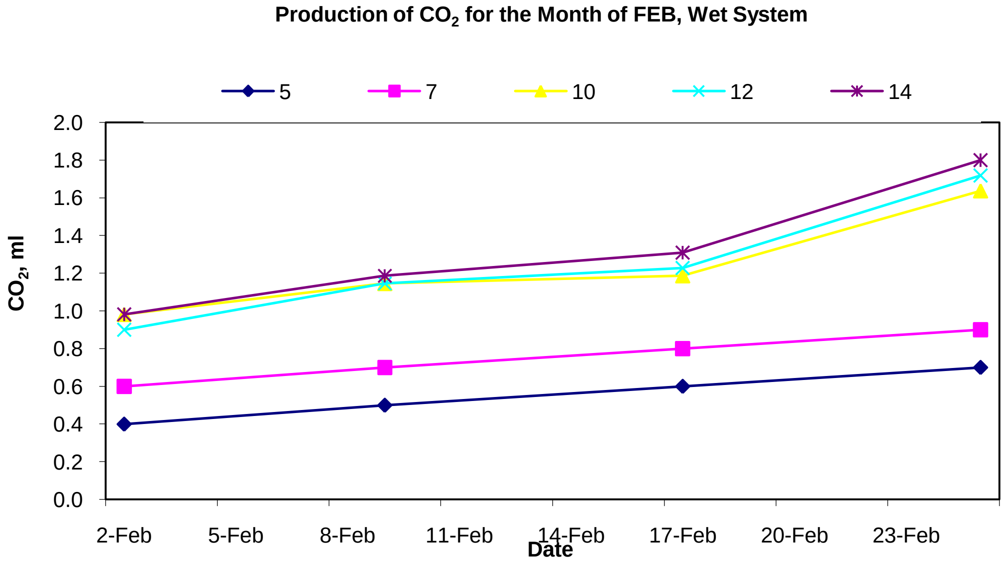

Fig. 9.variation of CO_2 production for the month of February in case of wet system

Table 9. CO_2 production for the month of February in case of wet system

DATE %DM	5	7	10	12	14
2-Feb	0.4	0.6	1.0	0.9	1.0
9-Feb	0.5	0.7	1.1	1.1	1.2
17-Feb	0.6	0.8	1.2	1.2	1.3
25-Feb	0.7	0.9	1.6	1.7	1.8

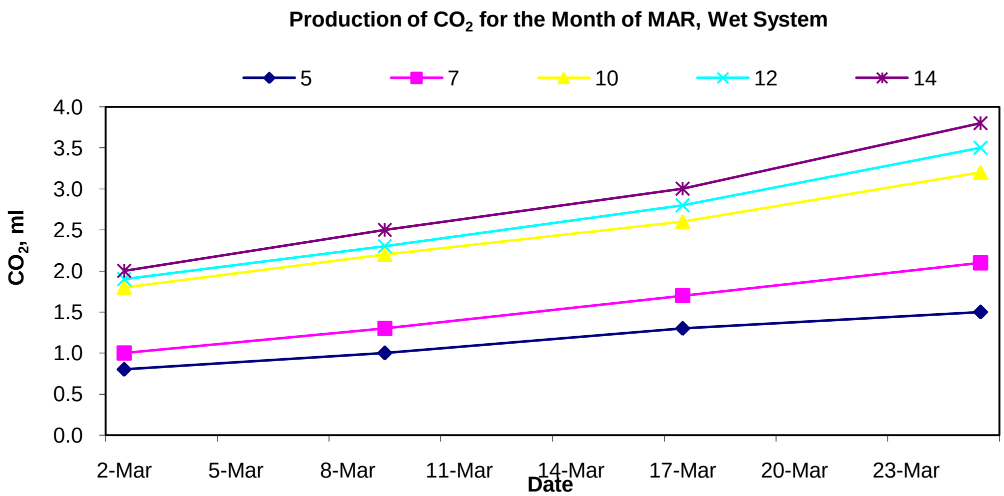

Fig. 10. Variation of CO_2 production for the month of March in case of wet system

Table 10. CO_2 production for the month of March in case of wet system

DATE %DM	5	7	10	12	14
2-Mar	0.8	1.0	1.8	1.9	2.0
9-Mar	1.0	1.3	2.2	2.3	2.5
17-Mar	1.3	1.7	2.6	2.8	3.0
25-Mar	1.5	2.1	3.2	3.5	3.8

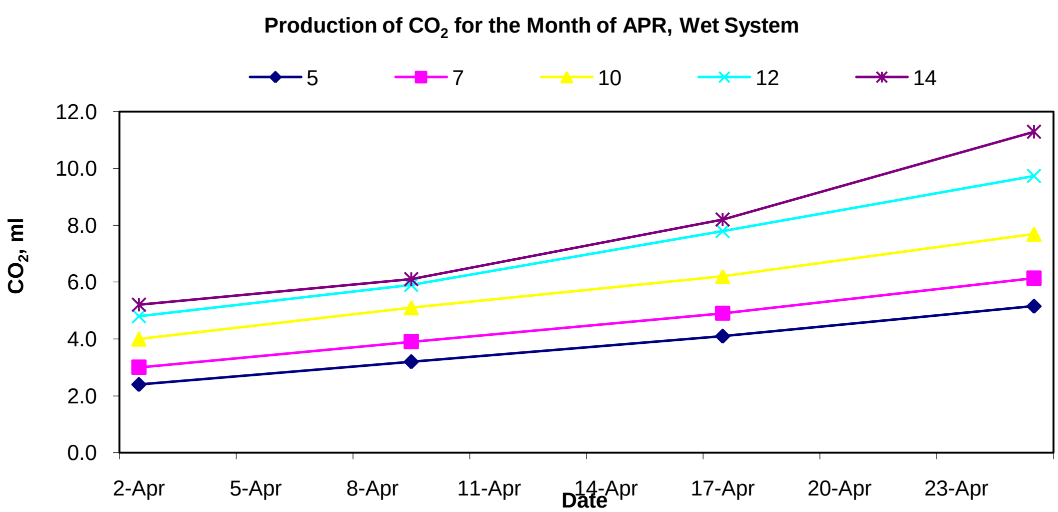

Fig. 11.variation of CO_2 production for the month of April in case of wet system

Table 11. CO_2 production for the month of April in case of wet system

DATE %DM	5	7	10	12	14
2-Apr	2.4	3.0	4.0	4.8	5.2
9-Apr	3.2	3.9	5.1	5.9	6.1
17-Apr	4.1	4.9	6.2	7.8	8.2
25-Apr	5.2	6.1	7.7	9.7	11.3

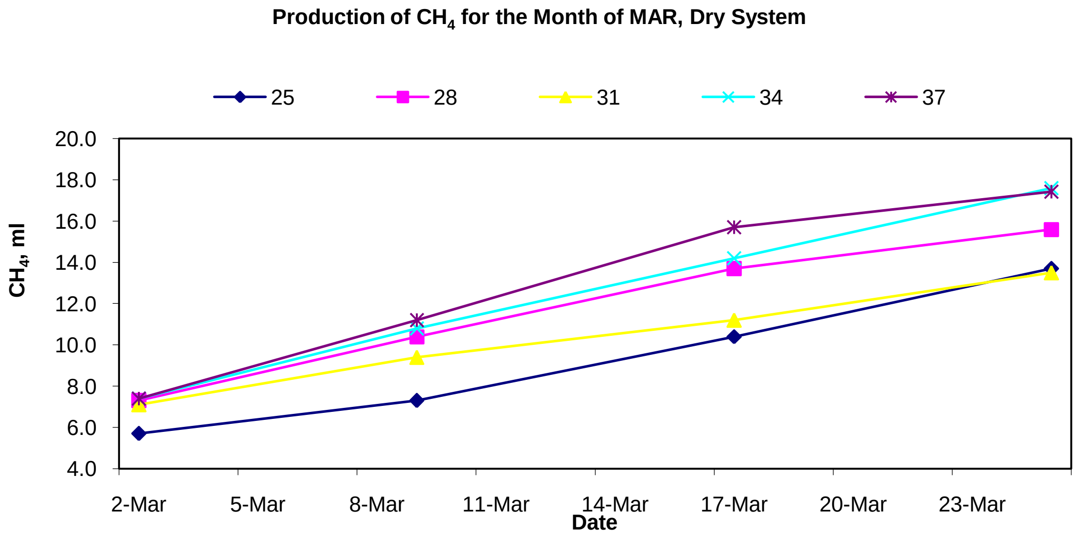

Fig. 12. variation of CH_4 production for the month of March in case of dry system

Table 12. CH_4 production for the month of March in case of dry system

DATE %DM	25	28	31	34	37
2-Mar	4.8	4.8	4.9	5.3	6.3
9-Mar	5.4	5.5	5.6	5.8	7.0
17-Mar	6.3	6.4	6.5	6.4	7.8
25-Mar	8.2	8.1	8.7	8.8	8.8

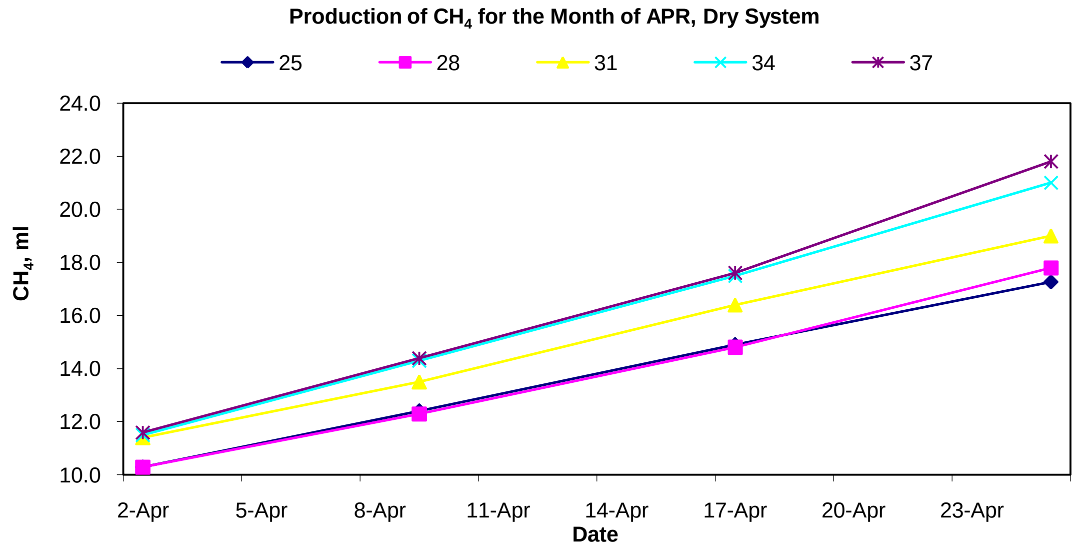

Fig. 13. variation of CH_4 production for the month of April in case of dry system

Table 13.CH_4 production for the month of April in case of dry system

DATE	%DM	25	28	31	34	37
2-Apr		10.3	10.3	11.4	11.5	11.6
9-Apr		12.4	12.3	13.5	14.3	14.4
17-Apr		14.9	14.8	16.4	17.5	17.6
25-Apr		17.3	17.8	19.0	21.0	21.8

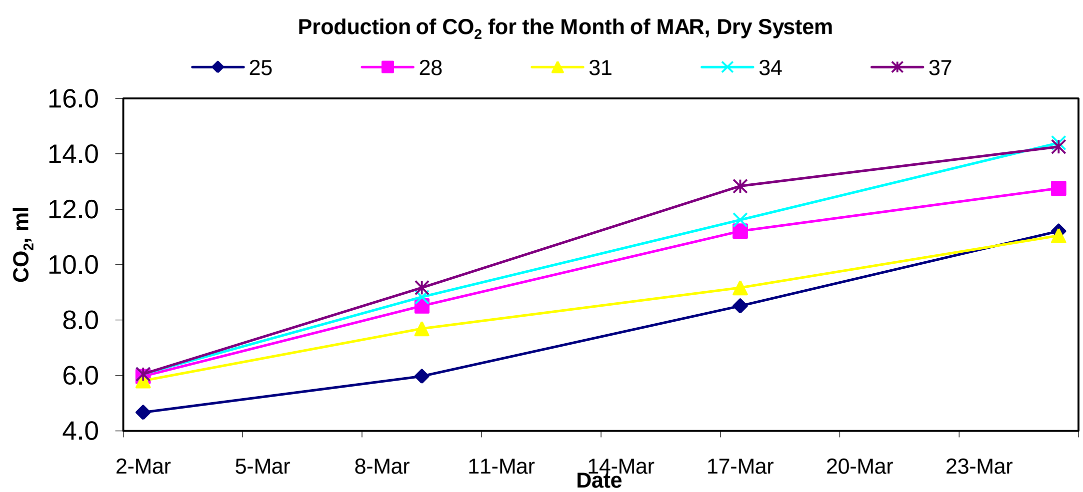

Fig. 14. Variation of CO_2 production for the month of March in case of dry system

Table 14. CO_2 production for the month of March in case of dry system

DATE %DM	25	28	31	34	37
2-Mar	4.7	6.0	5.8	6.1	6.1
9-Mar	6.0	8.5	7.7	8.8	9.2
17-Mar	8.5	11.2	9.2	11.6	12.8
25-Mar	11.2	12.8	11.0	14.4	14.3

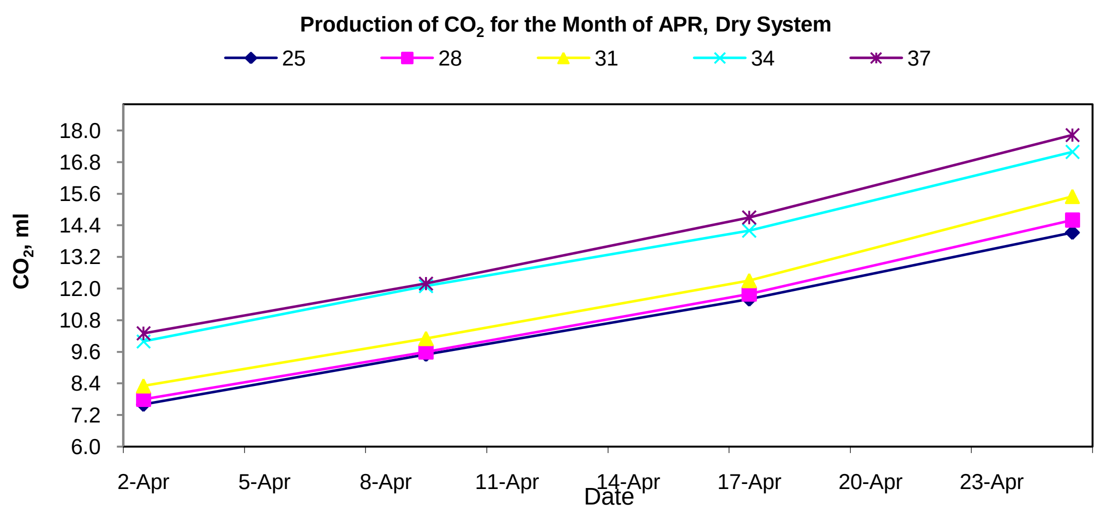

Fig. 15. Variation of CO_2 production for the month of April in case of dry system

Table 15. CO_2 production for the month of April in case of dry system

DATE %DM	25	28	31	34	37
2-Apr	7.6	7.8	8.3	10.0	10.3
9-Apr	9.5	9.6	10.1	12.1	12.2
17-Apr	11.6	11.8	12.3	14.2	14.7
25-Apr	14.1	14.6	15.5	17.2	17.8

4.2.Comparison of Increase in the production of CH_4 for every vs. total days for both wet and dry system.

As observed in section 4.1 results, for wet system as well as dry system, the increase in production rate gradually increased as the temperature increased. for the months of January and February, the temperature was below 20°C and hence due to lack of adequate temperature production, rate of gas production was also less but as the temperature started increasing from the month of March, production curve followed an increasing trend, although production rate does not change largely. It was also observed that the temperature difference between March and April is not much, stillincrease in gas production rate for the month of April is much higher than March, this can be explained as for the months of January and February temperature was very less so there were not much of decomposition due to the fact that microbial activities was not stabilized but when production phase changed from February to March then there was transition and increase in temperature thereby accelerating the microbial activities which in turn stabilized the anaerobic digestion process and as soon as stabilization occurred and at the same time temperature also continued to rise above 20°C in the month of April, there was a huge increase in the production rate of methane gas.Increment of CH_4Vs Total Days for wet as well as dry systems are presented using figure 16 to figure 17 and table 16 to table 17.

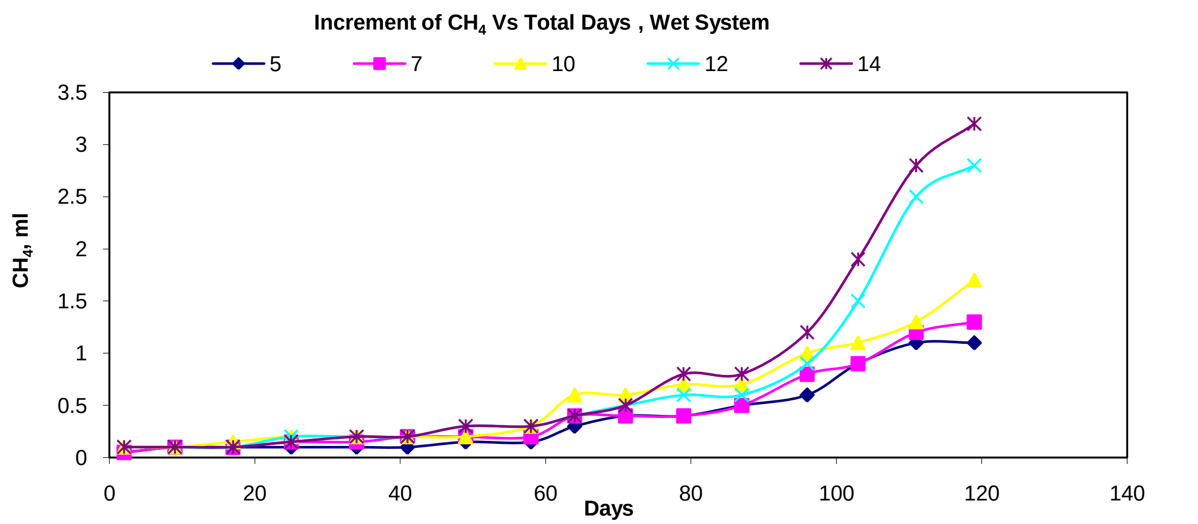

Fig. 16.Variation in increase for CH_4 for total days in case of wet system

Table 16. Increase in CH_4 production for total days in case of wet system

DAYS % DM	5	7	10	12	14
2	0.05	0.05	0.1	0.1	0.1
9	0.1	0.1	0.1	0.1	0.1
17	0.1	0.1	0.2	0.1	0.1
25	0.1	0.15	0.2	0.2	0.2
34	0.1	0.15	0.2	0.2	0.2
41	0.1	0.2	0.2	0.2	0.2
49	0.15	0.2	0.2	0.3	0.3
58	0.15	0.2	0.3	0.3	0.3
64	0.3	0.4	0.6	0.4	0.4
71	0.4	0.4	0.6	0.5	0.5
79	0.4	0.4	0.7	0.6	0.8
87	0.5	0.5	0.7	0.6	0.8
96	0.6	0.8	1	0.9	1.2
103	0.9	0.9	1.1	1.5	1.9
111	1.1	1.2	1.3	2.5	2.8
119	1.1	1.3	1.7	2.8	3.2

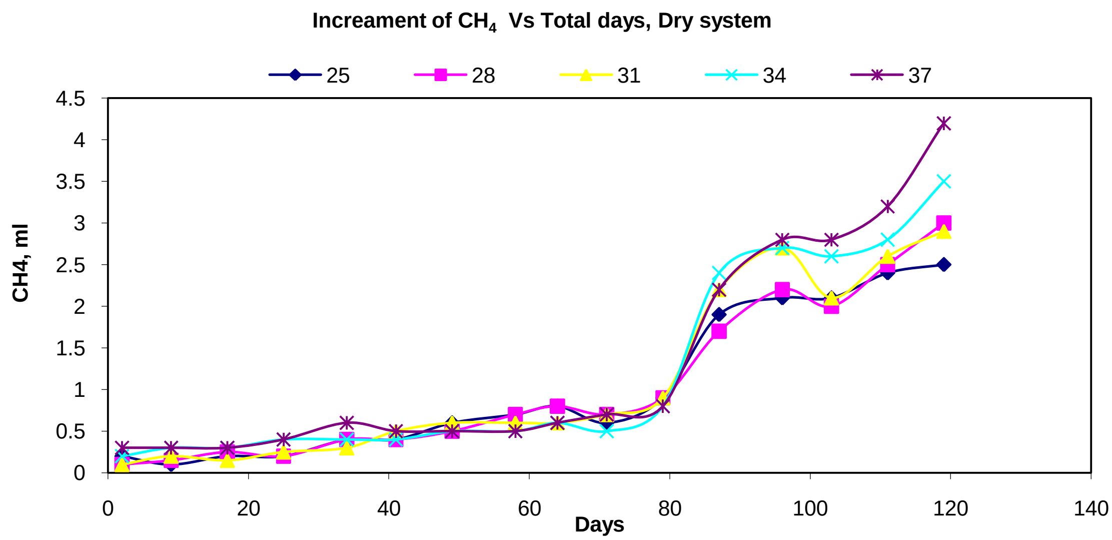

Fig. 17. Variation in increase for CH_4 for total days in case of dry system

Table 17.Increase in CH_4 production for total days in case of dry system

DAYS % DM	25	28	31	34	37
2	0.2	0.1	0.1	0.2	0.3
9	0.1	0.2	0.2	0.3	0.3
17	0.2	0.3	0.2	0.3	0.3
25	0.2	0.2	0.3	0.4	0.4
34	0.4	0.4	0.3	0.4	0.6
41	0.4	0.4	0.5	0.4	0.5
49	0.6	0.5	0.6	0.5	0.5
58	0.7	0.7	0.6	0.5	0.5
64	0.8	0.8	0.6	0.6	0.6
71	0.6	0.7	0.7	0.5	0.7
79	0.9	0.9	0.9	0.8	0.8
87	1.9	1.7	2.2	2.4	2.2
96	2.1	2.2	2.7	2.7	2.8
103	2.1	2	2.1	2.6	2.8
111	2.4	2.5	2.6	2.8	3.2
119	2.5	3	2.9	3.5	4.2

4.3 Rise in temperature Vs Total Days

As revealed in section 4.2, it can be seen that temperature gradually increased as we proceed from January to April which eventually assisted in higher production of gas suggesting that mesophilic condition is not suitable for methane gas production. Figure 18 and table 18 summarizes the data for variation in temperature w.r.t days.

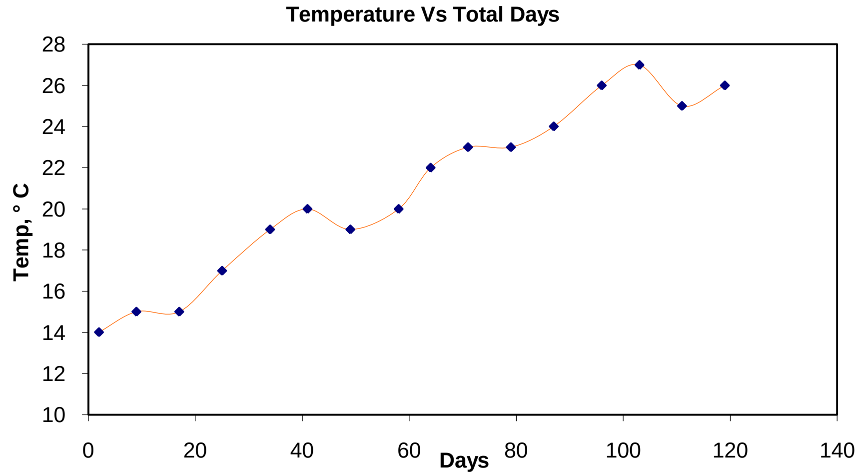

Fig. 18.Variation in temperature for total days

Table 18.Observation for temperature vs. total days

DAYS	2	9	17	25	34	41	49	58	64	71	79	87	96	103	111	119
Temp°C	14	15	15	17	19	20	19	20	22	23	23	24	26	27	25	26

4.4 Increase in CH_4 for every Month for Wet System and dry system

Change in production of gas with respect to proceeding months was in line with the other studies where it was observed that gas production was minimum for the month of January and maximum for the month of April. Primary reason for this can be attributed to the fact that out of four months, room temperature was minimum for the month of January and maximum for April and consequently gas production was maximum for the month of April. Results are illustrated using figure 19 to figure 26 and table 19 to table 26.

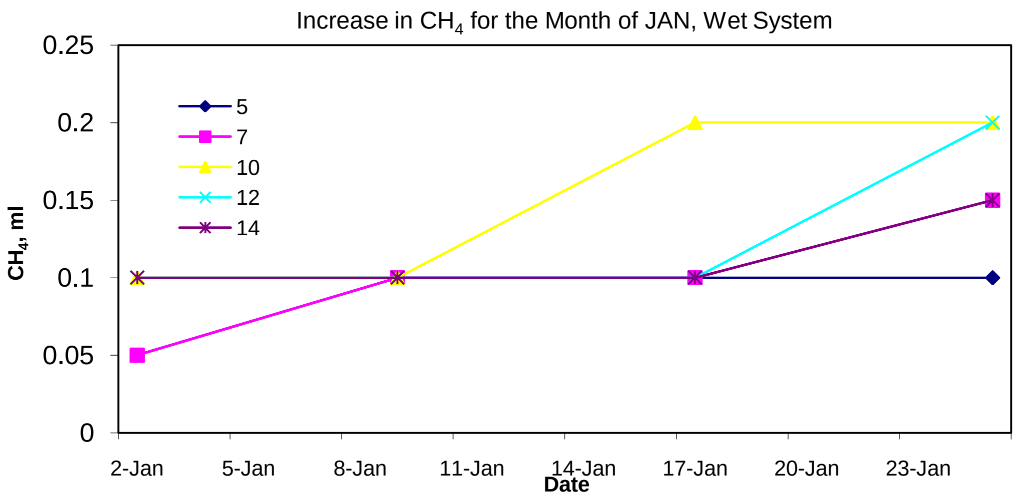

Fig. 19. Variation in increase for CH_4 for the month of January in case of wet system

Table 19.Increase in CH_4 production for the for the month of January in case of wet system

DATE	%DM	5	7	10	12	14
2-Jan		0.05	0.05	0.1	0.1	0.1
9-Jan		0.1	0.1	0.1	0.1	0.1
17-Jan		0.1	0.1	0.2	0.1	0.1
25-Jan		0.1	0.15	0.2	0.2	0.15

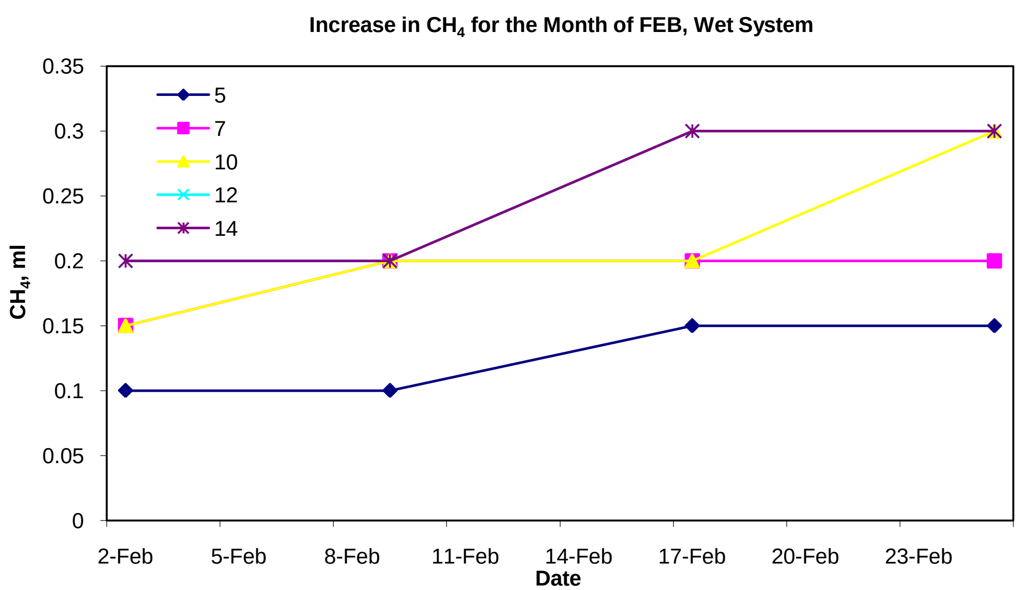

Fig. 20.Variation in increase for CH_4 for the month of February in case of wet system

Table 20.Increase in CH_4 production for the for the month of February in case of wet system

DATE %DM	5	7	10	12	14
2-Feb	0.1	0.15	0.15	0.2	0.2
9-Feb	0.1	0.2	0.2	0.2	0.2
17-Feb	0.15	0.2	0.2	0.3	0.3
25-Feb	0.15	0.2	0.3	0.3	0.3

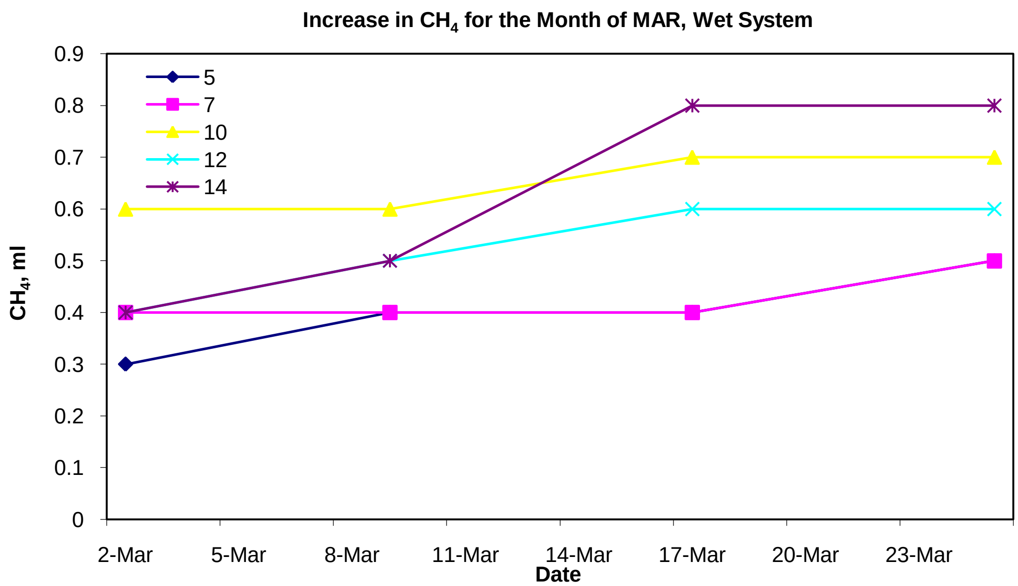

Fig. 21.Variation in increase for CH_4 for the month of March in case of wet system

Table 21. Increase in CH_4 production for the for the month of March in case of wet system

DATE %DM	5	7	10	12	14
2-Mar	0.3	0.4	0.6	0.4	0.4
9-Mar	0.4	0.4	0.6	0.5	0.5
17-Mar	0.4	0.4	0.7	0.6	0.8
25-Mar	0.5	0.5	0.7	0.6	0.8

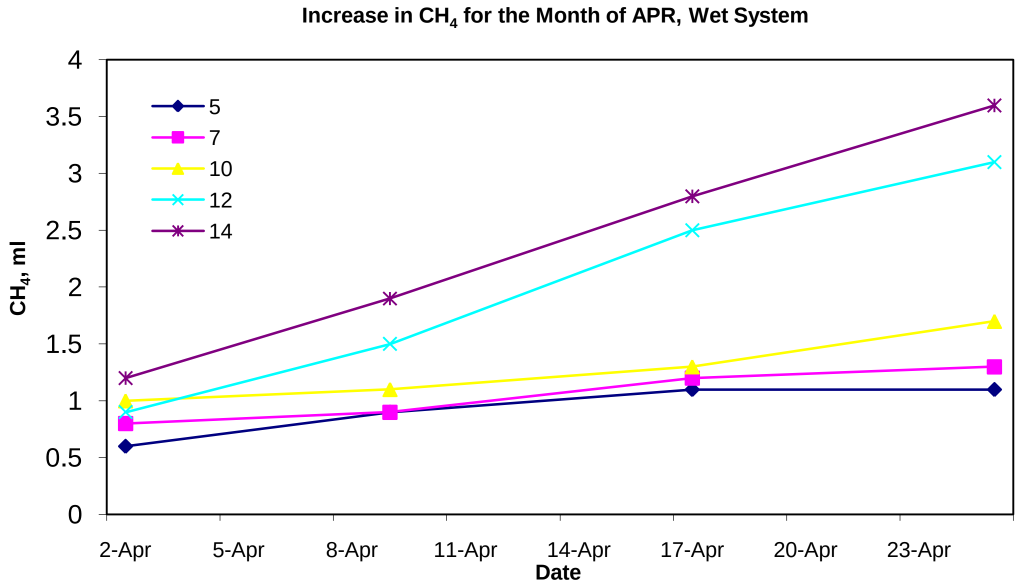

Fig. 22.Variation in increase for CH_4 for the month of April in case of wet system

Table 22.Increase in CH_4 production for the for the month of April in case of wet system

DATE %DM	5	7	10	12	14
2-Apr	0.6	0.8	1	0.9	1.2
9-Apr	0.9	0.9	1.1	1.5	1.9
17-Apr	1.1	1.2	1.3	2.5	2.8
25-Apr	1.1	1.3	1.7	3.1	3.6

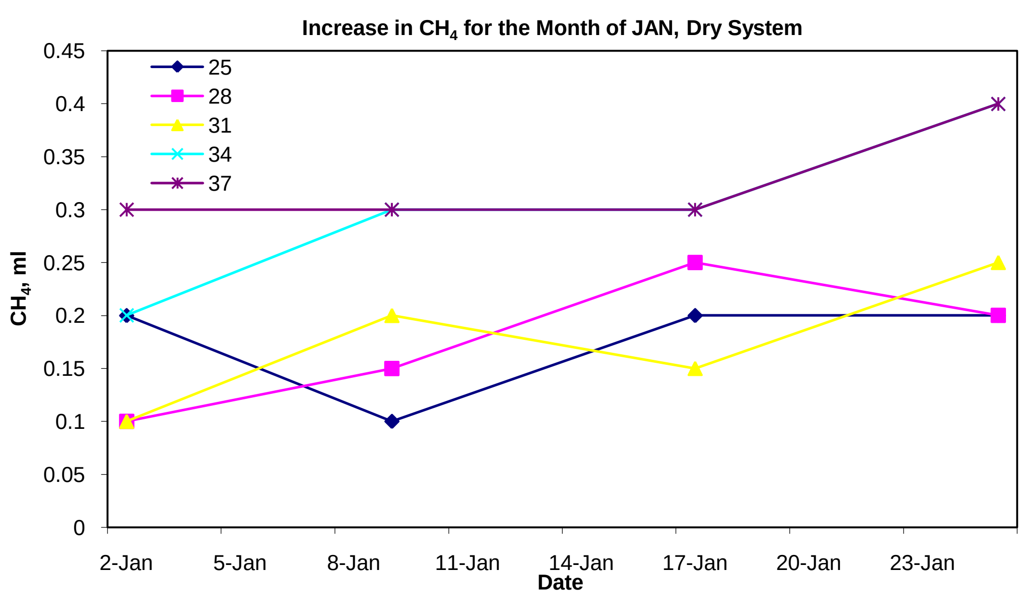

Fig. 23.Variation in increase for CH_4 for the month of January in case of dry system

Table 23.Increase in CH_4 production for the for the month of January in case of dry system

DATE %DM	25	28	31	34	37
2-Jan	0.2	0.1	0.1	0.2	0.3
9-Jan	0.1	0.15	0.2	0.3	0.3
17-Jan	0.2	0.25	0.15	0.3	0.3
25-Jan	0.2	0.2	0.25	0.4	0.4

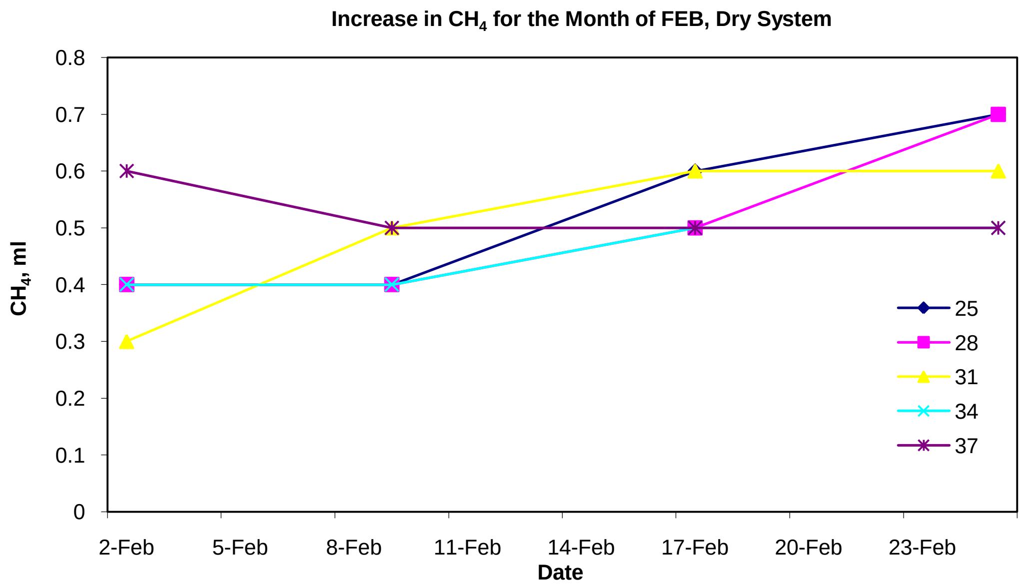

Fig. 24.Variation in increase for CH_4 for the month of February in case of dry system

Table 24.Increase in CH_4 production for the for the month of February in case of dry system

DATE %DM	25	28	31	34	37
2-Feb	0.4	0.4	0.3	0.4	0.6
9-Feb	0.4	0.4	0.5	0.4	0.5
17-Feb	0.6	0.5	0.6	0.5	0.5
25-Feb	0.7	0.7	0.6	0.5	0.5

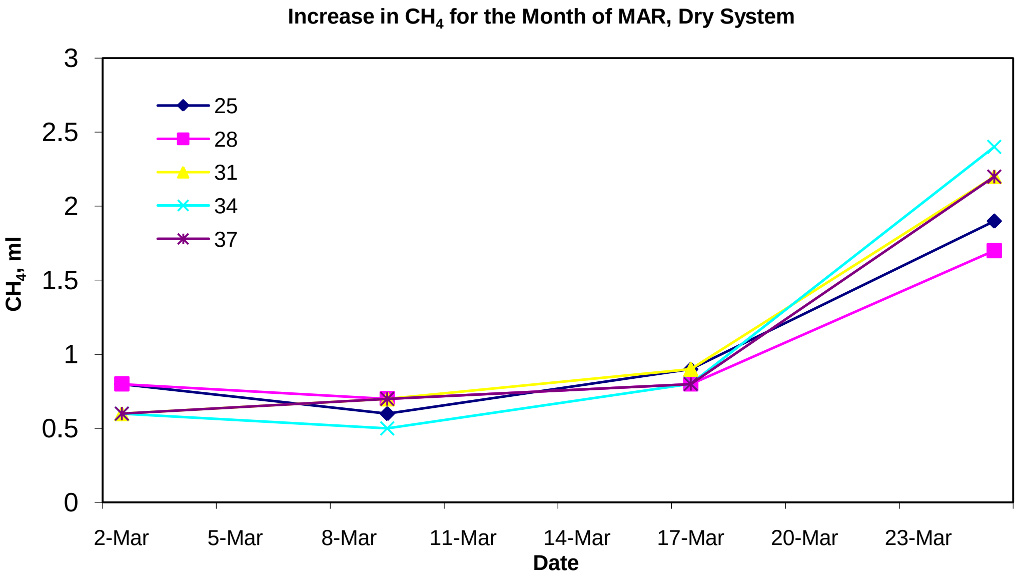

Fig. 25.Variation in increase for CH_4 for the month of March in case of dry system

Table 25. Increase in CH_4 production for the for the month of March in case of dry system

DATE \ %DM	25	28	31	34	37
2-Mar	0.8	0.8	0.6	0.6	0.6
9-Mar	0.6	0.7	0.7	0.5	0.7
17-Mar	0.9	0.8	0.9	0.8	0.8
25-Mar	1.9	1.7	2.2	2.4	2.2

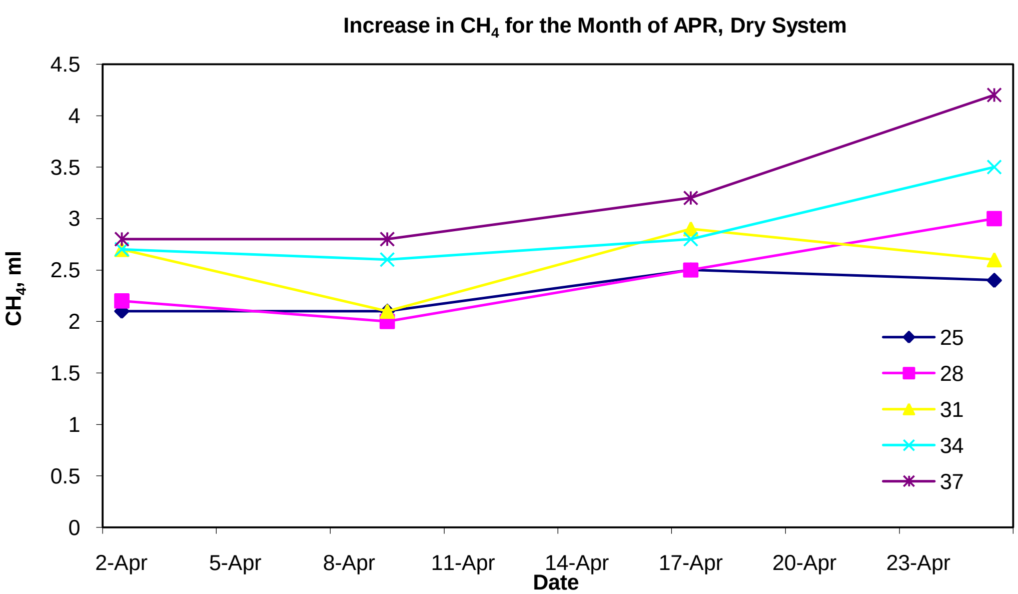

Fig. 26. Variation in increase for CH_4 for the month of April in case of dry system

Table 26. Increase in CH_4 production for the for the month of April in case of dry system

DATE \ %DM	25	28	31	34	37
2-Apr	2.1	2.2	2.7	2.7	2.8
9-Apr	2.1	2	2.1	2.6	2.8
17-Apr	2.5	2.5	2.9	2.8	3.2
25-Apr	2.4	3	2.6	3.5	4.2

5. Conclusion

As per objective of the study, consideration was on the production of gas based on the organic portion of MSW mainly food waste, where the rate of gas (CH_4 and CO_2) production was analyzed for two systemsi.e. dry system (Percentage of dry matter: 25%, 28%, 31%, 34%, and 37%) and wet system (percentage of dry matter: 5%, 7%, 10%, 12%, 14%) where the former system of setup contain higher percentage of organic matter relative to the later one with each system containing five setups each to compare the production of gases.Moreover, analysis for production of gas corresponding to weeks of every month, production of gas on monthly wise basis was done.Analysis is also done for increase in production of methane gas for corresponding week of every month, for week wise production for individual months for both dry as well as wet system. Based upon the experimentation work it can concluded that even with the simple men made digester, although the volume is quite less but there has been production of gas specially CH_4. Also, it is conclusive that at lower temperature range (15°C to 20°C) the production of methane gas is lower as compared to when the temperature rises (20°C to 26°C).

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