International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 05 | May-2018 www.irjet.net p-ISSN: 2395-0072

Anaerobic Co-digestion of Sewage Treatment Plant Sludge with Organic Fraction of Municipal Solid Waste

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Abstract - *Anaerobic digestion is used to treat the waste containing organic fraction due to their Methane potential. The present work involves co-digestion of sewage treatment plant sludge with organic fraction of municipal solid waste mainly focusing on following aspects:-1)To co-digest the multiple substrates i.e. Sewage treatment plant sludge and organic fraction of municipal solid waste to increase the rate and quantity of biogas generation. 2) To reduce the treated waste disposal problem from STP (i.e. the waste which remains after treating the sludge) 3) To decide different waste proportion and pretreatment which give good result in the form of methane generation. The study of co-digestion by mixing different organic waste in substrate better balanced and by providing mechanical pretreatment and maintaining operating condition such as pH, temperature, etc. which helps to improve both biogas yield and production efficiency.*

***Key Words*: Co-digestion, Anaerobic digestion, Pre-treatment, Operating condition, Methane potential**

1. INTRODUCTION

Co digestion is a term referred to the anaerobic digestion of multiple substrates in an anaerobic digestion system. In other words co digestion is a process of simultaneous digestion of more than one waste in same unit. Anaerobic digestion is the process in which decomposition of organic substrate takes place under oxygen free condition using anaerobic microorganism .The anaerobic digestion is mainly depend upon the environmental conditions such as pH, temp, nutrient contents, C/N ratio, particle size. The end products of A.D are generally biogas and organic nitrogen compounds.

The disposal of waste directly on ground decreases soil fertility, increases land pollution and wide spreading of diseases due breeding of flies over disposed waste. To avoid the dependency over the conventional source of energy, new source of energy are must. Therefore co-digestion is the best suitable technique.

1.1 Advantages of co digestion

1) Better digestibility.

2) Increase the rate of biogas generation.

3) Provide the required nutrients and moisture content for digestion.

1.2 Objectives of Study

1) To study the basics of co-digestion & anaerobic digester.

2) To design & prepare the experimental setup.

3) To carry out experimentation on setups and to compare the results in the term of biogas generation.

2. SUBSTRATES FOR CO- DIGESTION

The suitable substrates for biogas generation contain carbohydrates, proteins, lipids, cellulose and hemicelluloses. In this study, one of the substrate is digested sludge from the Sewage Treatment Plant. Another substrate is the Organic Fraction of Municipal Solid Waste which is collected from transverse station.

Among carbohydrate, proteins and lipids present in OFMSW, lipids provides high yield of biogas but it requires more retention time whereas on the other hand, proteins shows faster rate of generation with low yield.

2.1 Processes of anaerobic digestion

The four key stages of anaerobic digestion involve hydrolysis, acidogenesis, acetogenesis and methanogenesis.

The digestion process begins with bacterial hydrolysis of input materials. Insoluble organic, polymer, such as carbohydrates, are broken down to soluble derivates that become available for the bacteria. Acidogenic bacteria then convert the sugar and amino acid into carbon dioxide, hydrogen, ammonia and organic acids. These bacteria convert this resulting organic acid into acetic acid along with additional ammonia, hydrogen and carbon dioxide. Finally, methanogens convert these products to methane and carbon dioxide.

3. CO- DIGESTION PRETREATMENTS

In order to improve the stability of waste, and biogas production, pre-treatment is given to the substrates. In this study, pre-treatment is given in the terms of the mechanical pre-treatment.

3.1 Mechanical pretreatment

Mechanical pretreatment is given so as to reduce the size of particles and increase the surface area available to the microorganisms to improve biological process by increasing rate of degradation. It is provided in the form of shredding of substrates with the help of mixer.

Effect of shredding:-

1) If the fibre content in the substrate is high and degradability of substrate is low then the gas production rate would be higher.

2) Small size leads to the rapid digestion of the substrates. In these fibre can break down easily,

Due to the shredding, 25% reduction in volatile solid reduction was achieved (ARTICLE in BIORESOURCE TECHNOLOGY AUGUST 2000).

4. OPERATIONAL PARAMETERS

The degradation of the biological material depends upon the feed characteristics and environmental conditions required for the bacteria.

The requirements for effective operation of biogas system are as follows:-

A) pH

It is an important parameter in the biogas system. pH involves at all stages of degradation of material i.e. four phases of co digestion. Also it affects the growth of microorganism. For the growth of microorganism and higher biogas yield, pH should be maintained in the range of 6-8.5. In hydrolysis phase, waste containing carbohydrates, lipids and proteins are pH dependent (Zeeman et al. 1999).

B) Temperature

Temperature affects the all biological activity of the system. At lower temperature, methane forming bacteria are not activated.. For the small scale anaerobic digestion, temperature required is 30ºC to 35 ºC. There are two types of temperature range 1) Mesophilic temperature range and 2) Thermophilic 50-60ºC.

C) Solid Concentration

Co-digestion substrates contains high solid concentration, it is the degradable part of feed material in a unit volume of slurry. Total solid affect pH, temperature and efficiency of microorganisms. While designing the reactor solid concentration needs to determine.

D) C/N Ratio

C/N ratio affects the toxicity of waste if C/N ratio increases toxicity decreases. It also reduces the rate of reaction. The microorganisms utilize the 25 – 30 times C and N for bio-methane system.

E) Organic Loading Rate

Organic loading rate helps to decide the size of digester . The organic loading rate(OLR)is an important parameter because it indicates the amount of volatile solids to be fed into the digester . Volatile solids represent that portion of the organic-material solids that can be digested, while the remainder of the solids is fixed. The 'fixed' solids and a portion of the volatile solids are non-biodegradable.

F) Mixing

Mixing provides suitable condition for the A.D. it create uniformity between OFMSW & Sludge. But excessive mixing disturb the granular structure of substrate so it can affect the rate of reaction.

5. EXPERIMENTATION

Experiments were carried out in 900 ml airtight glass bottle and water displacement method was used to measure the biogas.

Materials used for designing and development of digester:-

1. Digester- 4 Batch type airtight glass bottle of capacity 900ml were used.

2. Gas measurement device: - 1000ml plastic cylinders along with beakers (1000ml) were used for the water displacement method to measure the gas and also saline tubes were used to carry gas during water displacement method of measurement.

3. Input materials: - Substrates used for generation of biogas were OFMSW which includes vegetables, fruits and kitchen waste. The waste was collected from transverse station. The waste was chopped in appropriate size with the help of mixer. Another substrate used was sewage treatment plant sludge and cow manure.

The ratios adopted for feeding of digester are as follows:-

Table -1: Operational Parameters maintained in digesters

Reactor	B1	B2	B3	B4
Input	S+W	S+W	C+W	S+W
Substrate (OFMSW)	Selected	Selected	Selected	Combine
Free board	450ml	450ml	450ml	450ml
Ratio(By weight)	1:1	1:2	1:1	1:2
pH	5.5	5.6	5.9	5.8
Temp.(ºC)	30.5	31.1	31.3	9.3
T.S (%)	6.467	8.57	13.718	7.951
T.V.S (%)	5.154	7.144	12.324	6.419

here S= Digested slurry from STP.

W=Organic fraction of Municipal Solid Waste.

C=Cow dung Slurry

Selected substrate=Green Coriander, Banana peels, cabbage, ladyfinger ,pineapple peels, green beans, spinach, pumpkin, chicken, cucumber, cauliflower, salad.

Combined Substrates=Drumsticks, potato, ginger, carrot, muskmelon, processed food, green mix vegetables, bringle along with selected

In B1 and B3 bottles the ratio selected was 1:1 each. i.e. 50% of OFMSW and 50% of Slurry. For the higher solid content 1:2 is adopted for B2 and B4. In three bottles B1, B2 and B3 selective type waste is fed into digester, while B4 is a combined type of waste,

As B1 and B3 have same ratio and type of waste (i.e. selective) thus comparison of biogas yield is done on the basis of differed input.

B1 and B2 have same input and type of waste (i.e. selective) thus comparison of biogas yield is done in terms of differed ratio.

B2 and B4 have same ratio and input hence biogas yield can be compared on the basis of differed type of waste.

Fig -1: Digesters

6. RESULTS

Cumulative biogas generation for the reactors B1, B2, B3 and B4 for detention period of 10 day is given below:-

Table -2: Cumulative biogas generation

B1 (ml)	B2 (ml)	B3 (ml)	B4 (ml)
1797	1623	1517	2327

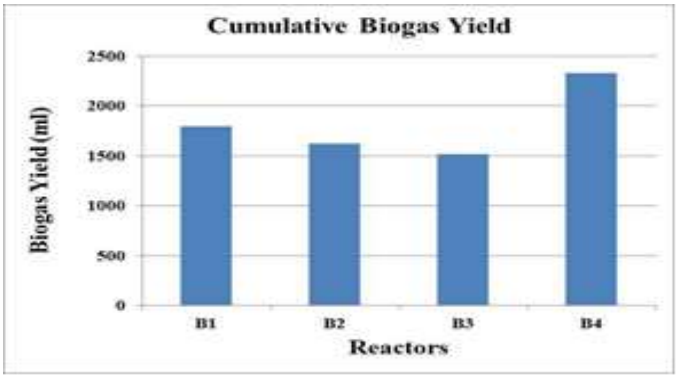

Fig -2: Cumulative Biogas yield

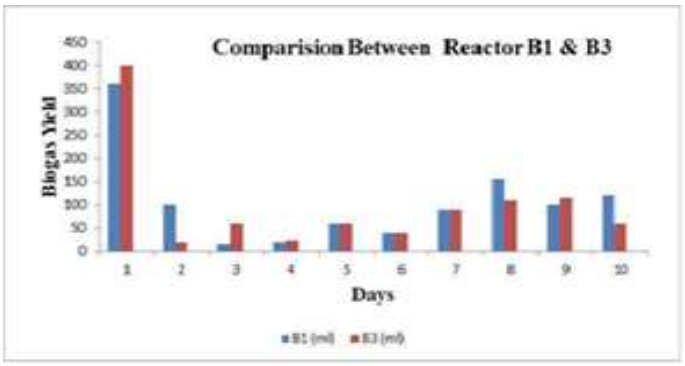

Fig -3: Comparison between B_1 and B_3

Graph showing biogas yield in digester B2 and B4:-

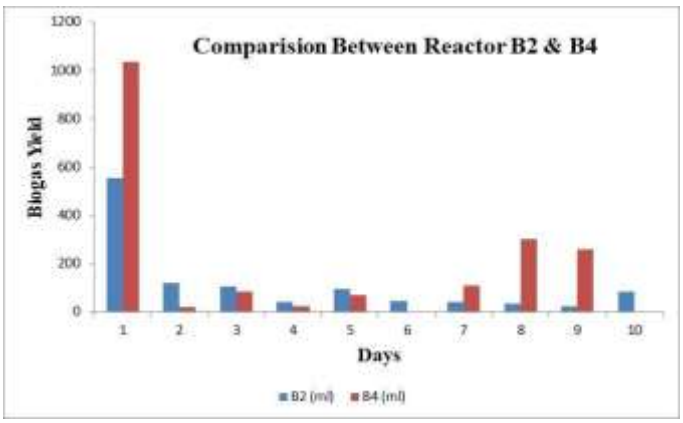

Fig -3: Comparison between B_2 and B_4

Graph showing biogas yield in digester B_1 and B_2:-

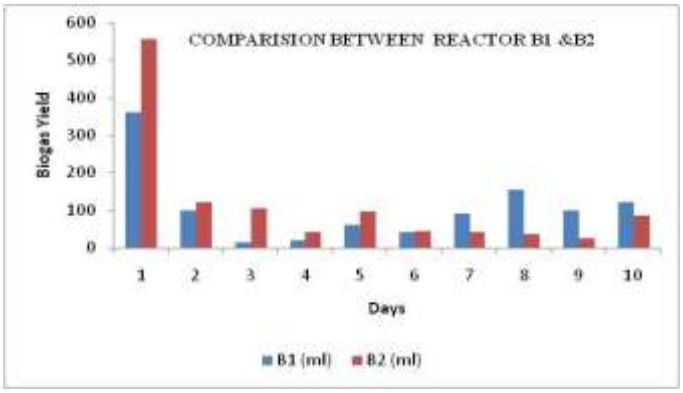

Fig -4: Comparison between B_1 and B_3

7. CONCLUSION AND DISCUSSIONS

In conventional process of waste treatment, the organic waste is directly dump at dump yard without any pretreatment. Hence there is no scope for energy generation and it causes land pollution. Thus, co digestion is the feasible and efficient way to manage the waste in comparison to the landfill and it also allows methane potential which is available in waste can be used to generate energy.

The experimental setup, i.e. the digester was designed for various proportions of OFMSW and slurry. Depending on the proportions the size of the digester was decided.

The results from the experimental setup 3 were satisfactory and the following conclusions can be drawn from those results:

Among all the 4 digester, maximum biogas generation was generated in digester B1. The settlement of the mix was found to be 3.5 cm. Among all the 4 digester, maximum settlement was found in digester B3, due to presence of more microorganism and high rate of degradation.

Inoculum used in the digester B1 and B3 is sludge and cowdung respectively. Though the proportion of both, sludge and cowdung are same i.e. 1:1 (sludge: cowdung). The amount of active microorganism is more in sludge resulting in more generation of biogas.

The proportion of inoculums and OFMSW is same in digester B2 and B4. The only difference being the OFMSW in digester B2 was selected one. (Carbon content is high) Whereas the OFMSW in the digester B4 was not segregated.

The selected OFMSW in digester B2 resulted in restricted carbon content as compared to digester B4.The result of this can be seen in the biogas generated in B2 is less than the biogas generation in B4.

ACKNOWLEDGEMENTS

We are privilege to take this opportunity to thank Dr. S. T. Mali our project guide and Prof. A. P. Sinha our project co-guide who have been constant source of inspiration and also took keen interest in each and every step of project development. We are grateful for their encouragement in shaping the idea and valuable suggestions in making it a reality.

Again we take the opportunity to express our deep sense of gratitude of valuable guidance and for providing lab facilities to Prof. Tanmay Khambekar and Dr. S. T. Mali as a HOD of Civil Department in Pimpri Chinchwad College of Engineering.

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