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Experimental Study of Different Parameters Affecting Biogas Production from Kitchen Wastes in Floating Drum Digester and its Optimization

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Abstract: **Recent challenges for fossil fuels, concerns over the environment issues and rising costs for energy demand encourages researchers to search for an alternate source of renewable energy . An attempt has been made to produce biogas from kitchen waste following anaerobic digestion process where the bacteria degrade organic matters in the absence of oxygen. Kitchen waste is used as the best raw material for the Bio-gas plant. Biogas contains around (55-85)% of methane (CH_4), (30-40)% of carbon dioxide (CO_2) , a trace of hydrogen sulphide (H_2S) and moisture (H_2O).The calorific value of biogas is around 4700 kcal or 20 MJ. In this paper, different samples of biogas have been taken to optimize methane (CH_4) content by controlling the pH value, Temperature, concentration of slurry, retention time, C/N ratio and rate of loading. This experiment was done in a floating drum type anaerobic digester of 1cubicmeter capacity and it is made of fiber material. The maximum pH level is maintained to 7.3, maximum fermentation process at (30-35)°C , maximum Bio-gas produced 0.950m^3 and the maximum methane(CH_4) is found to be 85%.**

Keywords: **Floating drum type Digester, Slurry, anaerobic digestion (AD), PH Value.**

I. INTRODUCTION

Biogas is produced from all kind of biological organic waste like animal manure and industrial waste, human manure, restaurant waste etc. Such wastes become a major source of air and water pollution and responsible for 18% of the overall greenhouse gas and 64% of anthropogenic ammonia emission. Biogas is produced from organic wastes by the help of various groups of anaerobic bacteria through anaerobic decomposition. Anaerobic digestion (AD) is a biochemical and thermo chemical process which produces biogas. It has been found during anaerobic digestion that the microbial population makes use of about 25 to 30 times carbon faster than nitrogen [2]. In order to control excessive production of ammonia during AD is to increase the C/N ratio of feedstock. This can be done by co-digesting with other waste feedstock that is high in biodegradable carbon to improve the performance of AD.

Kitchen waste is an organic material having high calorific value and nutritive value to microbes, so efficiency of methane production can be enhanced by several orders of magnitude. It means higher efficiency and size of reactor and cost of biogas production is reduced. Also in most of cities and places, kitchen waste is disposed in landfill or discarded which causes the public health hazards and diseases like malaria, cholera, typhoid. Inadequate management of wastes like uncontrolled dumping bears several adverse consequences. It not only leads to polluting surface and groundwater through leachate and further promotes the breeding of flies, mosquitoes, rats and other disease bearing vectors. Also, it emits unpleasant odour and methane which is a major greenhouse gas contributing to global warming [3].

At present biogas is used mainly in cooking and lighting. Produced biogas is generally stored in large impermeable bags at biogas plant site. The gas produced in digester is transported by piping to nearby kitchens on pressure developed in digester. But this pressure is not sufficient to transfer gas to farther distances from the biogas generation site. The main problem of biogas is its low energy content and it is difficult and costlier to liquefy it. This requires compression of biogas to as higher pressure as possible. Storage of the gas is another concern as cylinder becomes heavy and bulky for higher pressures. This may increase weight of the cylinder and hence affect its portability. So to increase energy content, other techniques like removing incombustible gases are to be implemented.

II. MATERIALS AND METHODS

2.1 Characterization of Biogas

Biogas is produced by methenogensis bacteria through biodegradation of organic material under anaerobic conditions. Natural generation of biogas is an important part of bio-geochemical carbon cycle. It can be used both in rural and urban areas. Main products of the anaerobic digestion are biogas and slurry. In composition of biogas methane, carbon dioxide, hydrogen sulfide, nitrogen, oxygen, ammonia, chlorinated organic matter, silanes, siloxanes, volatile phosphorous substances and other volatile trace compounds are found.

Table 1 Composition of Biogas

Component (Volume)	Concentration
Methane (CH_4)	55-60%
Carbon Dioxide (CO_2)	35-40 %
Hydrogen Sulphide (H_2S)	2%
Water Content (H_2O)	2-7%
Ammonia (NH_3)	0-0.005 %
Nitrogen (N_2)	0-2%
Oxygen (O_2)	0-2%
Hydrogen (H_2)	0-1%

2.2 Mechanism of Anaerobic Digestion

Anaerobic digestion occurs inside the digester with certain bacterial fermentation. The entire process of digestion is completed in a sequence of stages like Hydrolysis, Acidogenesis, Actogensis, and Methanogenesis. In the first stage Hydrolysis process involves convert complex organics to sugars and amines, second stage involves in converting the organic acids to acetic acids.

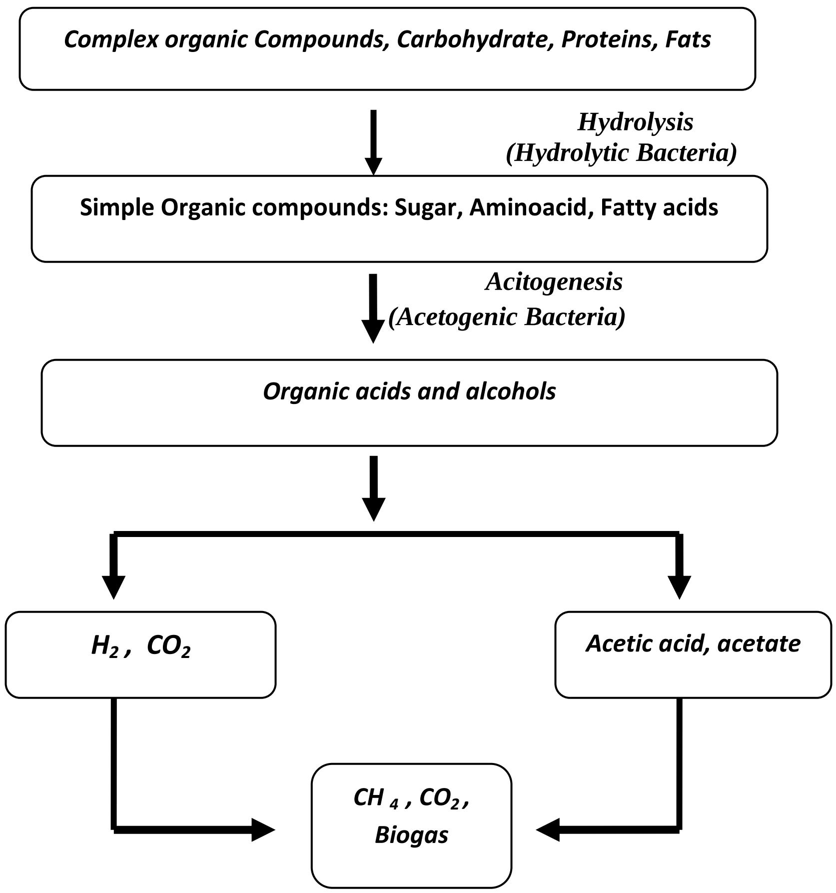


Fig 1 Schematic diagram of Anaerobic Digestion process

The approximate chemical formula for organic waste is $C_6 H_{10} O_4$ (Shefali & Themelis 2002).

Hydrolysis reaction of organic fraction is represented by following reaction:

$C_6 H_{10} O_4 + 2\, H_2 O \rightarrow C_6 H_{12} O_6 + 2H_2$ (Ostrem & Themelis 2004)

The End digestion period of the conversion of acetic acid into methane and carbon dioxide is called as the methanogenic phase.

$$2CH_3CH_2\,OH + CO_2 \rightarrow 2\,CH_3COOH + CH_4$$

$$CH_3COOH \rightarrow CH_4 + CO_2$$

$$CH_3OH + H_2 \rightarrow CH_4 + H_2\,O$$

The growth of methenogenesis bacteria basically depend on various parameters like pH value, temperature, C/N ratio, organic loading rate, digester design, etc. Bio digester is operated on temperature range for psychrophilic below 28^0C, mesospheric at medium temperature range from 29^0C to 40^0C and thermopile temperature from 50^0C to 55^0C.

2.3 Experimental set up of biogas plant

The biogas plant made up of PVC fiber with 1 Cubic meter capacity with a loading rate of 10kg bio waste daily with a 1:1 proportion with water. The plant is set outside so that the digester and dome both can directly receive sunlight. Fibre material digester is basically used as it is low cost, easily available, easy to give shape, low weight and nonreactive with the gases generated inside the dome. The different tests are conducted under the different climatic conditions during the month of January to June.

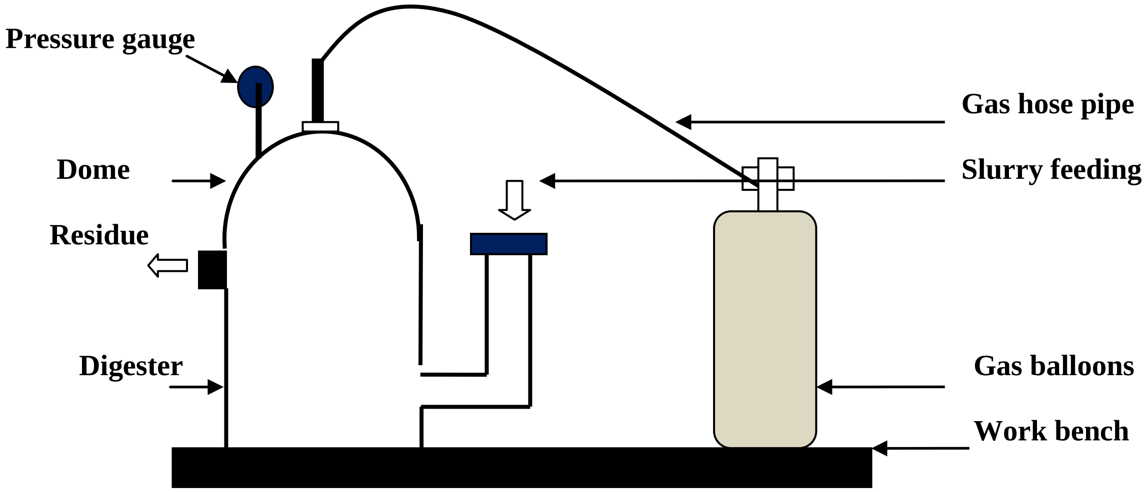


Fig 2 Schematic diagram of experimental set up

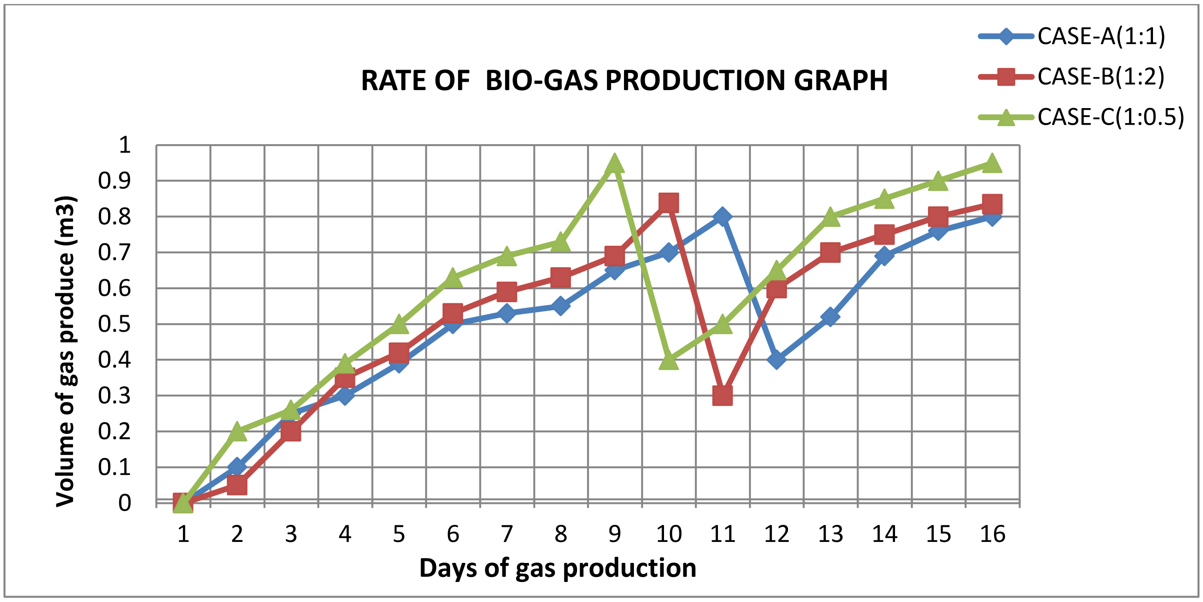
The residue left from the digester can be used as good manure. The observation data taken during day time at 12:00 PM to 3:00 PM. Ambient temperature, slurry temperature, relative humidity and the volume of biogas produced is measure and recorded for every day.

BIO-GAS PLANT

GAS STORAGE BALLOON

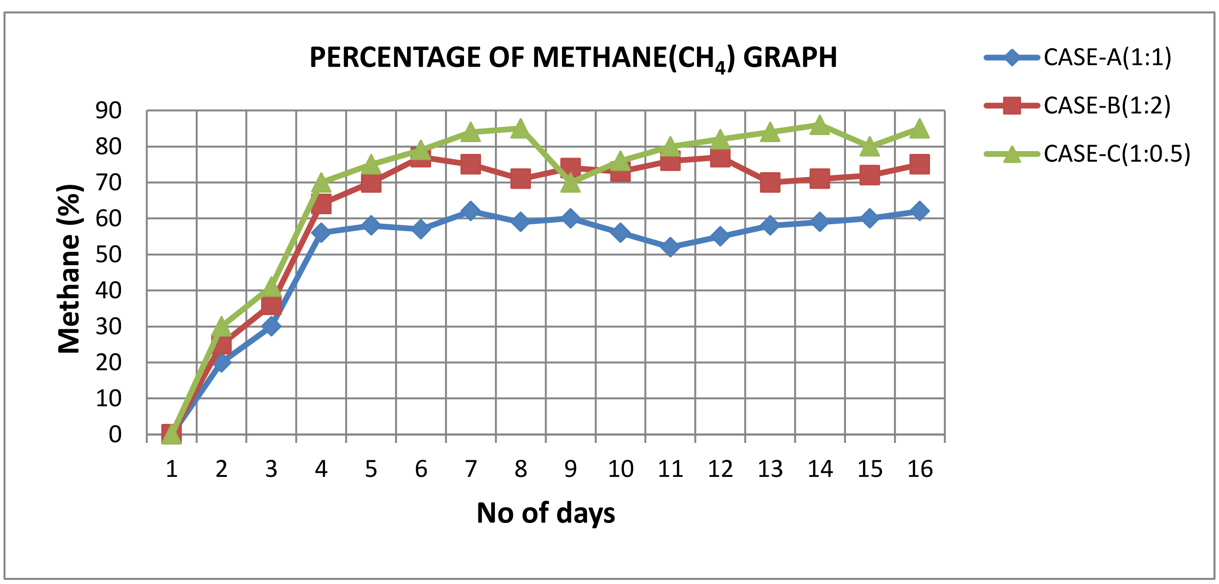
III. RESULT AND DISCUSSION

The slurry is prepared with kitchen waste and water by different proportion and put into the digester for fermentation process. The process takes 10 to 15days to produce the gas in anaerobic conditions. We get approximately 6kg of methane from 10kg of biomass. The gas produced can burn continuously 2hrs at a stretch twice a day with double burner. The analysis is made to calculate the pH value of the slurry, ambient temperature, biogas production rate, methane percentage, etc. The readings are taken in batch production and real time.



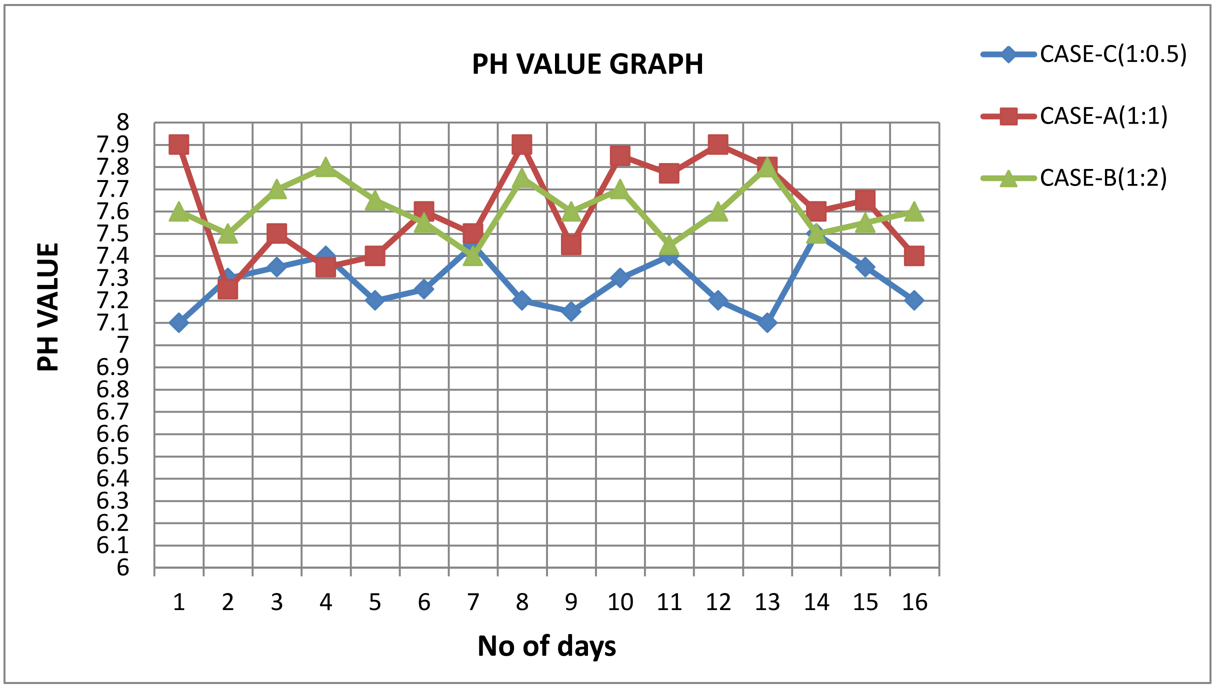
[Graph 1 volume of gas production in length of time]

From the above graph, it indicates that the retention time is also affecting the biogas production and the the slurry prepared with different ratio of biomass and the gas production is found higher when the ratio of waste to water is 1:0.5. The total gas collected is around 0.95 m^3 with methane content of 85% and pH value of 7.3. The maximum volume of gas produced with slurry ratio of 1:05 and minimum with 1:1.



[Graph 2 volume of gas production in length of time]

From the above graph, it is found that the percentage of methane (CH_4) is higher in CASE-C with retention time of 10 days and slurry ratio (1:0.5). The maximum methane (CH_4) content is 85% of total volume of biogas produced. But in CASE-A, we get the lowest percentage of methane (CH_4) when we feed the slurry of 1:1 ratio. The maximum methane present in the produced biogas is 60%. In CASE-B, we get the medium percentage of methane (CH_4) production, when we feed the slurry prepared with 1:2 proportions. The maximum methane (CH_4) present in the produce Bio-gas is 75%.



[Graph 3 volume of gas production in length of time]

The above graph explains that the best pH value of the slurry is in CASE-C that is when we feed the slurry prepared with 1:0.5 ratios. The maximum pH value of the slurry is 7.3. But in CASE-A, we get the highest pH value of 7.9. In CASE-B, we get the medium pH value of the slurry 1:0.5 ratio. The maximum PH value of the slurry is 7.6. This is very important to maintain a constant pH value of the slurry feed to the digester for getting a maximum quantity of biogas.

IV. CONCLUSION

The slurry temperature and concentration inside the digester is very important for maximum biogas production. The temperature of the digester is significantly changing with ambient conditions. The homogeneity of the slurry is also important for maximizing the volume of gas production.

The following conclusions were drawn on successful completion of the experimentation on biogas production from kitchen wastes in a floating drum digester:

- The maximum slurry temperature is maintained at 38-39^{0}C for maximum volume of production.
- The substrate prepared with a ratio of 1:0.5 gives good result with required pH value of 7.6 maintained inside the digester.
- The homogeneity of the mixture is also important for better gas production.
- The volume of gas produced maximum with a favourable ambient condition around the month of April –May.

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REFERENCES

[1]. Johnson, Owe, et al. "Sustainable gas enters the European gas distribution system." Danish Gas Technology (2002).

[2]. T. R. Yadvika, K. Sreekrishnan, V. Sangeeta, and A. Rana,“Enhancement of biogas production from solid substrates using different techniques- a review,” *Bioresource Technology*, vol. 95, no.

[3]. Production and Analysis of Biogas from Kitchen Waste Ziana Ziauddin1, Rajesh P2 1, pp. 1- 10, October 2004. Bagi, Zoltán,

et al. "Biotechnological intensification of biogas production. "Applied microbiology and biotechnology 76.2 (2007): 473-482.

[4]. Amar Kumar Das, Shovan Nandi, Subrat Kumar Patra, Scope of Biogas generation from Kitchen wastes and its economical adoptability , International Journal of Latest Engineering and Management Research (IJLEMR) ISSN: 2455-4847 www.ijlemr.com || Volume 02 - Issue 05 || May 2017 || PP. 01-05

[5]. I.J.Dioha, C.H.lkeme, T.Nati'u, N.I.Soba and Yusuf M.B.S, .aeaffect of carbon to nitrogen ratio on biogas production Energy Commission of Nigeria, Vol 1,PP.1-10(2013).

[6]. K.Kaygusuz, A.kaygusuz, Renewable Energy.25 (2002)431-453.

[7]. R.Alvarez, R.Villica, G, Liden, Biomass and Bioenrgy, 30(2006)66-75.

[8]. Meena, K., Kumar, V., & Vijay, V. K. (2011, June). Anaerobic technology harnessed fully by using different techniques: Review. In Clean Energy and Technology (CET), 2011 IEEE First Conference on (pp. 78-82). IEEE.

[9]. Bougrier, C., et al. "Effect of ultrasonic, thermal and ozone pre-treatments on waste activated sludge solubilisation and anaerobic biodegradability." Chemical Engineering and Processing: Process Intensification 45.8 (2006): 711-718.

[10]. Li, Yebo, Stephen Y. Park, and Jiying Zhu. "Solid-state anaerobic digestion for methane production from organic waste." Renewable and sustainable energy reviews 15.1 (2011): 821-826.