Effect of Total Solids, Agitation Time on biogas yield using Rice Husk

Article *in* International Journal of Ambient Energy · August 2017

DOI: 10.1080/01430750.2017.1372815

3 authors:

Sathish Saravanan
Hindustan University
61 PUBLICATIONS **322** CITATIONS
SEE PROFILE

Dr.M. Chandrasekaran
Vels institute of Science Technology and Advanced Studies
207 PUBLICATIONS **2,640** CITATIONS
SEE PROFILE

Gnanadurai Ravikumar Solomon
Hindustan University
20 PUBLICATIONS **297** CITATIONS
SEE PROFILE

International Journal of Ambient Energy

ISSN: 0143-0750 (Print) 2162-8246 (Online) Journal homepage: http://www.tandfonline.com/loi/taen20

Effect of total solids and agitation time on biogas yield, using rice husk

S. Sathish, M. Chandrasekaran & Gnanadurai Ravikumar Solomon

To cite this article: S. Sathish, M. Chandrasekaran & Gnanadurai Ravikumar Solomon (2017): Effect of total solids and agitation time on biogas yield, using rice husk, International Journal of Ambient Energy, DOI: 10.1080/01430750.2017.1372815

To link to this article: http://dx.doi.org/10.1080/01430750.2017.1372815

Accepted author version posted online: 29 Aug 2017.
Published online: 21 Sep 2017.

INTERNATIONAL JOURNAL OF AMBIENT ENERGY, 2017
https://doi.org/10.1080/01430750.2017.1372815

Taylor & Francis
Taylor & Francis Group

Effect of total solids and agitation time on biogas yield, using rice husk

S. Sathish[a], M. Chandrasekaran[b] and Gnanadurai Ravikumar Solomon[a]

[a]Department of Mechanical Engineering, Hindustan University, Chennai, India; [b]Department of Mechanical Engineering, Vels University, Chennai, India

ABSTRACT

The rice husk contains a high amount of organic matter, which is broken down by microbial activity using anaerobic digestion, yielding biogas. The various percentages of total solids (Ts) concentration of rice straw effect of agitation time, pH, temperature and effectiveness of microorganisms in the decomposition process were studied in order to determine the conditions for an optimum biogas yield. A floating dome anaerobic digester wasutilised, which contains different percentages of the Ts, and the biogas yield is monitored directly by a digital gas flow meter. It is observed that the amount of biogas yield generated for 10% Ts, 20% Ts and 30% Ts was 1.13, 1.25 and 1.03 m^3, respectively. The result shows that 20% Ts concentration and 15 min agitation time and pH of 7.2 had the maximum biogas yield.

ARTICLE HISTORY
Received 22 July 2017
Accepted 21 August 2017

KEYWORDS
Total solids; biogas yield; anaerobic digestion; agitation time; temperature; microorganisms

1. Introduction

When agriculture straw residues are burned to generate energy directly through combustion, only a low percentage of the waste has been obtained, due to utilisation of insufficient burner, as reported by Suntikunaporn et al. (2014). Hence, in the pursuit to develop an efficient usage of its potential energy content, anaerobic digestion process is discovered to generate a clean, environmentally healthy and economical gas as one of the best options for straw residues (Krishania et al. 2012). The amount of agricultural straw generated in India is approximately 60,000 tons/day, which contains more than 80% of alkaline materials (Riya et al. 2016). Among the various renewable energy resources available, biomass is one of the most important promising renewable energy, which will play an important role in the future. Biogas is a gaseous product obtained upon anaerobic decomposition of organic materials and a renewable source to generate biogas (Abubakar and Ismail 2012). There are various factors that affect the biogas yield such as inoculum, total solids (Ts), volatile solids, stirring effect and temperature.

Among these factors, Ts and agitation time are the prime factors that affect the survival growth and activities in the biogas production (Yavini, Chia, and John 2014). Acid production (pH) is an important factor affecting the development of microorganisms during the digestion period. Generally, maximum biogas yield is obtained using an anaerobic reactor in the pH range of 6.8–7.2 (Tanimu et al. 2014). It occurs as a volatile acid, which is converted to CH_4 and carbon dioxide. The pH range of an anaerobic reactor is significantly affected by the methane content of biogas yield (Weiland 2010). It is stated that the higher the amount of Ts fed into the digester, the larger the amount of volatile acids formed in the digester, which shows the higher impact of alkalinity and pH value of the digester. Generally, reactor conditions such as pH value, temperature, Ts and agitation time as well as feedstock characteristics such as volatile solids content, carbon/nitrogen ratio, particle size of the feeding materials and bio-degradability affect the performance of the digester and biogas (Sathish and Vivekanandan 2015a, 2015b). Agitation of digester slurry is a process to make stability by preventing stratification of digester materials and temperature for uniform contact between the microbial community and organic loading rate (Weiland 2010). There are different anaerobic microbe communities functioning in the different temperature ranges such as mesophilic (35°C) and thermophilic (55°C).

This makes the thermophilic process more efficient and it will generate a higher rate of biogas yield. The biogas generation rate mainly depends on substrate concentration (Babaee and Shayegan 2011). This work examines the rice husk to produce the maximum biogas yield with the effect of different percentage of Ts, pH and agitation time. The sizes of the reactor determine the scale of biogas plants, which vary from few cubic metres and other the case of small household installations (Figure 1).

Anaerobic digestion of rice husk and cow dung is considered to improve their fertiliser value. Because straws and slurries from different wastes are mixed and co-digested, providing a more balanced content of nutrients to increase the biogas yield (Deressa et al. 2015). This type of digestion process achieves multiple environmental benefits and generates a renewable resource. Biogas technology is also potentially useful in the recycling of nutrients back to the soil (Jin et al. 2014). Burning non-commercial fuel sources, such as rice husk and cow dung in our countries where they are used as fuel instead of as fertiliser, leads to a severe ecological imbalance, since the nutrients, nitrogen, and phosphorus, potassium and micronutrients are

CONTACT S. Sathish sathishamg88@gmail.com

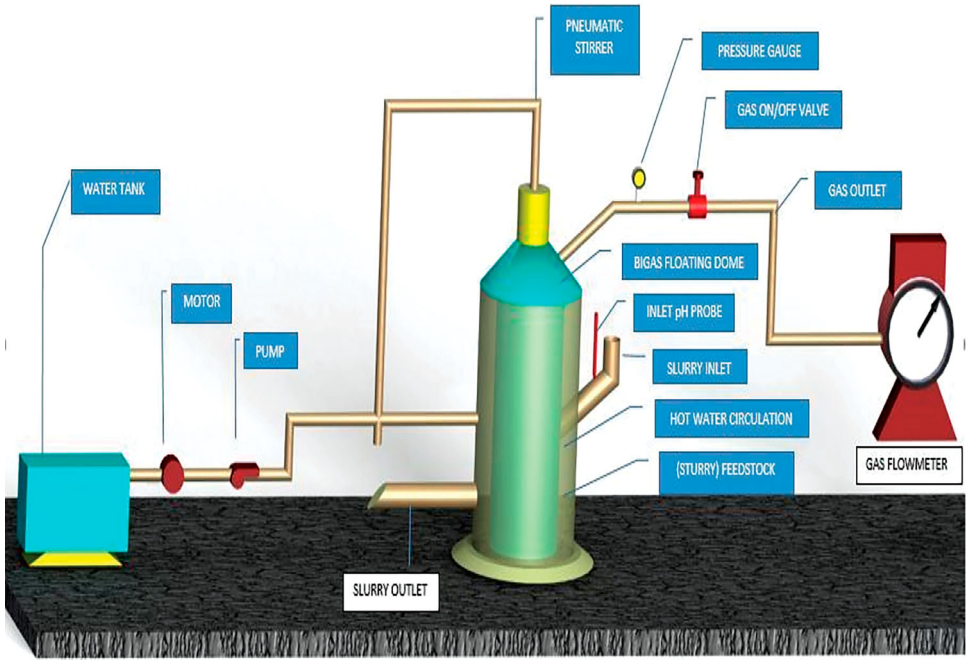

Figure 1. Schematic view of the experimental setup.

essentially lost from the ecosystem (Sathish and Vivekanandan 2015a, 2015b).

The methane and acid-producing bacteria act symbiotically where acid-producing bacteria create an atmosphere with ideal parameters for methane-producing bacteria (anaerobic conditions, compounds with a low molecular weight). On the other hand (Sathish and Vivekanandan 2016), methane-producing microorganisms use the intermediates of the acid-producing bacteria.

2. Experimental and materials

This study is carried out in a portable anaerobic floating dome-type digester with a capacity of 1.0 m^3. The experiments were conducted with batch-type process under fixed hydro retention time (HRT). The reactor is made up of fibre material.

The raw materials such as cow dung and rice husk are taken from the nearby Chennai city and the feeds are dried 10 days in sun light and crushed mechanically. The slurry of cowdung as an inoculum is the starter for the digester. The bio-reactor is fed with waste by volume as 60:40 with different percentages of Ts – 10%, 20% and 30%, respectively. The temperature was maintained between 30°C and 50°C with different stirrer timings to agitate the digester slurry at 5 to 25 min. The acid production pH level is maintained using NaOH solution. In all cases of experiments, the quantity of biogas yield is measured at intervals of 24 hours with an analog digital gas flow meter in the period of HRT at 25 days for all three different percentages of Ts. The temperature of the reactor is measured with thermocouples, and then initial and final pH are monitored using a pH digital redox meter. The pneumatic stirrer is used to agitate the digester slurry regularly and the digested slurry is collected from the digester to be used as an organic fertiliser.

3. Result and discussion

It has been found from Figure 2 that the maximum daily biogas yields are1.25, 1.1 and 1.0 m^3, respectively. It is obtained on17th day of digestion from 20% Ts, 10%Ts and 30% Ts, respectively. The formation of biogas yield is high during 17th to 20th day since, 20% Ts with temperature of 42°C. The biogas yield is very high in 20% Ts when compared to the other Ts percentage.

Biogas yield from 20% Ts is due to the enhancement of nutrition present in the feedstock content and also C/N content increases the methanogenic bacterial growth, in response to this it also make a bad odour in the period of fermentation suggested (Sathish, Chandrasekaran, and Parthiban 2017). The acid production pH of the digester decreases at the time biogas yield is very low rate. Figure 3 shows the pH range with respect to hydraulic retention time. The maximum biogas yield was achieved during17th to 19th day of digestion, with a pH of 7.2 to 7.4.

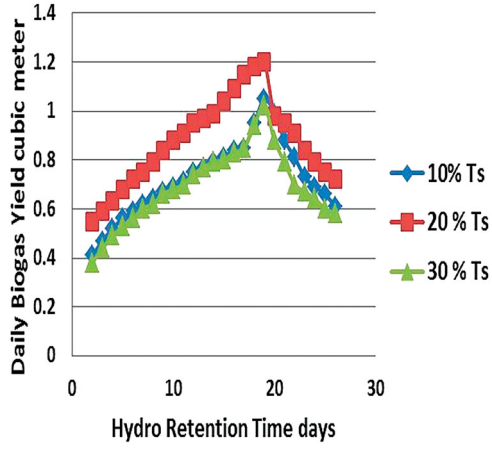

Figure 2. Daily biogas yields with HRT.

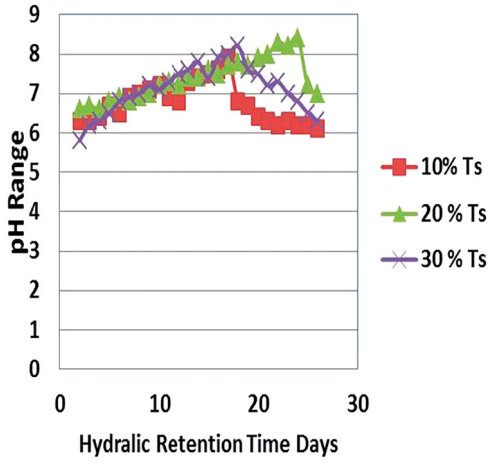

Figure 3. Acid production pH ranges with HRT.

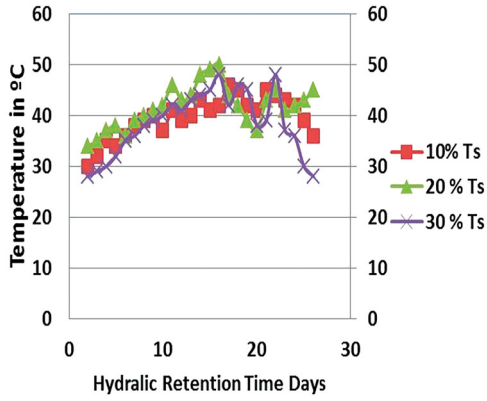

Figure 5. Temperature of digester slurry with HRT.

The range of pH is gradually increased than end of digestion value is reduced. When the pH value is maintained at a proper range, the time digester performance is high. Biogas yield decreases when the pH range obtained is lower than 5, as the methanogenic generation is decreased in the digestion period. On the other hand, Figure 4 shows the effect of the agitation time on biogas yield with HRT. The results indicated that the period of 20–25 min is the best option for floating dome-type digesters obtaining the maximum biogas yield. Therefore, the pneumatic stirrer had a slight force on biogas yield with different percentage of Ts. These results noticed that the stirring process is a most important parameter that enhances the biogas production from bio-digesters as well as enhances its efficiency of the floating dome-type digester.

Figure 5 illustrates the effect of temperature in biogas yield with respect to HRT. Temperature is also accounted for in the analysis of biogas yield. When the temperature of the digester fluctuates, a change in biogas production is expected. The results noticed that the maximum biogas yield achieved in the temperature range of 45–50°C. Hence, in this experiment, 45–50°C is found to yield a higher amount of biogas and a higher efficiency of the digester. Methanogen, hydrolysis and acidification were all affected by temperature fluctuation, as indicated in another study (Desai, Palled, and Mathad 2013). Generally, most of the pathogenic bacteria are destroyed in the thermophilic temperature range. The performance of the floating drum digester is very efficient and satisfactory. The problem of corrosion, which influences the generation of biogas yield, is ruled out because a fibre-type floating dome digester is used which can withstand higher temperature and different Ts concentrations.

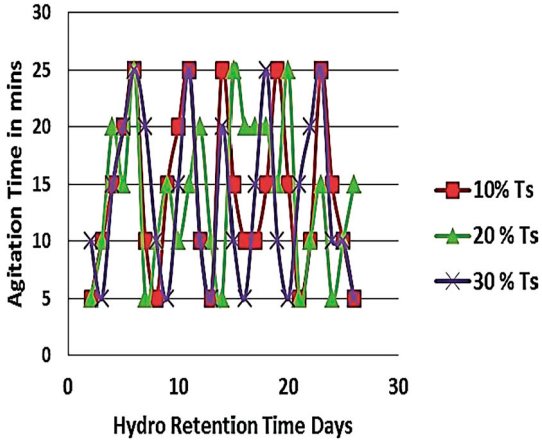

Figure 4. Agitation time with HRT.

4. Conclusion

The outcome of this work has shown that most of the microorganisms associated with the anaerobic digestion of rice husk with the cow dung. This type of digestion is the best method for biogas generation from rice husk. Generally, production of biogas from biomass is based on the amount of acid formation, which depends on the type of biomass used. The biogas yield rate is found to vary according to total solid concentrations, stirring time and temperature.

The important factor to be controlled during the period of anaerobic digestion process is the amount of Ts, temperature, pH range and agitation time. Therefore, anaerobic digestion using rice husk to generate biogas represents an environmentally attractive method to treat and simultaneously convert such a waste mixture to a useful energy source. The digestate could be utilised as a fertiliser in soils that requires moderate or no phosphorous supplementation due to digestate high nitrogen-to-phosphorous ratio.

Acknowledgement

The authors thank Hindustan University, Padur, Tamil Nadu, for their valuable support to this research.

Disclosure statement

No potential conflict of interest was reported by the authors.

References

Abubakar, B. S. U. I., and N. Ismail. 2012. "Anaerobic Digestion of Cow Dung for Biogas Production." *ARPN Journal of Engineering and Applied Sciences* 7 (2): 169–172.

Babaee, A., and J. Shayegan. 2011. "Effect of Organic Loading Rates (OLR) on Production of Methane from Anaerobic Digestion of Vegetables Waste." In World Renewable Energy Congress-Sweden, 8–13 May, 2011, Linköping; Sweden, No. 57, pp. 411–417. Linköping University Electronic Press.

Deressa, L., S. Libsu, R. B. Chavan, D. Manaye, and A. Dabassa. 2015. "Production of Biogas from Fruit and Vegetable Wastes Mixed with Different Wastes." *Environment and Ecology Research* 3 (3): 65–71.

Desai, S. R., V. Palled, and R. Mathad. 2013. "Performance Evaluation of Fixed Dome Type Biogas Plant for Solid State Digestion of Cattle Dung." *Karnataka Journal of Agricultural Sciences* 26 (1).

Jin, W., X. Xu, Y. Gao, F. Yang, and G. Wang. 2014. "Anaerobic Fermentation of Biogas Liquid Pretreated Maize Straw by Rumen Microorganisms in Vitro." *Bioresource Technology* 153: 8–14.

Krishania, M., V. Kumar, V. K. Vijay, and A. Malik. 2012. "Opportunities for Improvement of Process Technology for Biomethanation, Processes." *Green Processing and Synthesis* 1 (1): 49–59.

Riya, S., K. Suzuki, A. Terada, M. Hosomi, and S. Zhou. 2016. "Influence of C/N Ratio on Performance and Microbial Community Structure of Dry-thermophilic Anaerobic Co-digestion of Swine Manure and Rice Straw." *Journal of Medical and Bioengineering* 5: 11–14.

Sathish, S., and S. Vivekanandan. 2015a. "Experimental Investigation on Biogas Production using Industrial Waste (Press mud) to Generate Renewable Energy." *International Journal of Research in Engineering and Technology* 4 (2): 388–393.

Sathish, S., and S. Vivekanandan. 2015b. "Optimization of Different Parameters Affecting Biogas Production from Rice Straw: An Analytical Approach." *International Journal of Simulation Science and Technology*.

Sathish, S., and S. Vivekanandan. 2016. "Parametric Optimization for Floating Drum Anaerobic Bio-digester using Response Surface Methodology and Artificial Neural Network." *Alexandria Engineering Journal* 55 (4): 3297–3307.

Sathish, S., M. Chandrasekaran, and A. Parthiban. 2017. "Effect of Co-digestion Agricultural-industrial Residues: Various Slurry Temperatures." *International Journal of Ambient Energy*. doi:10.1080/01430750.2017.1318791.

Suntikunaporn, M., S. Echaroj, W. Rimpikul, P. Kaewprapha, N. Puttarak, B. Geethalakshmi, and P. Yiarayong. 2014. "Evaluation of Agricultural Wastes for Biogas Production." *Thammasat International Journal of Science and Technology* 19 (1): 1–8.

Tanimu, M. I., T. I. M. Ghazi, R. M. Harun, and A. Idris. 2014. "Effect of Carbon to Nitrogen Ratio of Food Waste on Biogas Methane Production in a Batch Mesophilic Anaerobic Digester." *International Journal of Innovation, Management and Technology* 5 (2): 116.

Weiland, P. 2010. "Biogas Production: Current State and Perspectives." *Applied Microbiology and Biotechnology* 85 (4): 849–860.

Yavini, T. D., A. I. Chia, and A. John. 2014. "Evaluation of the Effect of Total Solids Concentration on Biogas Yields of Agricultural Wastes." *International Research Journal of Environment Sciences* 3 (2): 70–75.