PAPER • **OPEN ACCESS**

Performance and Analysis of Floating dome Anaerobic Digester with Wet and Dry Feedstock

To cite this article: S. Sathish *et al* 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **183** 012033

Performance and Analysis of Floating dome Anaerobic Digester with Wet and Dry Feedstock

S.Sathish[1], A.Parthiban[2] , S.Venugopal[2], V.M.Jothi Prakash[3]
[1, 2, 3]Department of Automobile Engineering, Vels University, Pallavaram, Chennai, India.
E-mail: sathishamg88@gmail.com1,

Abstract. The objective of this study is to evaluate the feasibility of anaerobic digestion to generate biogas yield and it's performed using wet and dry feed stock. The laboratory experiment is conducted in a floating dome type anaerobic digester with 1m3 capacity. It is made up of fibre material at continues process. The starter cowdung used as an inoculum of the anaerobic digester. Then raw materials feeded as a wet type wheat straw and dry type wheat straw is the ratio of 1:1 waste/water in both the experiments wet and dry wheat straw. In this experiments are fermented at 30ºC to 35ºC temperature is maintained. The daily biogas yield, cumulative biogas yield, pH, CH4, and hydro retention time these parameters is studied and analysed. The maximum daily biogas is 25liters and 42% of methane is achieved in dry wheat straw at 15th day of digestion. The highest gas yield obtained in dry condition compare to wet condition and acid level also decreased in wet digestion.

1.**Introduction**

The anaerobic digestion converts organic waste materials into useful biogas yield from microbial consortia under presence of oxygen and absence of oxygen. Anaerobic digestion one of the few technologies that the both produce energy and treated waste streams. In this process involved in four stages like, hydrolysis, acidogenesis, acetogenesis, and methanogenesis, create the microorganisms of the digestion[1]. Biogas generation can be enhanced by using abundant lignocellulose materials such as agricultural and forest residues, however the complex lignocellulose structure limits the accessibility of the sugar in cellulose material and hemicellulose. It means pretreated is Necessary for wheat straw why because it's one of the lignocellulose materials [2]. Basically floating drum digesters can be operated on the three temperature ranges (i) psycrophilies below 28ºC (ii) Mesophilic range at 30ºC to 40ºC (iii) thermophilic range at 40ºC to 60ºC [3]. Generally the methanogenic bacteria and microorganisms growth is mainly depends on different parameters like pH range, digester design, digester temperature, Carbon/Nitrogen ratio, organic loading rate, chemical oxygen demand, biological oxygen demand and hydro retention time [4]. The anaerobic digestion process (AD) of wheat straw or waste/energy crops, paddy is considered as an important role in the renewable energy source. It is important in contribution of climate change mitigation [5]. The pH is the important factor affecting the growth of microorganisms during the anaerobic digestion process. The most anaerobic bacteria, including methane formation bacteria, exclude well within a pH range of 6.8-7.5. It is generally considered suitable for optimum biogas generation [6]. Biomass can be pretreated by physical and chemical methods. Some of the physical treatments are sizing the biomass particles and drying and removing inorganic from the feedstock etc. There are many chemical pre-treatment methods. The main aim of this method is to make the cellulose surface accessible to cellulose enzymes during the subsequent hydrolysis process. Pre-treatment prior to anaerobic digestion proves to be one of the simple and effective methods to improve biodegradability and increase biogas production of lignocellulosic materials [7]. In the agricultural wastes, particularly rice straws and rice straw have high lignocellulosic, hemicelluloses and cellulose is penetrating with the rigidifying binding material

is known as lignin. The polysaccharides are not usable for bioconversion process. Hence pre-treatment is involved to overcome the physical block of lignin and case sugar available for the microorganisms [8]. The dry anaerobic digestion process is have high ammonium concentration, it is one of the serious problem would be occurred by the low carbon/nitrogen ratio because of inherent higher ammonium concentration in a substrate such as straws, which leads to ammonia inhibition to methanogenic bacteria [9]. Recently, large amount of straws produce from agricultural form, feedlot farming high in annually, most of which are disposed into landfills or are applied to the land without treatment. AD process provides an alternative option for waste to use full energy. In this research, wheat straw is assessed for the use of anaerobic digestion with objectives of treating the wheat straw waste in wet and dry condition to decrease disposal costs and to produce biogas yield. The biogas yields mainly consist of methane and carbon dioxide and the methane is used as an energy source. The main aim of this paper is to investigate the effectiveness and the performance characteristics of floating drum anaerobic digestion process of wet and dry wheat straw for biogas generation in continuous operation. The wheat is an alkaline waste material so it pretreated with some chemical solutions. The lignocelluloses (rice straw) are a plant biomass, primarily consisting of three major elements such as cellulose, hemicelluloses and lignin. The other constituents such as water and protein are not organizing the structure of the material [10]. The conversion of agricultural wastes to energy and application of biogas had been widely accepted by household digestion process. The biogas anaerobic digestion of rice straw is converted into life fuel and also transformed to high quality of organic fertilizer [11].

2.**Experimental Setup**

In this experimental study a floating drum gas holder type biogas plant was used. The plant was made of fibre material, with a capacity of 1cubic meter bio-digester and the total volume of the digester was 1000 litters with an effective gas holder volume of 700 litters. Heat exchanger – hot water jacket around the digester tank by circulating warm water to raise the inside temperature of the digester in case of thermophilic condition. Gas holder – is an inverted fibre drum resting over the digester with gas holding capacity of 0.7m3. (i.e.) The drum can move up and down floating over the digester. The gas holder may float over the water jacket of the digester. This special arrangement prevents the leakage of biogas from the digester which may occur in other types of digesters. The gas valve of the gas outlet is opened to get a supply of biogas. Once the production of biogas begins, a continuous supply of gas can be ensured by regular removal of spent slurry and introduction of fresh slurry. The retention period represents the time period for which the fermentable remains inside the digester. The retention time ranges from 1 to 30 days. Longer retention periods need larger size plants and it allows more complete digestion of feed material. The figure 1 shows the schematic view of experimental setup. The cowdung were used as an inoculum of the digester, the wheat straw wet and dry condition is pretreated with 8% of NaOH which is dissolved in water to prepare NaOH solution and then added with wheat straw and mixed completely. In this study the digester feed with wet and dry wheat straw waste by volume 40:60, waste by water 30:70 in both the wet and dry condition. The digester temperature is maintained at the 30ºC to 35ºC. The experiment is started and the gas volume monitored daily with help of gas flow meter from 30 days of hydro retention time. The pH is measured using pH redox meter. The CH4 is measured using gas chromatography.

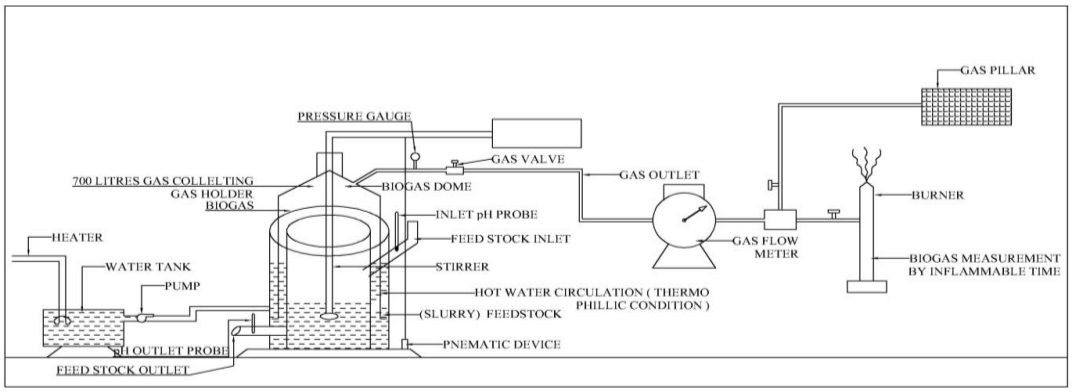

Figure 1. Schematic view of the Experimental setup

3.**Result and Discussion**

The daily yield during the study period or hydro retention time (HRT) is shown in figure 2. It is observed that biogas production is actually slow at starting and the end of observation in both the conditions. During the 13th day biogas yield is achieved at 39 liters in dry condition. There is less biogas yield obtained from wet condition and mainly due to the lag phase of microbial,

Growth whereas, from the range at 15 to 18 days of observation; biogas yield enhanced substantially due to the exponential growth of methanogenic bacteria. The similarly highest cumulative biogas yield from dry feedstock (wheat straw) compare to wet wheat straws.

This is probably due to high concentration of ammonia nitrogen is toxic to anaerobes, which will reduce to biogas yield from the digestion period. The cumulative biogas yield shown in Figure 3. During the anaerobic digestion of dry wheat straw is achieved at highest methane content of 42%.

The acidifying bacteria produced acids at a much higher rate, than the methane forming bacteria were able to cope with. Another reason could be that the substrate material is decomposed to easily and therefore very susceptible to acidification. That the methane content Exp2 constantly indicates that the certain areas possibly where a lot inoculum material is present, worked at a higher pH and produce gas while other Exp1 did not produce higher gas yield. Generally, Proper Carbon/Nitrogen ratio does the play an important role in the biogas production. Carbon/Nitrogen ratio ranging from 21:1 to 31:1 is always considered in suitable for anaerobic digestion by weiland [8]. During [9] the anaerobic digestion of beef manure in mixed and unmixed reactors. It is very clear that cow manure is an very effective feed materials for anaerobic digestion. It is significantly increase the cumulative biogas yield

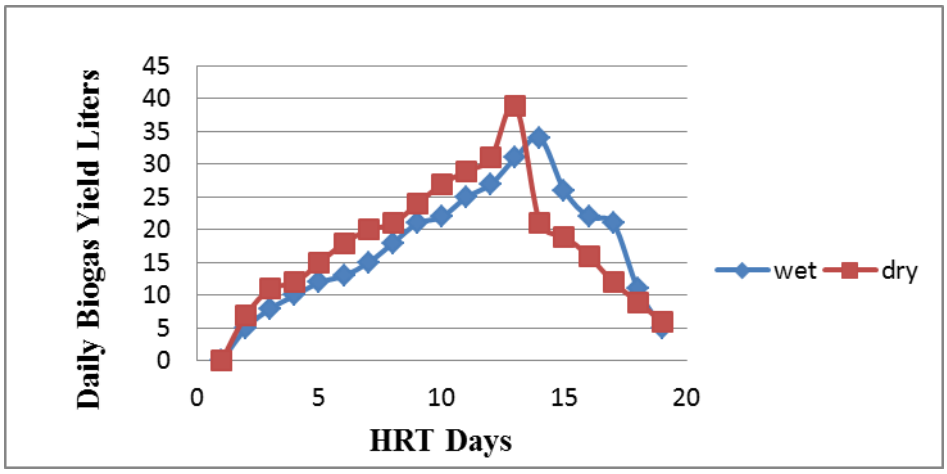

Figure 2. Daily biogas yields with HRT

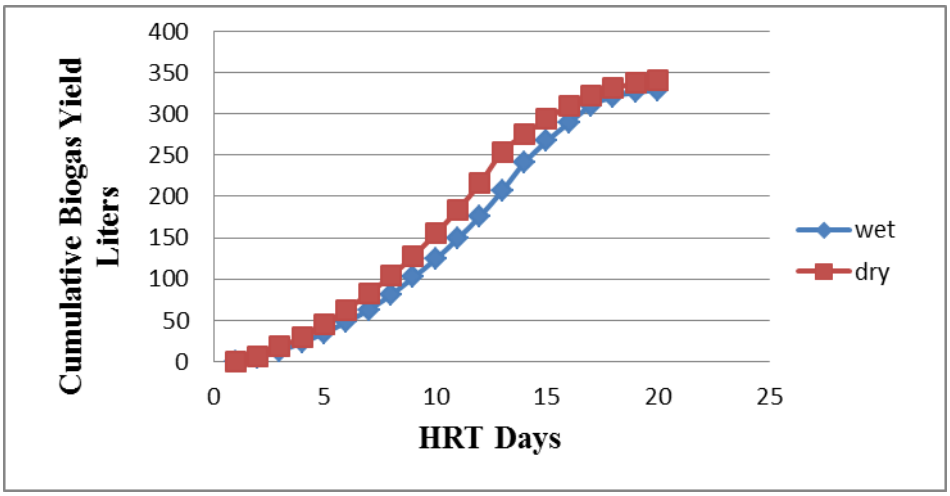

Figure 3. Cumulative biogas yields with HRT

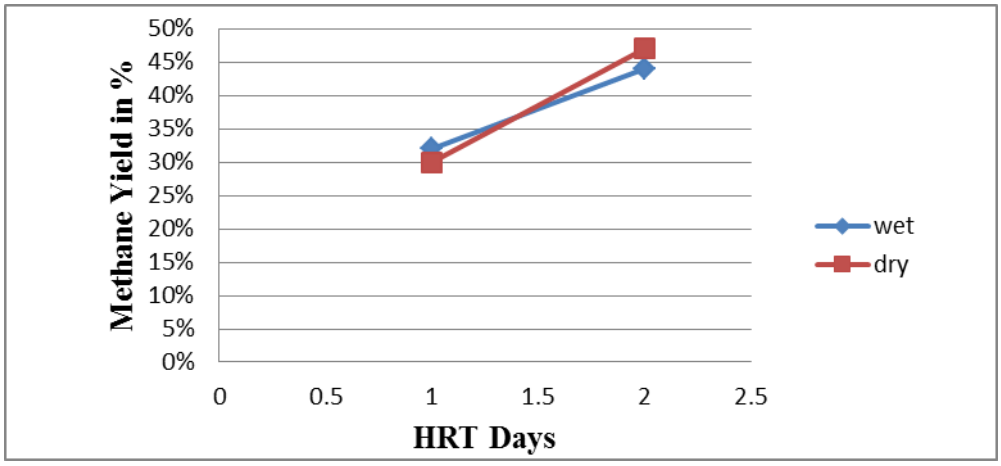

Figure 4. Methane percentage with Retention Time

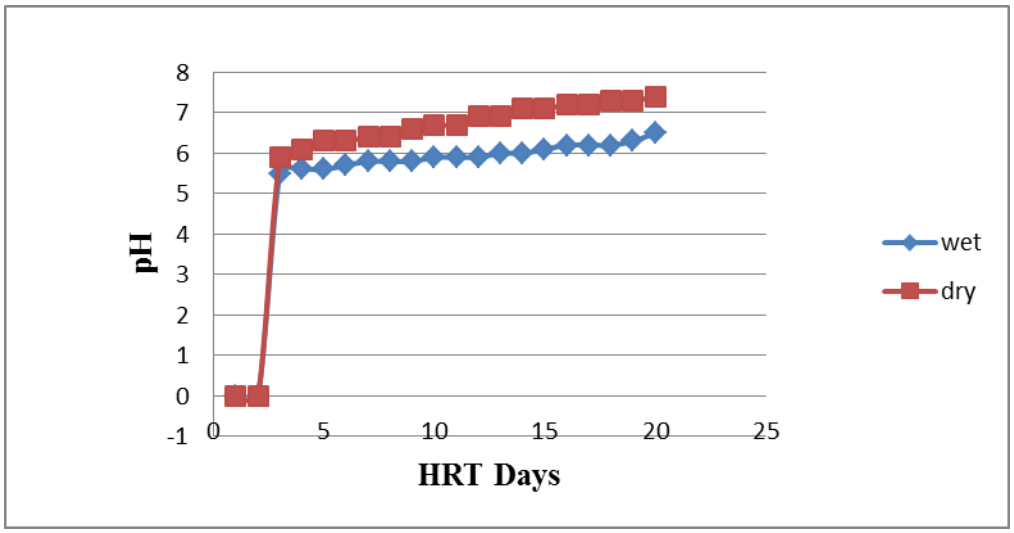

Figure 5. pH range with HRT

4.Conclusion

The result of this research, two types of feedstock's wet and dry wheat straw were attempted for biogas and methane production using floating dome anaerobic digester. Results revealed that the maximum methane and biogas production is found in dry wheat straw compared to wet wheat straw. The methane from dry feedstock is ignited the cumulative gas generation is found to be more qualitatively and quantitatively. The results showed that the dry wheat straw might be one of the feedstock for efficient biogas generation and waste treatment.

5.References

[1] Niu, Qigui, "Microbial community shifts and biogas conversion computation during steady, inhibited and recovered stages of thermophilic methane fermentation on chicken manure with a wide variation of ammonia." *Bioresource technology* **146** (2013): 223-233.

[2] Amon, Thomas, "Biogas production from maize and dairy cattle manure—influence of biomass composition on the methane yield."Agriculture, *Ecosystems & Environment* **118.**1 (2007): 173-182.

[3] Sathish S, Vivekanandan S. Experimental Investigation on Biogas Production Using Industrial Waste (Press Mud) To Generate Renewable Energy. *Int. J. Innov. Res. Sci. Eng. Technol*. 2015; **4**:388-92.

[4] Deepanraj A, Vijayalakshmi S, Ranjitha J. Production of Bio Gas from Vegetable and Flowers Wastes Using Anaerobic Digestion. In *Applied Mechanics and Materials* 2015 (Vol. **787**, pp. 803-808). Trans Tech Publications.

[5] Vivekanandan, S. Sathish. S "To study the effect of temperature using pretreated rice straw to generate biogas." *International of Environmental Science and Engineering*.2015 (Vol **10**) No 2, pp631-636.

[6] Kuruti K, Rao AG, Gandu B, Kiran G, Mohammad S, Sailaja S, Swamy YV. Generation of bioethanol and VFA through anaerobic acidogenic fermentation route with press mud obtained from sugar mill as a feedstock. *Bioresource technology*. 2015 Sep 30; **192**:646-53.

[7] Sathish S, Vivekanandan S. Parametric optimization for floating drum anaerobic bio-digester using Response Surface Methodology and Artificial Neural Network. *Alexandria Engineering Journal*. 2016 Sep 28.

[8] Kaparaju P, Serrano M and Thomsen AB and Kongjan and Angelidaki I. Bioethanol, biohydrogen and biogas production from wheat straw in a biorefinery concept. *Bioresource Technology*. 2009 May **31**; 100(9):2562-8.

[9] Riya S, Suzuki K and Terada A and Hosomi M and Zhou S. 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* Vol. 2016 Feb; 5(1).

[10] Zheng, Yi, "Pre-treatment of lignocellulosic biomass for enhanced biogas production." *Progress in Energy and Combustion Science* **42** 2014: 35-53.

[11] Sathish, S., and S. Vivekanandan. "Optimization of Different Parameters Affecting Biogas Production from Rice Straw: An Analytical Approach." *International journal of simulation science and technology*, 2015Feb, pp: 78-84.