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To study the effect of temperature using pretreated rice straw to generate biogas

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Abstract: *The objective of this study was to investigate the effect of pretreatment and operating temperature during the anaerobic digestion by using rice straw as biomass. The experiment was conducted for 30days under both for mesophilic 30 to 40˚C and thermophilic 45 to 60˚C condition by continuous digestion process. Rice straw is a lignocellulosic biomass use as feedstock with to effect of pretreatment by NaOH was investigates for biogas generation. Quantity of biogas yield was reported as 0.73m^3, hence pH level was 7.2 is obtained at 50˚C was achieved in 18th day of thermophilic anaerobic digestion with respect 0.58for mesophilic digestion at 10th day of anaerobic digestion, Since the thermophilic anaerobic digestion having higher biogas yield compare to mesophilic anaerobic digestion process.*

Keywords: *Anaerobic digestion, biomass, biogas yield, NaOH, pretreatment, rice straw.*

I. Introduction

The main aim of this research to investigate the performance of thermophilic and mesophilic anaerobic digestion using pretreated rice straw used to produce biogas yield. Lignocellulosic biomass and composition was selected in this study. Hence in India, lignocellulosic materials such as agricultural residues are abundant but most of them are not applied efficiently for energy purpose. While biogas production from rice straw is obtain a very good response due to its economical and eco-friendly usage of agricultural residues. [Zheng, i et al, 2014] is reported that the lignocelluloses is a plant biomass, primarily consists of three major elements such as cellulose, hemicelluloses and lignin. The other constituents such as water and proteins do not participate in organizing the structure of the material. 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 converted into life fuel and also transformed to high quality of organic fertilizer reported by [Sathish S et al, 2015].

In the agricultural wastes, particularly rice straws having high lignocellulosic, hemicelluloses and cellulose are penetrating with the rigidifying binding material is known as lignin. The polysaccharides are not usable for bioconversion process. Hence pretreatment is involved to overcome the physical block of lignin and case sugar available for the microorganisms' indicated by [Mette Hedgard et al, 2005].

Due to the unmanageable properties of lignocellulosic biomass, alkaline pretreatments can be conducted on this research since the lignocellulosic biomass to enhance the specific biogas production (sbp) in anaerobic digestion. [Mtui, God et al, 2009] was suggested the characteristic of the lignocellulosic biomass is presented in Table 1. Since that the rice straws contain high lignin delivering its anaerobic digestion delay compare with formal digestion methods so, these rice straws cannot be directly used for biogas generation in this research. So to crack the lignin content using different pretreatment methods can be implemented which include the biological and chemical pretreatment methods in anaerobic digestion technology.

Table .1characteristics of the lignocellulosic biomass

S.No	Characteristics	Mean Value (%)
1	Physical characteristics (wet basis)	
	a) Moisture	89.6
	b) Total solid	91.4
	c) Volatile Solid	84.6
	d) Ash	20.30
	e) Specific gravity	20.56

2	Chemical characteristics (dry basis) (i) Elemental analysis a) Carbon b) Hydrogen c) Nitrogen d) C/N ratio	 44.24 05.70 02.16 28.51
	ii) Organic composition a) Hemicellulose b) Cellulose c) Lignin	 38.5(0.9) 8.6(0.7) 9.7

Indian government has approached the sustainable rural energy development in the last ten years, and one of the most important issues is to increase the biogas production by promoting pre-treatment of technique for biomass and different temperatures. The idea of biogas production is to alter the physical and chemical structure of lignocelluloses through applying with NaOH pretreatment with different slurry temperature working in this experimental study. These studies proved that maximum biogas yield obtained from when slurry temperature at 50˚C. Alkali pretreatment consists in the addition of alkali solution like NaOH, KOH, and Ca $(OH)_2$ or ammonia to remove lignin and hemicelluloses. The first steps in alkali pretreatment are salvation and saponification. NaOH is one of the more effective alkaline reagents and has been used to treat a variety of lignocellulosic feedstock were used anaerobic digestion process [Zhu, J, et al, 2010].

[Vivekanandan S et al] reported the Among various pretreatment methods, sodium hydroxide (NaOH) has been proved to be capable of releasing digestive material from the cell wall and is suitable for upgrading lignocellulosic materials

It is founded from the present study that biogas yield increased from temperature 50 to 55˚C in thermophilic anaerobic digestion process. Since, [Yadvika A et al.2004] is suggested that the temperature of thermophilic anaerobic digestion process is prefered worldwide because, it is very easier to operate and improve the digester efficiency. Thermophilic bacteria are more stable than the mesophilic bacteria. It produced high quality of biogas and methane yield.

previous studies [Santosh y et al, 2004] described that the While rice straw and rice husk materials are reluctant to the impact of temperature, this almost presence of lignin and enhancement of silica (Just about 21-27%) in both the case of agricultural residues.

The reactor curbing lignocellulosic biomass sustained at 55˚C produced more gas than the bio-reactor maintained at 45˚C [Kim et al, 2006]. In virtually all the cases of biogas generation potential as well as the biogas yield was the highest at 56˚C followed by 50 and 45˚C respectively reported by [Garba et al, 1996].

II. Experiments and methods

The cow dung and rice straw used in this study were collected from nearly village at Chidambaram town, the cow dung were used as an inoculum of the digester. The rice straw was grounded into 0.5 to 1.2mm particle by using grinding machine after being air dried. The straws are pretreated with NaOH. First 8% NaOH was dissolved in water to prepare NaOH solution and this solution was added with rice straw (RC) and mixed completely. Alkali pretreatment (Sodium hydroxide) has been studies in many literatures. Therefore Alkali pretreatment requires normal temperature and pressure and it also the dilute NaOH pretreatment makes the substrates (lignocelluloses) swollen, and then the degree of crystalline decreases and structure of lignocellulosic material has been destroyed. The moisture content of the straws is adjusted to 80% by adding water. This procedure is reaped in all 30 days of experiment. Figure 2.1 and 2.2 showed that the Line diagram and photographic view of the experimental setup. In this study the experimental values are compiled using trial and error methods followed by [Montgomery et al 2014].

The pretreated rice straw mixed with water using floating drum anaerobic continues digestion process carried in $1m^3$ portable digester. The total volume of the digester was 1000liters with an effective slurry volume of 700liters. For digester loaded with waste by volume 40:60 and waste by water 30:70 and the feeding concentration of 80, 90,100 and 110,120 were used for this study. Feeding concentration was defined as the dry weight of rice straw feed per liter and the effective volume of the digester (kg/l TS). The digester slurry temperature was seeded with a mesophilic 30 to 40˚C and thermophilic 45 to 60˚C were operated in this study. Figure 2.1and2.2 illustrates the photographic view of the alkaline biomass and anaerobic digester.

Figure.2.1 photographic view of the Rice Straw

Figure.2.2 photographic view of the Experimental setup

The experiment was started and the gas volume was monitored daily for 30days of retention time. The pneumatic stirrer used in the digester, since this device agitates the digester slurry at every 2 to 8sec for both the digestion periods. The gas production was measured at intervals of about 24 hours by [Air bug gas flow meter] and pressure and temperature of the digester was measured using thermocouples and pressure gauge. The pH formation of the digested slurry was measured using pH redox meter.

III. Results and Discussion

From the results shown that the biogas production was found to be higher with optimum temperature for methanogenesis bacteria is 50 to 55˚C compare to 30 to 45˚C mesophilic anaerobic digestion. During the 18^{th} day and third week, the rate of digestion was more and biogas yield achieved at $0.73m^3$. The optimum pH level was 7.2 reductions in pH level causes major problem during the mesophilic anaerobic digestion reported by [Sathish S et al 2015]. Figure 3.1 and 3.2 illustrate the biogas yields and different slurry temperature with respect to Retention time.

The results indicate that the gas production stopped at an average 30days HRT using daily anaerobic digestion process. This is because of the balanced nutrition and proper earlier digestion. When the rice straw was added in this digester, the flow rate of biogas yield increased with 220 l/day to 320 l/day, which is the most prominent value compared to other agricultural wastes also examined by [Suntikunaporn et al, 2014]. The anaerobic digester working at the optimum temperature for biogas production means increase temperature range, which should not have negative effects in the anaerobic digestion process. Therefore it is suggested to carry out similar experiments to test the effect of temperature production using various agricultural wastes at 50˚C. From this result, anaerobic digestion of pretreated rice straw and recorded that the flow of biogas yield by thermophilic anaerobic digestion was higher than that of mesophilic digestion process. It is incurred from the present study that with enhance the temperature from 30 to 60˚C, in thirty days of experiment.

The results examine variety of lignocellulosic biomass biogas yield is larger for higher temperatures. The anaerobic digestion carrying lignocellulosic biomass maintained at 50˚C. Generate more quantity of biogas than the anaerobic digestion maintained at 40 and 60˚C reported by [Kim et al, 2006]. Hence the temperature improves the biogas yield as well as the efficiency of the anaerobic digester. The digester working in thermophilic condition was interesting because it resulted to faster reaction rates and high quantity of biogas production compare to mesophilic condition.

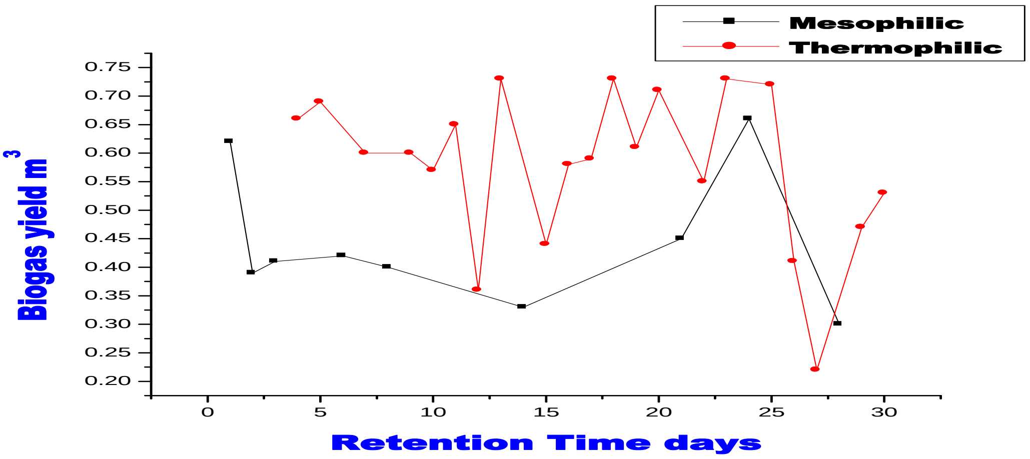

Figure.3.1 Biogas yield with respect to Retention time

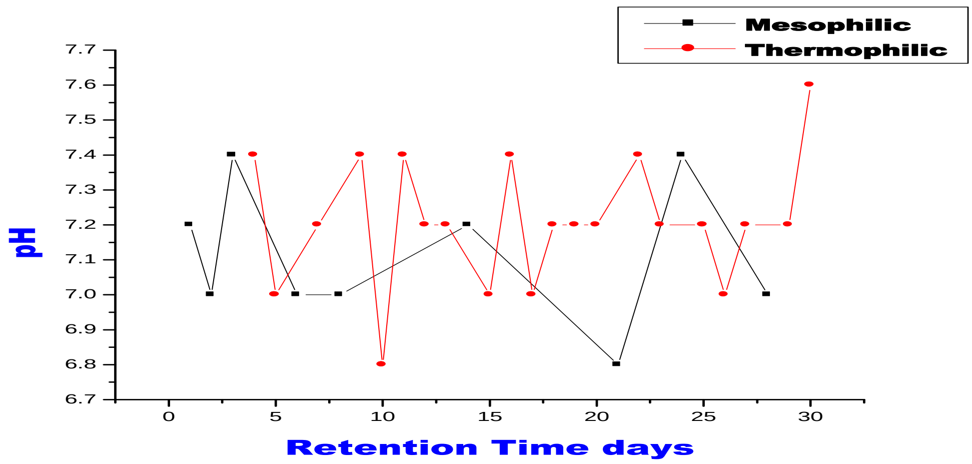

Figure.3.2 Change in pH with respect to Retention time

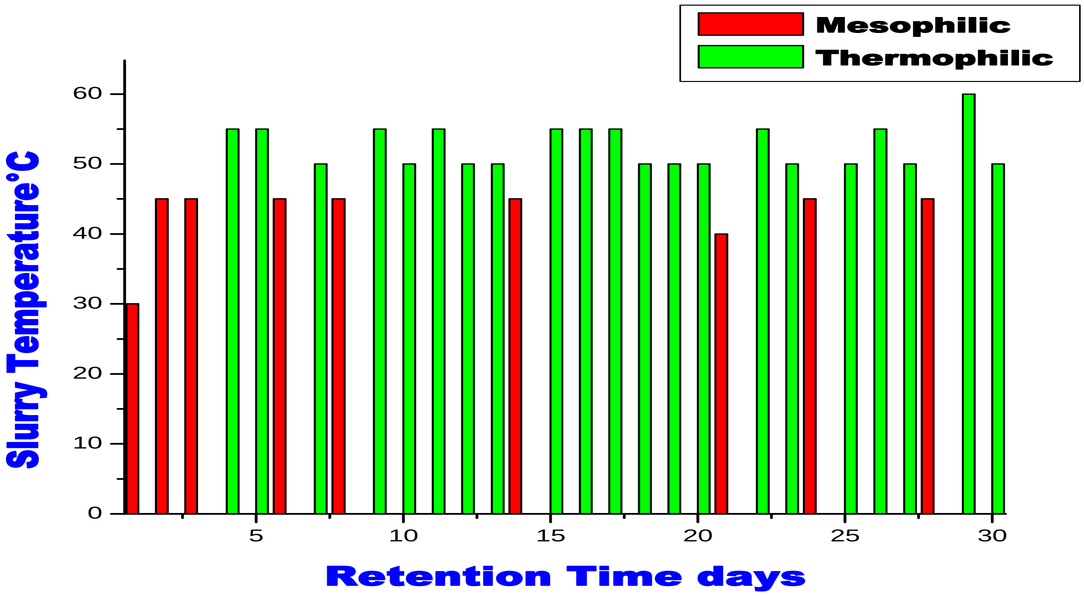

Figure.3.3 Temperature with respect to Retention time

Hence the biogas generation mainly depending on the solids concentration and amount of microorganisms presence in the feeding materials [AOAC, 14TH EDITION 1980]. So pretreatment of rice straw is generally required for biogas generation. The process of pretreatment to eliminate the lignin and hemicelluloses enhance the microorganisms and porousness of materials. Amongst various pretreatment methods NaOH method has been tested to be capable of eliminating material for promoting lignocellulosic biomass [Alriva p et al, 2010]. So from this result alkali pretreatment as well as the NaOH addition can be also extended to the continue digestion tests 8% of NaOH dose was obtained maximum gas production from this research.

This study would provide relevant information about the effect of temperature and these treatments on biogas production from rice straw (lignocellulosic) materials. Figure 3.4 and 3.5 shows the substrate concentration and pressure of the anaerobic digester during the digestion periods. The biogas yield was greatly increased at substrate concentration at 110kg. The average biogas productivity 0.73m^3 was also higher with substrate concentration at 110kg compared with other feeding concentrations.

The anaerobic digestion process is strongly determined by change in pH formation. It is takes place optimum neutral condition of the pH is 7 and optimal value of pH among with 6.8 - 7.5[MonaH et al, 2013].

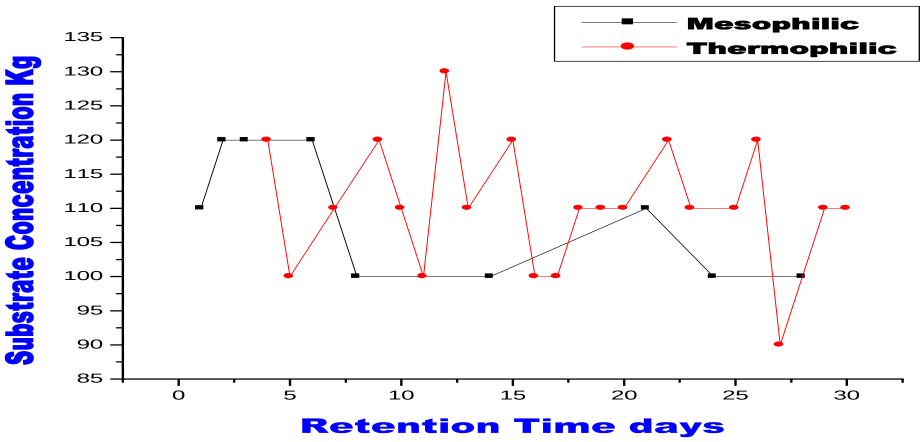

Figure.3.4 Substrate concentration with respect to Retention time

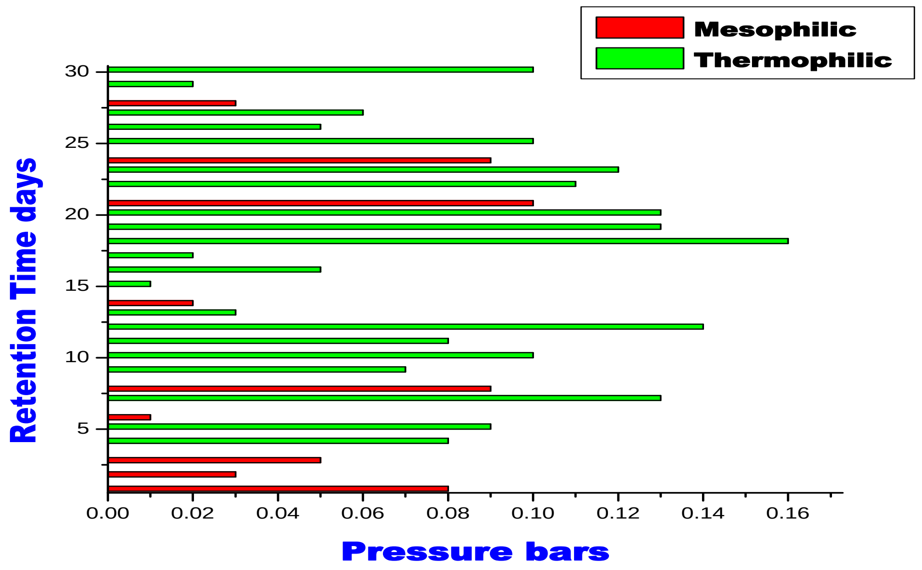

Figure.3.5 Change in pressure with respect to Retention time

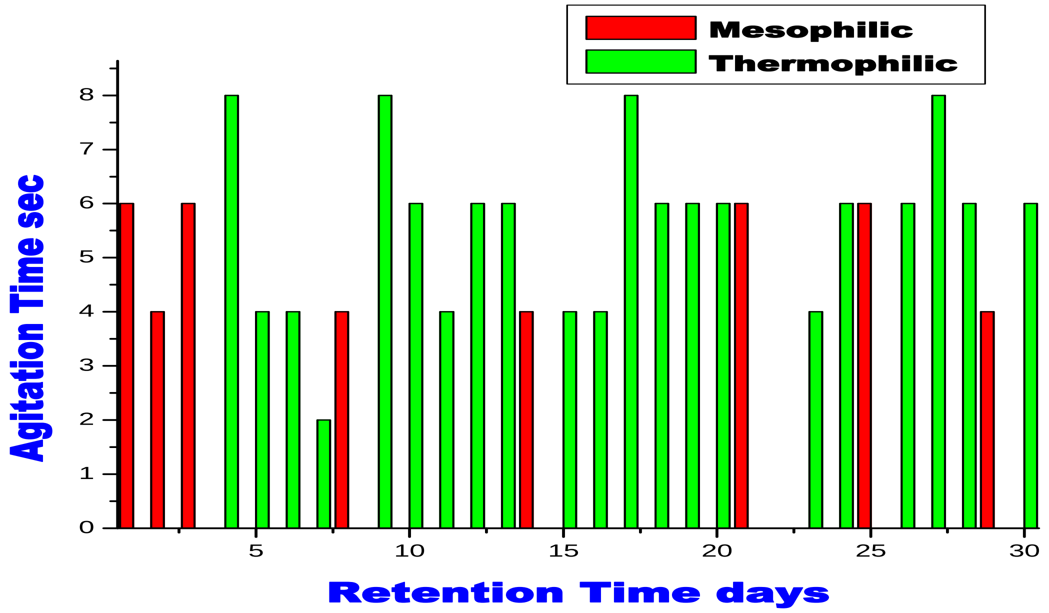

Figure.3.6 Change Agitation time with respect to Retention time

The results indicated that, NaOH pretreatment was attributed to more balanced nutrients and enhance the buffering capacity of the digester. From the results indicates that of NaOH pretreatment is yet another cause for effective biogas yield from the rice straw with abundant rich lignocellulosic rice crop residues. The effect of alkalinity is to improve the biogas yield significantly. Furthermore, pretreatment of straws was proven shorten digestion time by approximately 50% reported by [Ye, J et al 2013]. The digester obtained at a maximum pressure of 0.16 bars in 14th day of digestion and 0.59m^3 volume of biogas produced from the digester.

When the digester slurry stirred at 6sec that time digester recorded highest biogas yield in 0.62 to 0.73m^3. The results indicated the potentiality of rice straw, with substrate concentration at 110kg and pH maintained 7.2 in a thermophilic anaerobic condition at 50 to 55˚C and also the digested slurry stirred at 6sec in same condition of an anaerobic digestion process. Figure 3.6 illustrates the Agitation time of the digester slurry with respect to Retention time.

Using the constitutional stirrer, the slurry was agitated regularly to circulate and keep up uniformity of temperature, hence the thickening and caking of impurities was prevented by [Onah D.U.2014]. Previous results proved that he NaOH pretreatment is an effective method to improve the biodegradability of corn stover with straws and anaerobic biogas production. The NaOH does used in this study were 4%, 6% 8% and 10% on dry basis of corn and straws. The optimal dose of NaOH was 8% and the recommended thermophilic temperature at 50˚C to 60˚C and loading rate was 120 kg/L, Under these conditions the biogas production achieved was 48.5% more than the control (without pretreatment) with a BioEnergy gain of 71% was obtained by [Pang et al 2008].

IV. Conclusion

The experimental results that biogas could be efficiently produced from pretreated rice straw and both the temperature ranges using continue anaerobic digestion process. The NaOH pretreatment applied to anaerobic digestion contributes to promoting the degradability of the feed stock and increasing the biogas yield. Finally the thermophilic digestion offers advantages over mesophilic digestion by increasing the rate of biogas yield and efficiency of the digester.

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