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EXPERIMENTS ON BIOGAS YIELDS FROM DE-OILED CAKES ON THE INFLUENCE OF WORKING PARAMETERS

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ABSTRACT

This paper presents the biogas yield of various de-oiled cake wastes like groundnut de-oiled cake; coconut de-oiled cake, mustard de-oiled cake, and sesame de-oiled cake under anaerobic digester process in a floating dome type gas digester of 0.5 m^3 capacity. The working parameters such as concentration of slurry, total solids, pH, temperature, carbon nitrogen ratio and the effectiveness of inoculums for biogas production was investigated in a batch type process for fixed hydro retention time. Hence, the best de-oiled waste materials, that can produce the maximum amount of bogus and percentage of methane fraction from each waste material has been found in a mesophilic temperature range (28^{o}C to 40^{o}C). The results show that groundnuts de-oiled and coconuts de-oiled cakes waste yield the maximum volume of biogas generated from the four substrates are 21.28, 25.26, 19.2 and 16.37 liters, respectively. Quantity of methane fraction was an analysis of the biggest yield has also been carried out along with comparing the four types De-oiled cake waste slurry. The results show that the maximum of 67% of methane fraction for coconut de-oiled cake waste followed by 58% methane fraction for ground de-oiled cake, when compared with other two de-oiled cake wastes.

Key words: Anaerobic digestion, Biogas, De-oiled cakes, Methane fraction, Total solids.

INTRODUCTION

The biogas is generated by anaerobic digestion of biodegradable wastes such as plant and crop residues etc. In recent years, energy crops have gained[1] increasing attention as substrate in anaerobic digestion for biogas yield. The application of anaerobic digestion process has a scope for further sustainability for both agricultural waste-stabilization method in converting solid bio-waste and agro waste into renewable energy with nutrient rich organic manure[2]. Biogas is a colorless flammable gas produced in an anaerobic digestion of animal, plant, human, industrial and municipal waste. Biogas is mixture mainly methane (50-60˚%) carbon dioxide (20-40%) and traces of some other gases[3]. The yield of biogas from any

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organic substrate highly depends on the loading rate, C/N ratio of the material, pH, and temperature[4]. This study presents biogas production from the anaerobic digestion process of agricultural waste of de-oil cakes such as groundnut de-oiled cake, coconut de-oiled cake, mustard de-oiled cake and sesame de-oiled cake. The de-oiled cake is by products from the edible oil industry and has vast potential reserves for suitable organic waste in an anaerobic digestion technology[5]. De-oil cakes contain high cellulose, sugars, protein and volatile organic material effects of higher biogas productivity[6]. The objective of this work is to find out the biogas yield from the different de-oiled cake and to compare the quality of methane fraction of the biogas yield with the influence of different working parameters.

Biogas gas achieved is potentially utilized for electricity production and convert to value added transportation fuels[7]. The digester contained 25% TS and achieved maximum methane production[8]. They investigated the effect of temperature on food waste using lab scale anaerobic batch reactors and found that high methogenic activity was there at temperature of 50^{o}C[9]. It was also demonstrated that food waste has an appropriate co-substrate for the enhancement of hydrogen production in dark fermentation[10]. Characteristics and applications of the products obtained, reaction conditions employed depending on raw material, kinetics of reaction and amino acid degradation are discussed as well. Similar reviews have been recently published regarding the use of this technique for extraction of sugars, phenols, tannins, lignin or flavonoids among other compounds of interest[11]. Anaerobic digestion has been assessed and applied to a plethora of different substrates/wastes/low value or negative value by products including animal manures[12], industrial wastes and wastewaters, municipal solid wastes, energy crops[13] and mixtures of different substrates in co-digestion schemes[14,15].

EXPERIMENTAL

Materials and methods

The waste like groundnut de-oiled cake, coconut de-oiled cake, mustard de-oiled cake, and seasame oil de-oiled cake are obtained from the edible oil. However, the oilcakes are chopped into small pieces using mortar as pestle. The experiment was conducted in an anaerobic floating drum type biogas plant with the digestive capacity of 0.5 m^3 and gas holding floating dome of 300 liters made of fiber material. The digester was operated in a batch process with the temperature between 28^{o}C to 38^{o}C for a fixed hydro retention time. The materials used in these studies are weighed to determine the weight of the raw materials. The redox pH meter was used to measure the pH from the slurry and the temperature indicator is used to measure the temperature. The feed stock was mixed with the digester in proper ratio. The stirrer breaks the scum in the digester and makes the homogenous mixture.

SH Alborg gas flow meter used to measure biogas. The total solids and volatile solids are measured by the methods suggested by APHA standard methods, 2014[16]. Biogas production is slow at the beginning and end of observation; this indicates that the biogas produced in batch condition corresponds to specific growth rate of methanogenic bacteria. These results suggest that, the solid concentration content affects the biogas yield. This is similar to the findings of Deeparaj et al.[17] The degradation process can be divided into four phases: hydrolysis, acidogenesis, acetogenesis, and methanogenesis; and in each individual phase, different groups of facultative or obligatory anaerobic microorganisms are involved[18].

Substrate preparation

The substrate was prepared by cow dung in the ratio of 1:1 with diluted water and the slurry[19] was fermented under anaerobic digestion process used as inoculums[20]. The composition of cow dung used in the study with Ts (mg/L) -159 Vs (mg1L)-34.5, moisture 42.6 and a pH usage from 6.8 to 7.6. The inoculum was loaded in the digester for the fermentation process.

Experimental setup

The schematic view of experimental setup and the photographic view of de-oiled cakes are shown in Figs. 1, 2 and 3. The experiments were conducted in four phases, each for 3 weeks hydro retention time using four different de-oiled cakes waste such as groundnut de-oiled cake, coconut de-oiled cake, mustard de-oil cake, and sesame de-oil cake waste materials[21] for a loading rate of waste/volume as 30:70 under anaerobic digestion process. In this study, the experiment was carried out with 10% to 12%. Total solid concentration with 0.5 to 0.6 Vs/Ts and 0.4 to 0.6 Vs/Ts in all the four phases[22].

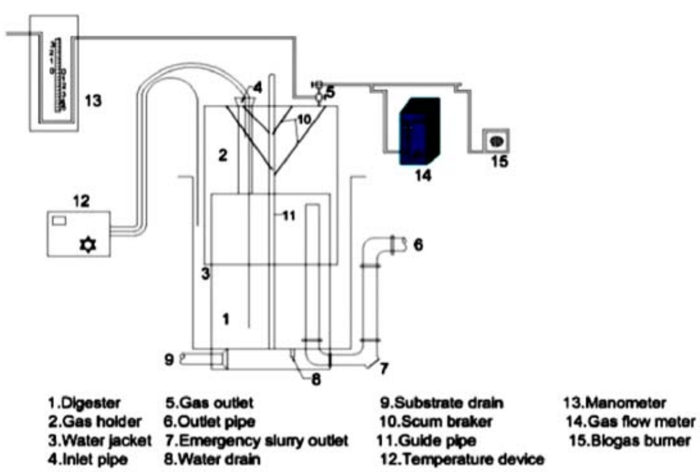

Fig. 1: Line diagram of the experimental setup

Fig. 2: Photographic view of the experimental setup

Fig. 3: Photographic views of the De-oiled cakes

The raw material was adjusted with pH ranges 6.5 to 7.5 before loading the digester. The rate of biogas production from the de-oiled waste in phase I groundnut de-oiled cake waste was dried in sunlight and cursed to 0.5 cm through sieve mesh and by mixing with water as 40:60 waste/water and the slurry was fed to the digester under anaerobic digestion process. The digester was loaded with 5% of inoculums and daily and cumulative gas production was measured. In phase II, coconut de-oiled cake was used by repeating the same procedure as Phase I. In phase III and IV, mustard de-oiled cake and sesame de-oiled cake was dried and cursed to 0.3 cm by mixing with 50:50 waste/water and the slurry was loaded to the digester with the 10% inoculum. Through this study, we are trying to evaluate the maximum rate of biogas production and also to compare the rate of biogas production from four de-oiled waste. This de-oiled cake waste is mainly carbon and nitrogen content. organic waste with carbon was used as energy source for a microbial growth, and nitrogen for structural growth of microorganism. In this observation, we have taken specific ratio of de-oiled waste with water with different amount of inoculums, which are anaerobically digester slurry containing methogenic bacteria responsible for more volume of biogas yield and methane fraction[23].

RESULTS AND DISCUSSION

In this study, all the experimental analysis has been done under the batch process. Hence, the digester slurry has been added once to the digester for whole biodegradation process. This observation has been done under 21 days observation for all the four phases using different de-oiled cake organic waste.

Effect of hydro retention time with daily biogas, cumulative biogas, pH, temperature and methane fraction

Fig. 4 shows the observation of bio gas in the digester through the batch process for whole biodegradation. It has been observed the cumulative biogas production as more in phase II (coconut de-oiled cake) followed by phase I (groundnut de-oiled cake) as 25.26 liters and 21.26 liters, respectively for fixed hydro retention time. In both the cases, biogas production started after the third and fourth day of the digestion process. This is due to the inoculum, cow dung used to make the digestion process quickly. The rate of biogas yield increased gradually from the second week as a peak gas production reported on 11th and 12th days of digestion and then continually started to decrease due to the substrate availability and reduction in methanogen activities in the slurry.

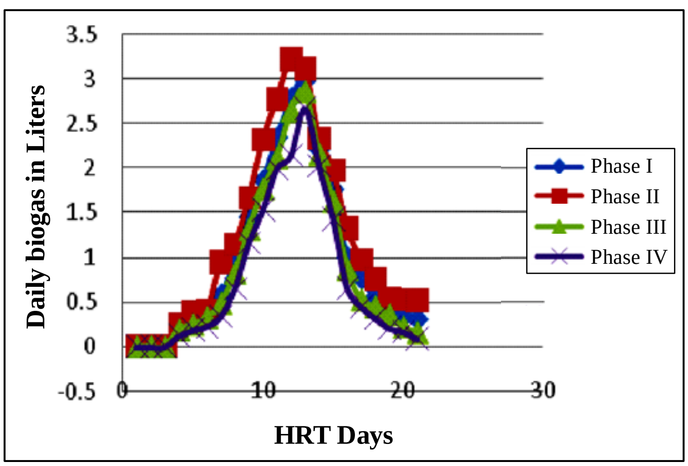

Fig. 4: Hydro retention time Vs daily biogas in liters

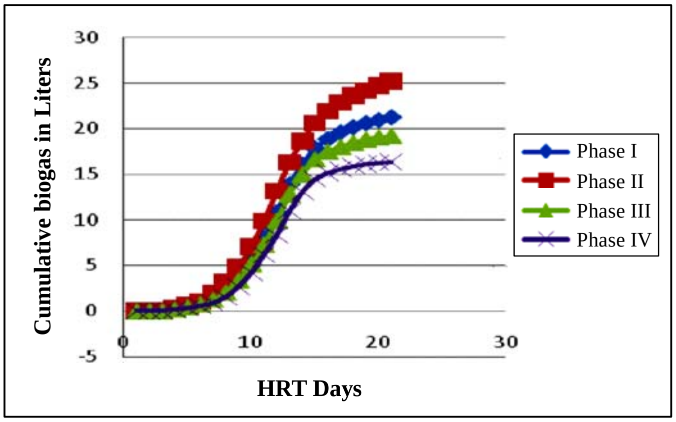

Fig. 5: Hydro retention time Vs cumulative biogas in liters

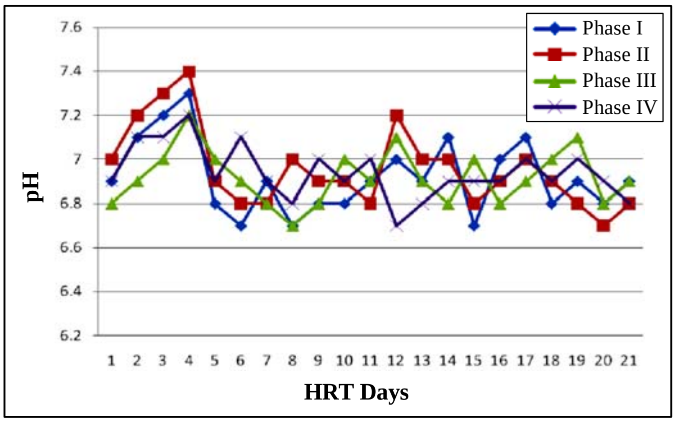

Fig. 6: Hydro retention time Vs pH

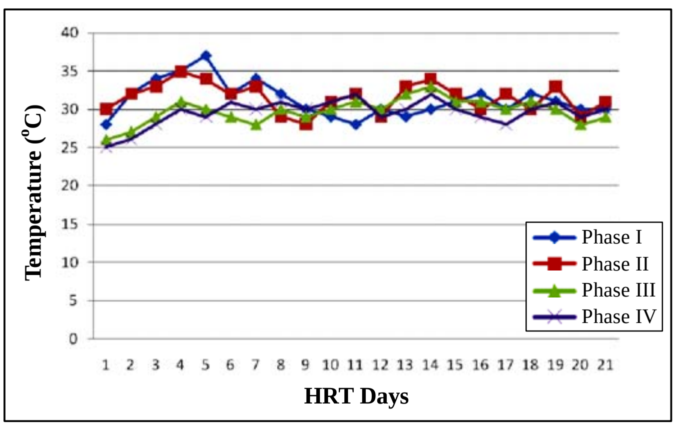

Fig. 7: Hydro retention time Vs temperature ^oC

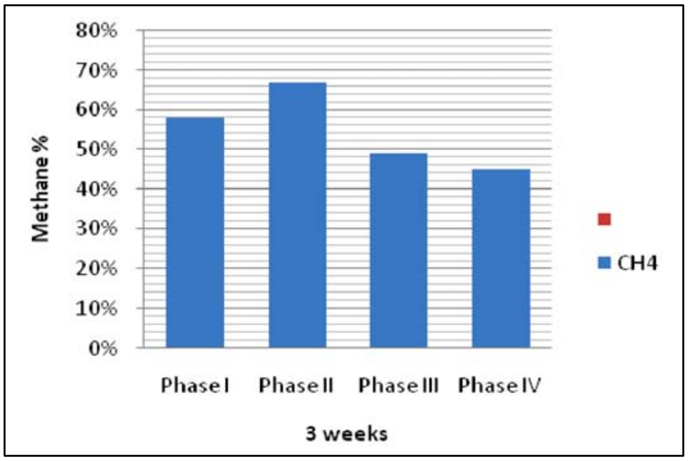

Fig. 8: Hydro retention time with methane fraction in percentage

The rates of biogas yield increased in both the cases due to the crude protein and carbon/nitrogen ratio of the organic waste and the initial pH were adjusted to 6.8 to 7.5 leads to more biogas yield and more methane fraction was obtained from both the cases. The properties of de-oiled cake shown in Table 1. In this observation, the phase III and IV using mustard de-oiled cake and sesame de-oiled cake has been observed has 19.2 liters 16.7 liters, respectively. The rate of biogas increases at the beginning and reaches peak production during the second week and then decline towards third week.

Table 1: Properties of different de-oiled cakes

Feedstock	Dry matter	Crude protein	Crude fiber	Ash	Ca	P
Mustered de-oiled cake	89.8	38.5	3.5	9.9	0.05	1.11
Groundnut de-oiled cake	92.6	49.5	5.3	4.5	0.11	0.74
Sesame de-oiled cake	83.2	35.6	7.6	11.8	2.45	1.11
Coconut de-oil cake	92.8	51.5	5.3	4.9	0.11	0.74

Hence, less protein and carbon nitrogen ratio are the reason for less biogas yield as reported using mustered de-oiled cake. Both are acidic in nature to optimize the pH level and enrich the degradable process. 10 percent inoculum was used in the phase III and IV of the experimental work. Table 2 shows anaerobic digestion of different de-oiled cakes. Agrahari and Tiwari[24] have reported. We have compared the biogas production from the four de-oiled cake the production rate and methane fraction. Percentage of total solids (Ts) and volatile solids (Vs), temperature, carbon nitrogen ratio and various parameters influences were observed[25-27].

Table 2: Anaerobic digestions of different de-oiled cakes

Particulars	Groundnut de-oiled cake-I	Coconut de-oiled cake-II	Mustard de-oiled cake-III	Sesame de-oiled cake-IV
Waste/volume	30:70	30:70	30:70	30:70
Waste/water	40:60	40:60	50:50	50:50
Inoculum	5%	5%	10%	10%
Initial Ts %	10%	10.8%	12.8%	12.9%
Initial Vs %	5.89%	6.54%	4.75%	5.78%
pH range	6.8-7.4	7.0-7.5	6.9-7.3	6.7-7.2
C/N ratio	29:1	30:1	27:1	28:1
Temperature (^oC)	28 to 38^oC	30 to 37^oC	29 to 36^oC	28 to 35^oC
Hydro retention time (HRT) days	21	21	21	21
Daily gas production (liters /day)	0.8 to 3.12	0.4 to 3.35	1.67 to 2.89	1.56 to 2.6
Cumulative biogas production (liters/HRT)	21.26	25.28	19.20	16-.37
Methane fraction (%)	20-58	28-67	16-49	11-45

The daily and cumulative biogas yields are shown in Figs. 4 and 5. It has been found in that the biogas production depends on the temperature and the pH as shown in Figs. 6 and 7. The methane fraction has also been observed under three weeks of hydro retention time for an aerobically digested de-oiled cakes as shown in Fig. 8.

CONCLUSION

Biogas production from four edible organic waste like groundnut oil cake, coconut oilcake, mustard oil cake, and sesame oil cake, which have different charactertics were investigated comparatively. The results can be concluded based on biogas yield and its methane content was maximum in coconut de-oiled cake and groundnut oiled cake. It was digested anaerobically after adding with inoculum. These results indicate the carbon/nitrogen ratio, Ts and Vs are vital for the growth of anaerobic bacteria and methane fraction. The biogas yield and methane fraction is low in the case of mustard oil cake and sesame oil cake, even when 10 percent of inoculum was added in the digester. This result shows low protein and crude protein content, acidification during anaerobic digestion destabilize the digestion process and it results in low methane biogas yield in same hydro retention time. These studies reveals that the edible oil wastes can be used for biogas yield with the average methane yield of 50% even for a shorter hydro retention time.

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