Indian Journal of Science and Technology Vol. 4 No. 6 (June 2011) ISSN: 0974- 6846

The study of biogas production from rice chaff (karukka) as co-substrate with cow dung

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Abstract

The rice chaff with co-digestion of cow dung for biogas production at laboratory scale was the subject of this investigation. The study was carried out at mesophilic condition between (26-30°C) for a period of 60 days with seven percent total solid concentration was taken for the fermentation slurry. Experiment study was conducted for three different proportion case (i) 50% weight of boiled rice chaff plus 50% weight of cow dung (ii) 75% weight of rice chaff (boiled) plus 25% weight of cow dung (iii) 50% weight of raw rice chaff (without boiled) plus 50% of cow dung. The result showed a cumulative biogas production of 161.5ml in case (i) for the retention time of 60 days. In case (ii) showed the biogas production of 140.5 ml for the retention time of 70 days and in case (iii) there was no significant gas production due to high percent of lignin in raw rice chaff.

Keywords: Biogas, Co-digestion, fermentation, agriculture waste and rice chaff.

Introduction

Rice chaff is an agricultural waste which remains after the processing of the rice crop, like rice straw and rice husk. In Tamil it is called as (pather or karukka), rice chaff is the dry, scaly protective casings of the paddy seeds of cereal grain, chaff is inedible for humans, but livestock fodder, or is a waste material ploughed into the soil or burnt. In grasses (including cereals such as rice, barley, oats and wheat), the ripe seed is surrounded by thin, dry scaly bracts (called glumes, lemmas and paleas), forming a dry husk (Vaughan & Judd, 2003).

The composition of rich chaff varies widely as follows: crude protein (20-40%), crude fat (0-0.40%), Nitrogen (20-40%), crude fiber (30-50%), Ash (15-20%), pentasans (16-20%), cellulose (35-45%) and Lignin (20-50%) (Pillaier, 1988). This shows that the lignin content in raw rice chaff and husk is relatively very high. Alexandar (1977) reported that the characteristics of high value of lignin are resistance to enzymatic degradation which affect the biogas production. The need for more research into biogas production as a renewable energy source with added benefit of solving major environmental problems posed by the waste used as substrates is well established. Given the large scale production of rice in southern parts of India, large quantities of cow manure and rice chaff are produced annually. Approximately 125kg of rice chaff result from every one hectare of crop cultivation. This work was carried out to explore the potential of biogas production from rice chaff as co-digestion with cow dung.

Methods & Materials

Design method

The study was conducted by varying the proportion of biomass to be co-digested with rice chaff and cow dung and was taken as the digester slurry. Previous studies have shown that co-digestion of several substrates, for example , banana and plantain peels, spent grains and rice husk, pigwaste and cassava peels , sewage and brewery sludge, among many others, have resulted in improved methane yield by as much as 60% compared to that obtained from single substrates (Adeyanju, 2008; Babel *et al.*, 2009).

In our study the amount of total solid and detention time were kept constant. The rate of biogas production was found to depend on several factors such as pH, temperature, C:N ratio, retention time, etc. Also, the ratio of amount of total solid to water in each of the fermentation digester was the same.

Sample collection

Approximately, 1.5 Kg of cow dung was collected, dried and thereafter crushed mechanically using a mortar and pestle to ensure homogeneity. Rice chaff (1.5 kg) obtained as waste from paddy crop was crushed and boiled to a coarse form.

Materials / instruments & experimental setup

A set of 3 fixed dome plastic bio-digester with a capacity of 1 L was used and the digestion of different proportion for rice chaff with cow dung, was undertaken by batch-type anaerobic digestion, that is, one digester for each experiment . Thus, the biogas produced in the digester by the fermentation slurry passed through the connecting tube, the produced gas passed through brine solution, was collected by water displacement method to avoid the dissolution of biogas in water, which was subsequently collected and measured in gas collecting unit. The proportion of substrates in each case is shown in Table1. The pressure of the gas produced caused a displacement of the solution in mercury manometer.

The total solid was determined by the method of (APHA,1998). The composition of materials in each cases as follows: case (i) 7.5g of cow dung with 7.5g of rice chaff (boiled) represents the sum of the rich chaff and cow dung as 15g mixed with a total amount of water

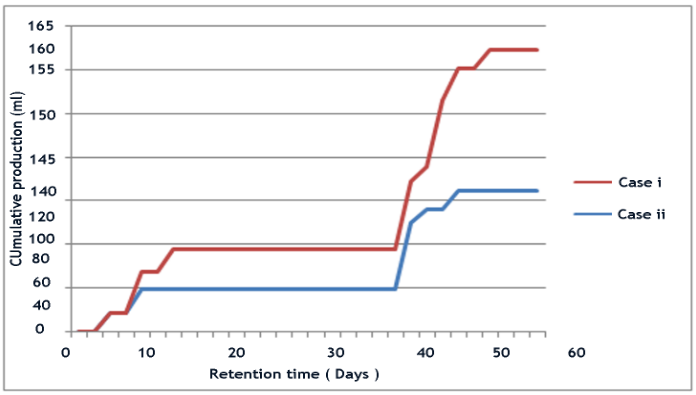
Table1. Different proportion of substrates

Experimental (Proportion)	% of A	% of B	% of C
Case (i)	50	50	-
Case(ii)	25	75	-
Case(iii)	50	-	50

A - represent the cow dung; B - represent the boiled rice chaff
C - represent the raw rice chaff

to give a mass of 172.5g. Case (ii) 11.25g of rice chaff (boiled) with 3.75g cow dung and a sum of 15g mixed with the water to give a mass of 172.5g and Case (iii) 7.5g of cow dung with 7.5g of raw rice chaff and the sum of 15g mixed with the amount of water to give a mass of 172.5g respectively.

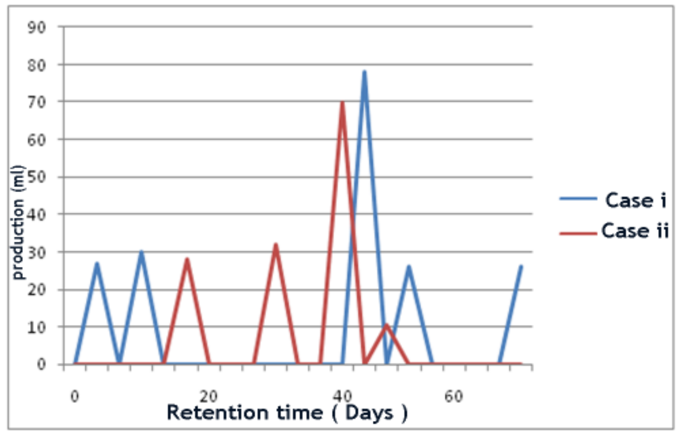
Fig.1. Cumulative gas production with time in case i and ii.



Parameters which influence the biogas production

The digester was operated at ambient temperature and a thermocouple device was used to measure temperature daily. A digital pH meter (HANNA Model PH-211) was used to determine the pH of the slurry and U-tube mercury manometer was used to monitor the pressure. pH values for experiment 1,2 and 3 were 7.29, 7.20 and 6.69 respectively, which were all within the pH range of biogas production and a retention time of 60 days was selected for this work. The total solid (Ts) of 7% in the fermentation was found optimum for biogas production (Itven *et al*., 2007). The collected gas commenced in the fermentation chamber was passed through the acidified brine solution, since the biogas is insoluble in the solution. The pressure build-up inside the digester acts as a driving force for displacement of the solution. The displaced solution was measured to represent the amount of biogas produced (Itodo *et al*., 1992).

Fig. 2. Biogas production with time at different mixing ratios



Results and discussion

The biogas production at different time interval for experiment 1,2 and 3 are shown in Table 2 and Fig.1 and 2. Case(i) 50 wt % cow dung plus 50 wt % rice chaff (boiled), was observed to produce the highest quantity of biogas. The initial anaerobic process that produced 27 and 30ml of biogas on the 3rd and 5th days, respectively is followed by 31 days of inactivity before a sudden burst of production of 78ml. The inactivity is probably due to the methanogens undergoing a methamorphic growth process (Dhaghat, 2001; Elijah *et al*., 2009). It is generally agreed that at the initial stages of the overall process of biogas production, acid forming bacteria produce volatile fatty acids (VFA) resulting in declining pH and diminishing growth of methanogenic bacteria (Cuzin *et al*., 1992). The low pH value inactivated microorganisms responsible for biogas production. Therefore, there is a drop in gas production after the 36th day, followed by dome production on the 38th day of 26.5ml, after which no appreciable production of biogas occurred. Until the 52nd day the cumulative biogas production increased in a step-wise fashion (Fig.1). The cumulative gas

Table 2. Biogas production with time for daily and cumulative

Day	Case i (ml)		Case ii (ml)		Case iii (ml)	
	Daily production	Cumulative production	Daily production	Cumulative production	Daily production	Cumulative production
1	-	-	-	-	-	-
2	-	-	-	-	-	-
3	27	27	-	-	-	-
4	-	27	-	-	-	-
5	30	57	-	-	-	-
6-35	-	57	28	-	-	-
36	78	135	32	-	-	-
37	-	135	-	110	5	-
38	26.5	161.50	-	129	5	-
39-51	-	161.50	-	140.5	-	-
52	-	161.50	-	140.5	-	-
55	-	161.50	-	140.5	-	-
60	-	161.50	-	140.5	-	10.50

Case i - 50% cow dung + 50% rice chaff (boiled); Case ii - 25% cow dung + 75% rice chaff (boiled); Case iii - 50% cow dung + 50% raw rice chaff production in case(i) as the 38th day was 161.5 ml shown in Table 2. The retention time for cow dung is 15 days was the best for maximum production of biogas reported earlier (Gadre *et al.*,1990). Due to the presence of rice chaff for the purpose of co-digestion with cow dung attributed the variation in optimum retention times of 15 days. At the end of the experiment, the biogas yield for case (i) per total solid was observed to be 10.78 ml/g total solid. In the case of experiment-2, the cumulative production 140.5 ml, and there was not significant gas production in case (iii).This is due to the high value of lignin content and lower value of cellulose in the case of raw rice chaff used in the case of experiment 3.

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