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Production methods and analysis of cotton waste bio-gas To reduce environmental pollution

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ABSTRACT

In this work an attempt has been made to generate methane from cotton waste by considering the problem of cotton waste from textile industries. Experiments were conducted with different proportion of water, and with or without addition of seeding materials. The bio gas production was optimized for maximum yield with high percentage of methane with respect to the percentage of different seeding material and working temperature. Using micro-organisms, it is possible to achieve a higher yield of enzymes, and to genetically manipulate the production with desired properties for the conversion of natural fats and oils into biodiesel. It was found that cotton waste with 10% seeding material like cow dung or pig dung at the temperature level of 30ºC are generating bio gas continuously after ten days of feeding with reasonably high yield value. The gas generated in this method was tested in gas chromatography and found that it contains 79% methane rather than 60% methane in other techniques, and hence it has high calorific value.

KEYWORDS: **Cotton Waste, Anaerobic Digestion, Bio-Gas, Methane, Alternate Fuel**

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INTRODUCTION

There is an increasing urgency in the world to search suitable alternative fuels that are environmental friendly. Environmental problems and the available petroleum resources have created interests in development of alternate fuels for automobiles[1]. Biogas appears to be a feasible fuel for cooking, lighting, running vehicles and generators, etc. in Indian context as they are having one of the largest cattle populations in the world[2]. Biogas is known as the mono-alkyl-esters of long chain fatty acids derived from renewable feedstock, such as vegetable oils or animal's fats, for use in compression ignition engines. Biogas is produced when certain bacteria decompose biological matter in an anaerobic (no oxygen is present) environment known as anaerobic digestion (AD)[3]. It is about 20% lighter than air and has an ignition temperature in the range of 650ºC to 750ºC. It is an odorless and colorless gas that burns with clear blue flame similar that of LPG gas and burns with 60% efficiency in a conventional biogas stove[4]. There are different types of bio gas plants such as Khadi, Pragati design, Ganesh Ferro cement digester. These are continuous feeding type digesters using biogas manure, sewage sludge, municipal solid waste, biodegradable waste as feed stock[5]. The basic gas producing reaction in these digester is $2C+2H_2O=CH_4+CO_2$. The methane has a specific gravity of 0.55 in relation to air. In other words, it is about half the weight of air and so rises when released to atmosphere, will rise slowly and dissipate[6]. The fuel value of biogas is directly proportional to the amount of methane.

Table 1
Contents of Cotton Waste

Contents	Percentage
Moisture	8.80
Ash % by weight	7.20
Ether extractive	12.00
Non-cellulose	16.00
Cellulose	54.00
Nitrogen	0.80
Metals & other	3.20

Figure 1
Cotton Waste - Comber Waste

Any material having cellulose as one of its constituents may be used to produce bio gas. India is one of the countries having large number of textile industries[7]. In these industries, the problem of cotton waste, the final scrap has now assumed serious consideration, since it has no resale value and pollutes the atmosphere[8]. Some places where more cotton waste generated are shown in Figure 1, 2, and 3. If these wastes are not degraded, they get accumulated and occupy space and lead to various infectious and allergic diseases, attract pests and spread foul odor to the environment. In India, the total fiber consumption is estimated to be 26 million tons per year of which approximately 0.21 million tons of cotton waste is generated during yarn manufacture[9]. At present this waste is not put in to any use except to some extent as compost for cultivating some vegetables. Mostly, it is disposed off by burning. This may increase the CO_2 level in the atmosphere and pollutes the surrounding areas. This powder waste also leads to the growth of harmful bacteria, which induce allergic reaction in human body[10].

MATERIALS AND METHODS

Cotton waste is a high solid content powder waste, which is rich in cellulose[11]. The samples from mills were analyzed for its content in SITRA (South India Textile Research Association) as shown in Table 1. The technological options for the utilizations of cotton waste at the spinning mills are: to generate biogas as an additional source of energy and manure and Converting the digested slurry into biomanure by incorporating recycling larva/grubs. Five kilograms of cotton waste could generate about 200 liters of biogas in 50 days. It is advantageous for the mills to use their non-saleable waste like cotton dust, which is in perennial supply for biogas generation at their premises itself. Normally bio gas is produced either by batch type or continuous type digesters. In this part of work batch type digesters are used because the scum which is a mixture of coarse fibrous material acts as an insulator for new input in the case of continuous type. In batch type two or more number of digesters may be connected in series and any one can be stopped to remove the scum and reloading without totally shut downing the plant. Cotton waste contains more than 52% of cellulose and this cotton waste could be economically converted into biogas and manure. It has high water retention capacity, sufficient carbon-to-nitrogen ratios, and low heavy metal content. These characteristics make cotton waste viable for direct land application as well as for composting to produce high-grade mulch (straw) top dressing, potting mix, etc. Cotton waste contains around 70% solid content against other raw materials like cow dung which has 15 to 18% and hence before loading it into the digester it requires cleaning and some retention time after mixing with water to convert in to slurry. Figure 4 shows the Spinning Mill Working Cycle and Waste Created in the textile industry. In the comber the waste produced is 16.75%. The unused waste is 7% which is open end waste. Figure 5 shows various samples of cotton waste with different seeding materials. The seeding materials are cow dung, pig dung and goat dung. Therefore, in this study, different parameters for the optimization of biodiesel production were investigated.

Figure 2
Cotton Waste – Blow Room Drops

Figure 3
Cotton Waste – Waste Room

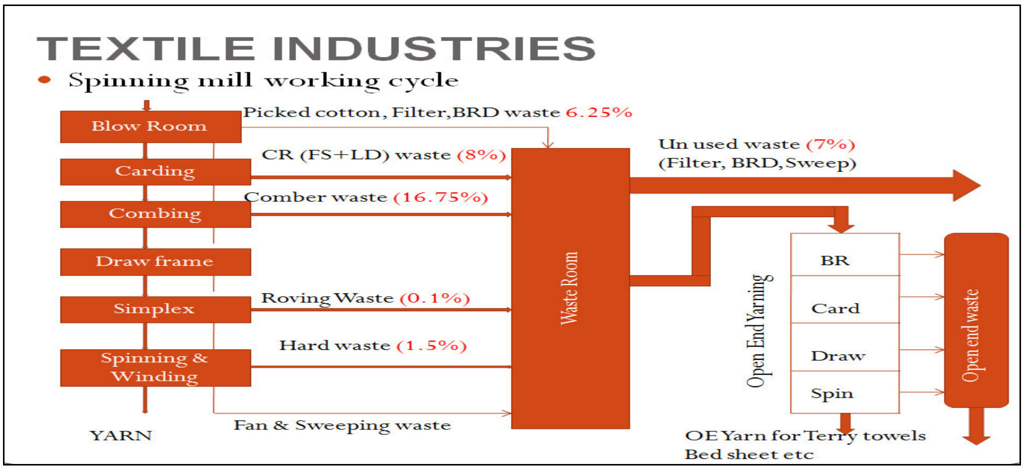

Figure 4
The Spinning Mill Working Cycle and Waste Created

EXPERIMENTAL SETUP

Biogas digester used for this processes is a fixed batch type. It consists of a container with a rigidly fixed lid with a provision for gas outlet. It is sealed completely to prevent leakage. Various samples of cotton waste with different seeding material are taken in the specially made digesters to generate biogas. As cotton contains about 54% cellulose, it is preferable to carry out the fermentation process in batch size. Material to water ratio is determined by the nature of the biomass whether dry or wet and light or heavy. Water is the medium that distributes the nutrients to the micro-organism and supplies or removes the intermediate products. There are some other factors such as nature of raw materials, presence if lignin, temperature, pH, etc., may affect the biogas production. In addition, quantity of water reduces the proportion of biomass in digester, which has a limited volume and increase pressure inside.

RESULTS

After pre-treatment of cotton waste (removal of foreign materials), it is mixed with water in the ratio of 1:2 along with seeding material are allowed for fermentation for ten days. From the 5th day onwards gas begins to produce, but the yield is continuous from the tenth day onwards as the fermentation starts slow in the initial stages and become active after 10 days. It was found that the reaction reduces after 25 days for a stock of 5 kg of cotton waste and nearly comes to an end after 45 days. The anaerobic digestion depends on temperature as the bacteria (Mesophile) is active between 30 to 38ºC and thermopile bacteria over 55ºC, percentage of seeding material, type of seeding material and percentage of water. Experiments were conducted at different ratio of feeding material and seeding material at various temperatures. The different seeding materials used are cow dung, pig dung and goat waste. The outlet gas is tested with Gas Chromatography and tabulated.

Figure 5
Various Samples of cotton waste with different seeding materials

Table 2
Bio-Gas production using Cow Dung as seeding

Sl.No	Constituents	Ratio of Seeding material (Cow Dung) with Cotton Waste				
		2.5%	5%	7.5%	10%	15%
1	CH_4	56	73	78	79	77
2	CO_2	42	27	23	22	20
3	N_2/Air	4.05	3.26	3.24	3.33	3.21

Table 3
Bio-Gas production using Pig Dung as seeding

Sl.No	Constituents	Ratio of Seeding material I Pig Dung with Cotton Waste				
		2.5%	5%	7.5%	10%	15%
1	CH_4	61	73	78	79	77
2	CO_2	35	23	19.8	18.45	19.55
3	N_2/Air	4.00	3.25	3.23	3.32	2.96

Table 4
Bio-Gas production using Goat Dung as seeding

Sl.No	Constituents	Ratio of Seeding material Goat Dung with Cotton Waste				
		2.5%	5%	7.5%	10%	15%
1	CH_4	52	66	69	71	70
2	CO_2	46	32	29	29	28.86
3	N_2/Air	4.22	3.31	3.34	3.22	3.21

Table 5

Bio-Gas production at different temperatures for 10% Seeding (Cow Dung)

Sl.No	Constituents	25ºC	27ºC	30ºC	32ºC	35ºC
1	CH_4	53	62.5	78	78.5	79.6
2	CO_2	45	34.25	20.8	20.25	19.15
3	N_2/Air	3.45	3.22	3.1	3.21	3.22

Table 6

Bio-Gas production rate for 10% seeding (Cow dung) at atmospheric temperature

Sl.No	Duration	Volume of Gas Collected /5 kg of Cotton Waste in liters
1	5 to 10 days	11
2	11 to 15 days	24
3	16 to 20 days	31
4	21 to 25 days	36
5	26 to 30 days	31
6	31 to 35 days	24
7	36 to 40 days	23
8	41 to 45 days	11
9	46 to 50 days	7

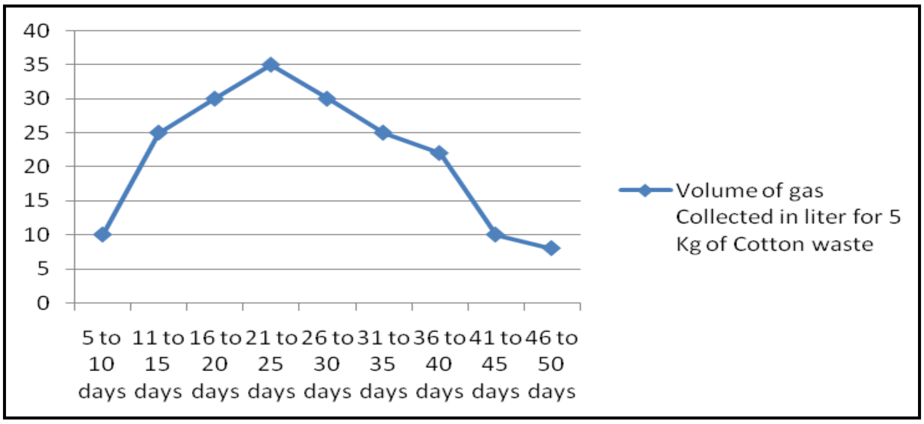

Figure 6

Volume of Gas Collected in Liters for 5 kg of Cotton Waste

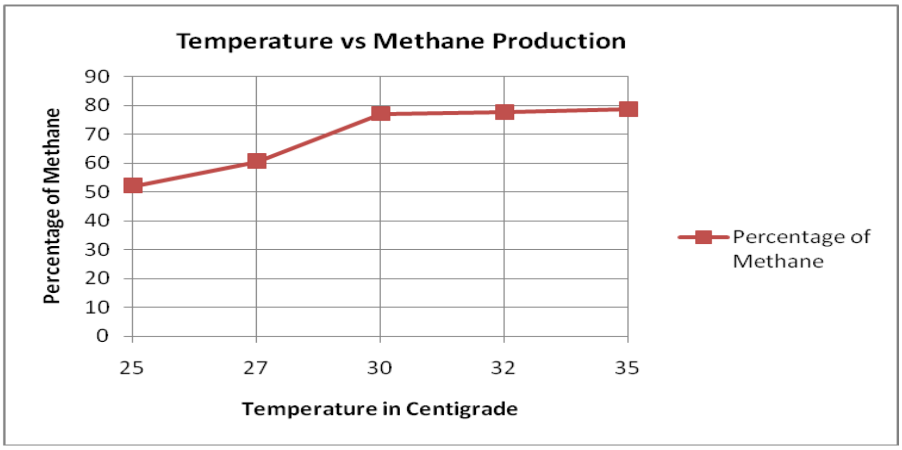

Figure 7

Variation of Percentage of Methane with Temperature

Table 2, 3 and 4 shows the constituent value of different seeding materials with cotton waste. From these tables it was found that cow dung produces more methane than pig and goat dung seeding with cotton waste. Table 5 shows the biogas production at different temperatures for 10% Seeding (Cow Dung). It was found that after 30°C the methane production is almost same around 80 %, which is clearly shown in Figure 7. The maximum volume of gas collected for 5 kg of cotton waste was 36 liters during the 21-25 days after seeding as shown in Table 6. After 46 days after seeding the volume of gas collected was as low as 10 liters, which is shown in Figure 6.

CONCLUSION

Generally, in textile mills waste like fly, raising fly, flat strip, dirty oily cotton, comber oil etc are lifted by traders and gets approximate value of Rs. 5 to 7/- per kg depending on the quality of waste and some grades are not utilized for any purpose. The problem of cotton waste has now assumed serious consideration, since it pollutes the atmosphere. Spinning mills are in the advantageous position to be able to utilize the biogas, which can be produced in their premises to avoid the problem of pollution. From the experimental results it was found that

- Cotton waste can efficiently be used as potential resource for biogas generation if proper conditions are maintained.
- Biogas production from cotton waste can be increased with cow dung, pig dung and goat dung as seeding material.
- 10% of cow and pig dung produces 79% of methane during fermentations.
- The production rate was maximum between the periods of 21st day to 25th day after starting fermentation.
- The optimum temperature for gas production is found to be 30ºC.
- Around 60% of diesel can be saved by using biogas as dual fuel.

CONFLICT OF INTEREST

Conflict of interest declare none.

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