

ANAEROBIC DIGESTION OF MUNICIPAL SOLID WASTE USING FUNGI CULTURE (ASPERGILLUS FLAVUS) WITH METHANOGENS

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Abstract— Municipal Solid Waste (MSW), mainly Kitchen Waste (K) with Cow Dung (C) and Fungi Culture (F) can be used to generate energy which could save on the fossil fuels conventionally used as source of energy. In this study, the possibility was explored to mix Cow Dung with Fungi Culture for anaerobic digestion, so that energy can be generated as biogas and at the same time digested sludge can be used as fertilizer for agricultural applications. Pre-treatment of Kitchen Waste was done by alkali method. Anaerobic digestion (AD) was carried out in mesophilic temperature range of 30°C to 37°C with different fermentation slurries of 8 % total solids. Digestion was carried for a retention period of 60 days. The gas produced was collected by the downward displacement of water and was subsequently measured and analyzed. The overall results showed that blending of Kitchen waste with cow dung and fungi culture (*Aspergillus flavus*) had significant improvement on the biogas yield.

Keywords— Anaerobic Digestion, Cumulative Biogas Production, Kitchen waste, Fungal Culture, Cow dung, Inoculums, *Aspergillus flavus*.

I. INTRODUCTION

The country's economy mainly depends on the energy resources available and utilized. Energy has been exploited since the prehistoric times. With the advent of industrial revolution use of fossil fuels began growing and increasing till date. The dependence on fossil fuel as primary energy source has led to global climate change, environment degradation and human health problems [1]. With increasing prices of oil and gas the world looks towards alternative and green energy resources. Anaerobic digestion (AD) offers a very attractive route to utilize certain categories of biomass for meeting partial energy needs. AD is a microbial decomposition of organic matter into methane, carbon dioxide, inorganic nutrients and compost in oxygen depleted environment and presence of the hydrogen gas. This process is also known as bi-methanogenesis. Anaerobic digestion has the advantage of biogas production and can lead to efficient resource recovery

and contribution to the conservation of non-renewable energy sources. AD can successfully treat the organic fraction of biomass [2]. AD is the controlled degradation of biodegradable waste in absence of oxygen and presence of different consortia of bacteria that catalyze series of complex microbial reactions [3]. The process is one of the most promising for biomass wastes as it provides a source of energy while simultaneously resolving ecological and agrochemical issues [4].

Fungi culture (*Aspergillus flavus*): *A. flavus* as well as some other fungi, proved to have capacity of maturing in 3 days in an anaerobic jar [5]. Fungi are found to be the major decomposers of cellulose and lignin [6]. The production of cellulose enzyme is a major factor in the hydrolysis of cellulosic materials [7]. *Aspergillus flavus* is capable of producing endoglucanase even from sawdust and corncob. *Aspergillus flavus* also possess the capacity to degrade the non- starch polysaccharide in the substrate to soluble sugar [8]. Most of the cellulolytic microorganisms belong to eubacteria and fungi can degrade cellulose. Cellulolytic microorganisms can establish synergistic relationships with non cellulolytic species in cellulosic wastes. The interactions between both populations lead to complete degradation of cellulose, releasing carbon dioxide and water under aerobic conditions and carbon dioxide, methane and water under anaerobic condition[9] The Strain *Aspergillus flavus* can be recommended for bioremediation programmes to clear cellulosic wastes [10].

II. MATERIALS AND METHODS

A. Sample Collection

Kitchen waste (K) was obtained from the canteen of Dayananda Sagar College of Engineering, Bangalore. Fresh cow dung was collected from a local cow yard in Yarab Nagar, Bangalore. Fungal culture *Aspergillus flavus* was procured from Department of Microbiology Culture Collection, Bangalore University, Bangalore.

B. Materials / Instruments

The materials/instruments used for the purpose of this research are as follows: Weighing balance (Systronics), Gas Chromatography (CHEMITO), pH meter (Systronics), thermometer (range 0°C to 100°C), Borosilicate desiccators, silica glass crucibles, oven, grinding mill, temperature controlled water bath, water troughs, graduated transparent glass gas collectors and biogas burner fabricated locally for checking gas flammability. AR grade sodium hydroxide and acetic acid manufactured by Ranbaxy laboratories were used as procured without further purification.

C. Analytical Methods

The following parameters of Kitchen Waste and cow dung were analyzed:

pH analysis: A glass electrode pH meter (Systronics) was used to monitor the pH of the sample.

Total Solids (TS) and total volatile solids (VS) analysis: TS were determined at 103°C to constant weight and VS were measured by the loss on ignition of the dried sample at 550°C.

Biogas analysis: Gas Chromatograph (Chemito 1000) equipped with a thermal conductivity detector was used to analyze the biogas sample. Hydrogen was used as a carrier gas (25 ml/min) with porapak Q column. Standard calibration gas mixture was used for calibration. The oven temperature of 40°C, detection temperature of 80°C and the detector current of 180 mA were used.

D. Biomethanation Unit

A schematic diagram of biomethanation unit is shown in Fig. 1 and water bath in Fig. 2. It consists of a temperature controlled thermo bath which is maintained at 35°C [11] and has a bio digester. Each bio digester is connected to a means of connecting tube. A stand holds all the gas collectors. Biogas evolved is collected by downward water displacement.



Fig. 1 Schematic picture of biomethanation unit



Fig. 2 Schematic picture of water bath

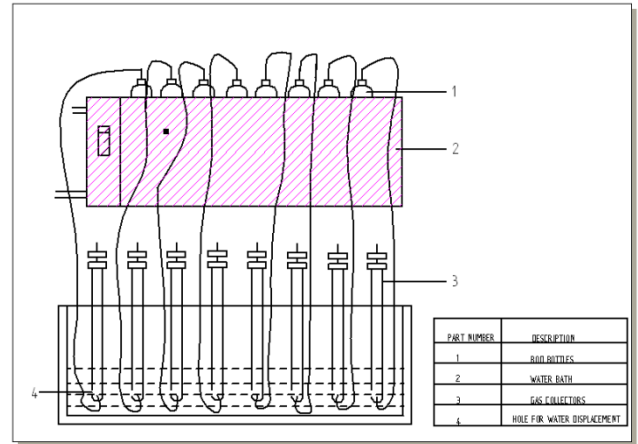


Fig. 3 Schematic diagram of water bath

E. Solid Analysis

Total solid (TS) and Volatile solid (VS) were analyzed for Kitchen Waste and Cow Dung according to standard methods [12]. Table.1 gives the solid analysis and pH data of Kitchen Waste and Fungi Culture.

TABLE I
SOLID AND PH ANALYSIS

Digester	pH	% TS	% VS
Kitchen Waste (K)	6.7	75.55	93.36
Cow Dung (C)	6.4	64.7	93.83

F. Fermentation Slurry Preparation

Fresh Kitchen Waste was initially collected and it was grounded to paste in the mixer. Material balance was made and different slurries with 8 % total solids were prepared by varying the amount of paste (grounded kitchen waste) and Water (W) [14]. The contents of each digester are shown in Table 2. Each digester was checked for neutral pH (i.e., 7.0), since the optimal pH for methanogenesis was found to be around 7.0 [15] When measured, each digester was found to have acidic pH (i.e., < 7.0), hence the contents were treated with 1 % NaOH (by volume) solution to bring them to neutral pH.

TABLE III
CONTENTS OF DIGESTERS

Digesters	Kitchen waste (g)	Water (g)	Fungi (g)	Cow dung (g)
DK	19.2	160.8	-	-
DKF	19.2	160.8	5	-
DKC	19.2	160.8	-	2
DKCF	19.2	160.8	5	2

III. RESULTS AND DISCUSSION

A. The Influence of Inoculums to Cumulative Biogas Productions

Anaerobic digestion of Kitchen Waste / Canteen Waste: The quantity of cumulative biogas production with time for all the digesters is given in Table 3. As shown in Fig. 3, Digesters DK, DKF, DKC and DKCF commenced biogas production from 5th day and evolved flammable biogas from 9th day. While digester Kitchen Waste Blank which serves as blank for Kitchen waste

commenced biogas production after 10 days and evolved flammable biogas on 20th day. The highest biogas yield was for digester DKCF (0.28 l/gVS). This performance could be because of optimum balance between the anaerobic bacteria consortium and amount of VS (23.76 g). This indicates digestion of Kitchen Waste and cow dung with fungi culture improves biogas yield significantly.

TABLE IIIII

CUMULATIVE BIOGAS PRODUCTION

Days	DK (l/g VS)	DKF (l/g VS)	DKC (l/g VS)	DKCF (l/g VS)
0	0	0	0	0
5	0	0.006	0.005	0.01
10	0.001	0.011	0.01	0.02
15	0.005	0.045	0.04	0.06
20	0.008	0.075	0.07	0.08
25	0.012	0.115	0.1	0.12
30	0.021	0.15	0.14	0.17
35	0.045	0.18	0.17	0.21
40	0.075	0.2	0.19	0.24
45	0.115	0.22	0.21	0.26
50	0.15	0.23	0.22	0.28
55	0.16	0.235	0.23	0.28
60	0.17	0.24	0.23	0.28

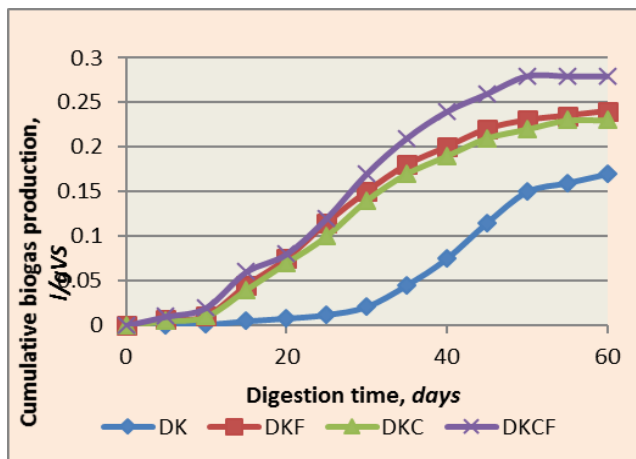


Fig. 3 Daily biogas production

B. Analysis of Biogas

With Biogas analysis was done for chief components CH₄ and CO₂ for biogas evolved from the digester DKCF. Biogas was sampled in a rubber bladder carefully. Gas chromatograph (Chemito 1000) equipped with a thermal conductivity detector was used to analyze the biogas sample. Hydrogen was used as carrier gas (25 ml/min) with Porapak Q column. Standard gas mixture was used for calibration. A fixed 500 µl volume was taken each time using a gastight syringe. The sample was then injected to gas chromatograph to analyze for methane and carbon dioxide. Following are the characteristics of the GC gas composition method:

Column : Porapak Q

Gas : Hydrogen with flow rate of 25 ml/min

Oven : 40°C

Detector : TCD at 80°C and 180 mA

The concentrations of methane and carbon dioxide were calculated using

$$\% \text{ of X} = \frac{(\text{Area of X in Sample})}{(\text{Area of X in Std})} \times (\% \text{ of X in Std})$$

The gas chromatogram obtained is shown in Fig. 4. The amounts of CH₄, CO₂ and CO in the biogas were found to be 59.3 %, 40.6 % and 0.1 % respectively. The biogas compositions from the other digesters were also found to be in the same range.

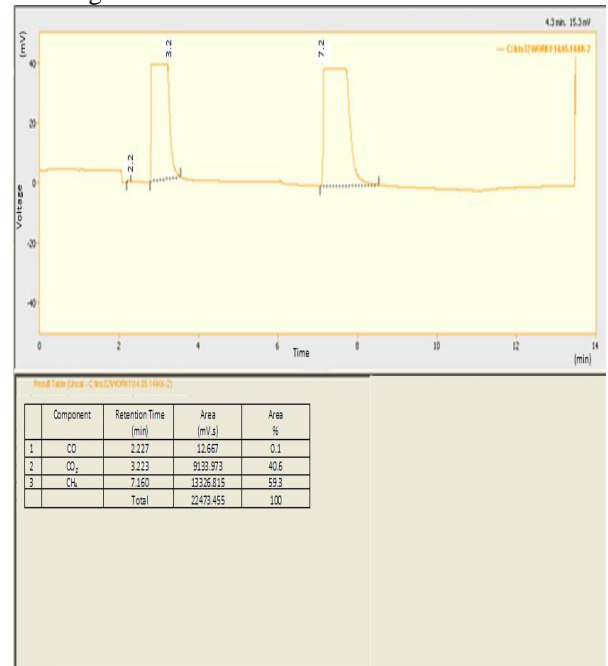


Fig. 4 Gas chromatogram for the digester DKCF

IV. CONCLUSIONS

Kitchen Waste is a very good biogas producer, needs minimal pre-treatment (soaking in NaOH solution and grinding) to enhance the biogas yield. The use of Cow dung with Fungi culture (*Aspergillus flavus*) for biogas generation therefore, will be a good energy source. The result of the study has shown that anaerobic digestion of ground Kitchen waste with cow dung and *Aspergillus flavus* improved biogas yield. This performance confirms the earlier reports by other researchers that combining cow dung with fungi culture catalyzes the biogas production with consequent increased yield [16].

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