Issue 9 vol 3 ISSN: 2321-8134

IJFEAT

INTERNATIONAL JOURNAL FOR ENGINEERING APPLICATIONS AND TECHNOLOGY

EFFECT OF ENHANCED BIOGAS PRODUCTION WITH PHYSICAL AND CHEMICAL PRETREATMENT OF MULE DUNG

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Abstract

Fossil fuels account for over 79% of the primary energy consumed in the world, and 57.7% of that amount is used in the transport sector and are diminishing rapidly. The World Energy Forum has predicted that fossil-based oil, coal and gas reserves will be exhausted in less than another 10 decades.Increasing the use of fossil fuel causes environmental problem both locally and globally. But India will face energy shortages significantly due to increase in energy prices and energy insecurity within the next few decades. For these reasons the development and use of renewable energy sources & technologies are becoming essential for sustainable economic development of India. Various types of renewable waste materials from agriculture (plant and animal wastes).Industries (sugar refinery, dairy wastes, confectionary waste, pulp and paper, tanneries) and domestic (kitchen waste and garden waste)are converted to useful energy forms like bio-hydrogen, biogas, bio alcohols, etc. for sustainable growth of energy. With this characteristic, renewable energy sources (mainly organic waste materials to energy) likely will become one of the most attractive substitutes in the near future

Keywords: *Fossil Fuel, Renewableenergy,Bio - Hydrogen, Bio-Gas,Fossil-Basedoil, Confectionarywaste.*

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1. INTRODUCTION

In India more amount of fossil fuel use. Fossil fuels account for over 79% of the primary energy consumed in the world, and 57.7% of that amount is used in the transport sector and are diminishing rapidly. The World Energy Forum has predicted that fossil-based oil, coal and gas reserves will be exhausted in less than another 10 decades [1]. Increasing the use of fossil fuel causes environmental problem both locally and globally. But India will face energy shortages significantly due to increase in energy prices and energy insecurity within the next few decades Increasing the use of fossil fuel causes environmental problem both locally and globally[2]. But India will face energy shortages significantly due to increase in energy prices and energy insecurity within the next few decad[2]. For these reasons the development and use of renewable energy sources & technologies are becoming essential for sustainable economic development of India. The most important property of renewable energy source is their environmental similarity. With this characteristic, renewable energy sources (mainly organic waste materials to energy) likely will become one of the most attractive substitutes in the near future [3]. Various types of renewable waste materials from agriculture (plant and animal wastes)industries (sugar refinery, dairy wastes, confectionary waste, pulp and paper, tanneries). And domestic(kitchen waste and garden waste) are converted to useful energy forms like bio-hydrogen, biogas, bio alcohols, etc. for sustainable growth of energy. India is an important agricultural dominated country and livestock plays an important role in Indian farming. They provides milk, meat, manure, wool, egg etc. Besides, they are extensively used for transport purpose [4]. As per livestock census the species covered in census namely Cattle, Buffalo, Sheep, Goat, Pig, Horses& Ponies, Mules, Donkeys, Camels, Mithun and Yak. The total livestock population consisting of Cattle, Buffalo, Sheep, Goat, pig, Horses & Ponies, Mules, Donkeys, Camels, Mithun and Yak in the country is 512.05 million numbers in 2012. The total livestock population has decreased by about 3.33% over the previous census. Livestock population has increased substantially in Gujarat (15.36%), Uttar Pradesh (14.01%), Assam (10.77%), Punjab (9.57%), Bihar (8.56%), Sikkim (7.96%), Meghalaya (7.41%), and Chhattisgarh (4.34%). There is positive growth s in Buffalo with 4.18%, Mithuns with 24.56%, Horses & Ponies with 1.31%, Mules with 46.23% and Poultry with 15.02% in Rural Areas[7]. Many works has emphasized on the production of biogas from different animal manure like cow, horse, cattel with different pretreatments. But no observation is made on the production of biogas from mule dung and the methane content in the biogas involving biochemical methane potential test (BMP) and different pretreatments of the mule dung at different ratio of inoculum. So the present study was carried out with the following objectives:

To study the characteristics of mule dung collected from selected hilly regions

To assess the biochemical methane potential (BMP) of mule dung[8]

To study the effectiveness of different pretreatments on mule dung and biogas production.[4]

The dung production from mule is very high in hilly region. Mule dung contains microorganisms and pathogens such as clostridium etc. There is high risk of human being acquiring skin and other contagious diseases that come in contact with fresh or partially degraded mule dung on hill tracts. Therefore, the utilization of mule dung for production of biogas and use as energy is very important. Methane emission from livestock waste provides an alternative source of energy. The feed materials for production of biogas such as animal and agricultural wastes are abundantly available in rural and semi-urban areas of country. Utilization of livestock manure for biogas production is an environment friendly solution. Biogas is obtained in the process of biodegradation of organic materials under anaerobic conditions. Biogas consists of mainly methane (CH4), carbon dioxide (CO2) and traces of other gases such as hydrogen (H2), carbon monoxide (CO), Nitrogen (N2), Oxygen (O2) and Hydrogen sulfide (H2S). Use of biogas as cooking fuel provides an efficient way of converting fuels to heat and reduces indoor air pollution[5]

2.MULE AND MULE DUNG

Biogas is a renewable energy source produced by a large number of anaerobic microbial species that ferment the organic matter under controlled temperature, moisture and acidity condition. Different raw materials can be used as organic matter for biogas production, e.g., animal waste, algae, municipal solid wastes, and every material containing lignocelluloses[2].

2.1 Mule

Mule is an equine animal, an offspring of male donkey (jack) and female horse (mare) which is used in carriage, transport, carting, tourism, building construction, and agriculture in hilly areas and inaccessible terrains. Utilization of mules for transport in hilly regions leads to accumulation of mule dung on hill tracts. It is very common to see mule dung deposits both in fresh and dry forms at hilly terrains of tourism and religious importance in India. Accumulation of mule dung on tracts affects the aesthetics of hill tracts besides generating foul odor and unhygienic conditions leading to health problems in human beings who come with contact with mule dung.[2]

2.2 Mule dung

Mule is stall fed, monogastric (non ruminant) and hind-gut fermenting animal. Mule is mostly fed with rice husk, wheat, chickpea (kabulichana). Some basic knowledge about mules and how they digest and metabolize food and produce manure (feces and urine) can help to control potential pollution more effectively.[2]

2.3 Anaerobic digestion

The digestion process occurring *without (absence) oxygen* is called anaerobic digestion which generates mixtures of gases. The gas produced which is mainly methane produces 5200-5800 KJ/m3 which when burned at normal room temperature and presents a viable environmentally friendly energy source to replace fossil fuels (non-renewable).[4]

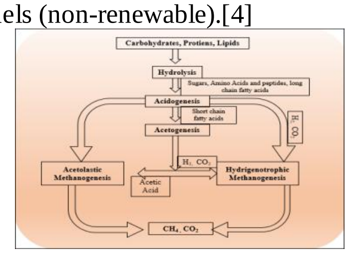

Fig. 2.1 Process flow during anaerobic digestion

Hydrolysis: This step involves the enzyme-mediated alteration of insoluble organic compounds with high molecular mass, i.e. proteins, fats, lipids, and carbohydrate etc, into soluble organic components such as amino acids, fatty acids, monosaccharide, and other simple organic compounds[4]

Acidification: In this stage, soluble compounds produced in the first stage are further degraded by a diversity of different facultative anaerobes through different fermentation processes. The fermentation results in the production of carbon dioxide, hydrogen gas, organic acids, alcohols, some organic-nitrogen compounds and some organic-sulphur compounds.[3]

Acetogenesis: The products produced in the acidogenic phase are consumed as substrates for the other microorganisms, active in the third phase. In the third phase, also called the acidogenic phase anaerobic oxidation are performed.

Methanogenesis: During this stage, methanogenic micro-organisms convert acetic acid, hydrogen and carbon dioxide to methane and carbon dioxide i.e. biogas. The remaining compounds like alcohols, organic-nitrogen compounds which methanogens cannot degrade will be accumulated in the digestate[6]

2.4 Biogas from Anaerobic Digestion through animal dung

Biogas, the metabolic product of anaerobic digestion, is a mixture of methane and carbon dioxide with small quantities of other gases such as hydrogen sulfide Methane, the desired component of biogas, is a colorless, blue burning gas used for cooking, heating, and lightin. Biogas is a clean, efficient, and renewable source of energy, which can be used as a substitute for other fuels in order to save energy in rural areas.

The usual composition of biogas is:

Methane (50% - 70%), Carbon dioxide (30% - 40%), Hydrogen (5% - 10%), Nitrogen (1% - 2%), Water vapor (0.3%), Hydrogen sulfide (traces)

The Biogas produced may vary in composition depending on the feed material. Biogas is lighter than air by 20% and the ignition temperature of biogas lies in the range 650 °C to 750 °C. Biogas has a calorific value of about 20 Mega Joules (MJ) /m^3 and has been reported to burn with 60 % efficiency when used for combustion in a biogas stove.[8]

2.5 Properties of biogas

1. Change in volume as a function of temperature and pressure.
2. Change in water vapors as a function of temperature and pressure.

3. MATERIALS AND METHODS

3.1 Collection of mule dung

In this study, mule dung use as a substrate for biogas production. It was considered as a lignocellulose material due to their chemical composition mainly cellulose, hemicellulose, lignin fractions. Mule dung was collected from Katra (Jammu and Kashmir) and stored it in cool place at 4º C before used it.

3.2 Collection of inoculum

Inoculum was collected from pilot plant present in National Environment and Research Institute (NEERI) Nagpur.

3.3Exprimental Setup

After all the pretreatments, 28 BMP bottles of 125 ml were used for done the experiments. The BMP bottles were filled with samples (untreated and pretreated) and inoculum in the ratio given in following table. Then the total bottles were sealed with rubber septa and aluminum crimp caps. These bottles were kept at atmospheric temperature in day time because in summer the temperature of the atmosphere is in between 35-50º C. in night time, the bottles were kept in shaker incubator at 37+/- 1ºC for maintaining the mesospheric temperature. After 2 days the gas production was started and measured it by syringe method with plastic syringe. The gas production increased day by day and methane (CH_4) and carbon dioxide (CO_2) were measured daily[5].

Plate 3.1 Experimental setup

Table 3.3.1 Amount of mule dung, inoculum used

Digesters	Mule dung	Inoculum	Ratio	Pretreatment
D1 D2	20 g	20 ml 40 ml	1:1 1:2	Nil Nil
D3 D4	20 g	20 ml 40 ml	1:1 1:2	Autoclave
D5 D6	20 g	20 ml 40 ml	1:1 1:2	Microwave
D7 D8	20 g	20 ml 40 ml	1:1 1:2	Autoclave + microwave
D9 D10	20 g	20 ml 40 ml	1:1 1:2	Acid
D11 D12	20 g	20 ml 40 ml	1:1 1:2	Alkali
D13 D14	20 g	20 ml 40 ml	1:1 1:2	H_2O_2

Mule dung were collected → Dried it and grinded in grinder

↓

Divided it into 3 equal parts for different pretreatment and control → Each pretreated samples were mixed with different inoculum ratios (1:1, 1:2) in different BMP setups

↓

Setups were placed in atmosphere temperature at day time (35-45º C) and at night time it was placed in shaker incubator at 37º C → Gas production was measured by syringe method

Fig. 3.1 Flow chart showing experimental procedure

3.4 Pretreatment procedure

At present the sample was dried then grinded in mixer grinder. Then the characterization of mule dung was done such as cellulose, hemicellulose, lignin, total solid, volatile solid, ash content, calorific value, Na, P, K, C, H, N, S, initial COD, etc. Then the sample was divided into three parts and labeled properly for with and without pretreatment. Then two types physical and chemical pretreatment were done.

A sample without pretreatment was kept as a control.

3.4.1 Physical pretreatment

Autoclave: 200 g of substrate was taken in 500 ml conical flask and added tap water used for wet the substrate. The contents were mixed well and kept in autoclave for heating. The temperature of autoclave was set at 121 º C with pressure of 15 lbs and contents were autoclaved for 30 min[9].

Microwave: 200 g of sample was taken in 1000 ml beaker and added sufficient amount of water used for wet the sample. The contents were well mixed and kept in microwave for heating. The temperature of the microwave was 110º C and time for heating is 15 min.

Combine autoclave and microwave: 200 g of sample was taken in 500 ml conical flask and added a tap water the put into autoclave for 30 min at 15 lbs pressure and 120º C temperature. Then this autoclaved sample was put into microwave for heating at 110º C for 15 min.

3.4.2 Chemical pretreatments

Alkali pretreatment: 2 N, 5 % (w/w) solution of NaOH was prepared and then poured it into 200 g of sample. Then mixed it properly and added sufficient amount of tap water.

Acid pretreatment: 2 N, 5% (w/w) solution of hydrochloric acid (HCL) was prepared and added into 200 g of sample. Then mixed it well and added sufficient amount of tap water.

H_2O_2 pretreatment: 2 N, 2 % (w/w) solution of H_2O_2 was prepared and added into 200 g of sample. Then mixed it well and added sufficient amount of tap water.

3.5 Preparation of biochemical methane potential (BMP) assay for production of biogas

3.4.1 Material required:

Mule dung, Inoculum, Alkali solution, Acid solution, H_2O_2 solution, Autoclave, Microwave, BMP bottles of 125 ml , Rubber septa, Aluminium crimp caps, Plastic syringe

4. RESULTS AND DISCUSSION

4.1 Characterization of mule dung and inoculum

In this result characterization of mule dung and inoculum were first carried out as shown in table given below. Based on this chemical analysis of substrate and inoculum, two types of substrate to inoculum ratio were selected: (1:1 and 1:2). Different types of physical and chemical pretreatment were given to the substrate and cumulative biogas production was observed from all setups for 20 days.

Table 4.1 Characterization of mule dung and inoculums

Parameters	Mule dung	Inoculum
Total solid (%)	18.97	2.69
Total volatile solid (%)	89.42	86.36
Moisture content (%)	81.02	97.31
Ash (%)	10.58	13.64
pH	7.2	7.6
Cellulose (%)	55.32	NA
Hemicellulose (%)	20.51	NA
Lignin (%)	28.33	NA
C/N	17	NA
Total COD (mg/l)	59	NA
Soluble COD (mg/l)	48	NA
Phosphorous (%)	0.16	NA

5. CONCLUSION

In order to efficient use of mule dung, a highly lignocellulose material anaerobic digestion is a sustainable option. In this study, it was observed that physical pretreatment as well as chemical pretreatment can enhance biogas production rate and methane concentration. Among the physical pretreatment, microwave pretreated samples mixed with inoculum at 1:2 ratios shows higher cumulative biogas production rate, VFA degradation rate and highest biochemical methane potential and among chemical pretreatments, alkali pretreated samples mixed with inoculum at 1:2 ratio shows the similar pattern as observed in microwave pretreated samples. Therefore, it can be concluded that microwave pretreatment and alkali pretreatment are the optimal one for enhanced biogas production from mule dung. For the researches are needed on the effect of enhanced biogas production with physic-chemical pretreatment of mule dung.

ACKNOWLEDGEMENT

This research work partially supported by Anuradha Engineering College, Chikhli. We thank our colleagues from [Anuradha Engineering College, Chikhli] who provided insight and expertise that greatly assisted the research, although they agree with all of the conclusions of this paper.We also thank Prof.V.D.Gurudasani [Head, Department of Chemical Engineering] for his assistance in using sophisticated analysis equipments.

REFERENCES

[1]. Agency, I.E., *Key world energy statistics*. 2007: International Energy Agency.

[2]. Kumar, A., et al., *Renewable energy in India: current status and future potentials*. Renewable and Sustainable Energy Reviews, 2010. **14**(8): p. 2434-2442.

[3]. Kothari, R., V. Tyagi, and A. Pathak, *Waste-to-energy: A way from renewable energy sources to sustainable development*. Renewable and Sustainable Energy Reviews, 2010. **14**(9): p. 3164-3170.

[4]. Bardiya, N., D. Somayaji, and S. Khanna, *Biomethanation of banana peel and pineapple waste*. Bioresource technology, 1996. **58**(1): p. 73-76.

[5]. Deivanai, K. and R. Kasturi, *Batch biomethanation of banana trash and coir pith*. Bioresource technology, 1995. **52**(1): p. 93-94.

[6]. Lay, J.J., *Biohydrogen generation by mesophilic anaerobic fermentation of microcrystalline cellulose*. Biotechnology and bioengineering, 2001. **74**(4): p. 280-287.

[7]. Kalia, V., et al., *Frementation of biowaste to H2 by Bacillus licheniformis*. World Journal of Microbiology and Biotechnology, 1994. **10**(2): p. 224-227.

[8]. van de Klundert, A., J. Anschütz, and A. Scheinberg, *Integrated sustainable waste management: the concept. Tools for decision-makers. experiences from the urban waste expertise programme (1995-2001)*. 2001: WASTE.

[9]. Adekunle, K.F. and J.A. Okolie, *A review of biochemical process of anaerobic digestion*. Advances in Bioscience and Biotechnology, 2015. **6**(03): p. 205.

[10]. Şentürk, E., M. Ince, and G.O. Engin, *Kinetic evaluation and performance of a mesophilic anaerobic contact reactor treating medium-strength food-processing wastewater*. Bioresource technology, 2010. **101**(11): p. 3970-3977.