American Journal of Environment, Energy and Power Research
Vol. 2, No. 2, November 2014, pp. 1 - 9, ISSN: 2329 - 860X (Online)
Available online at http://www.ajeepr.com/

Research article

Evaluating of Biogas Production from *Euphorbia tirucalli*

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Abstract

The study was conducted to assess biogas production from euphorbia tirucalli, to determine the amount of biogas production from euphorbia tirucalli. The highest biogas production was observed in 1:10 Euphorbia tirucalli to water ratio (55.70 liters) when compared with 1:15 (30.97 liter) and 1:20 (18.07 liter) Euphorbia tirucalli to water ratios. Too much water will reduce the rate of biogas production per unit of volume within a certain time. There is highly significance difference among the biogas production from 1:10, 1:15 and 1:20 Euphorbia tirucalli to water ratio. A digital pH meter was used to determine the pH of the slurry. The pH values Euphorbia tirucalli around the neutral condition which was favorable for the growth of important microorganisms to support high biogas production. The temperature of the slurry was found as mesophilic condition suitable for the growth of important microorganism that facilitate the biogas generation. Euphorbia tirucalli is economically very important to produce sufficient amount of biogas to solve energy deficiency of the country and using this material for biogas production has not an impact on the deforestation. Euphorbia tirucalli does not need any chemicals to generate the biogas production.

Keywords: Ambient, Biogas, Euphorbia tirucalli, Mesophilic, pH, Slurry

INTRODUCTION

The increase of atmospheric CO_2 has been implicated in global warming and global climate change. An effort to control global warming and climate change, the governments of the U.S. and of the European Union announced ambitious programs for the increase of the production of plant-based fuels [1 and 2]. Because renewable energy plays an important role in reducing the atmospheric CO_2; particularly energy from biomass could contribute significantly as it is a ‘‘carbon neutral” fuel. Biogas is a type of biofuel which is excellent source of energy. It is a mixture of methane and carbon dioxide as the major components and H_2, NH_3, H_2S as minor components. Methane is representing a valuable renewable energy source and reduces greenhouse gas emissions when it is collected and substituted for fossil fuels. Biogas is produced when bacteria decompose organic material especially in the absence of oxygen (anaerobic). The anaerobic process involves four major steps hydrolytic, acidogenic, acetogenic and methanogenic process [3, 4 and 5].

Euphorbiaceae plants posse sufficient amounts of latex, sugars and cellulose, which can be converted to biogas through anaerobic digestion. The major constituents of latex are isomers of triterpenes ($C_{30}H_{50}O$) (MW: 426), such as euphol, tirucallol, glut-5-en-3-β-ol, cycloeuphordenol, euphorginol, α-amyrin, lanosterol, cycloartenol, and others[6].

Euphorbia tirucalli is a type of Euphorbiaceae plant species. Euphorbia tirucalli is relatively easy to grow in different soil types, under diversified conditions, and does not require special management practices. It is widely used as a live fence and in hedge rows to control soil erosion. Under optimal conditions, *Euphorbia tirucalli* produces between 200 and 500 metric ton of fresh biomass per hectare per year. The gross energy content of dry Euphorbia tirucalli is 17,600 kJ/kg [7].

Ethiopia has high resources of natural euphorbia tirucalli. For instance, it is found in Wello, Gojam, Gonder, Shoa, Tigray, Harerge, Sidamo, Gamo gofa, Ilubabor and Bale [8]. In Ethiopia, *Euphorbia tirucalli* is used as a live fence, fire wood and in hedge rows but not used for other purposes. So, Ethiopia can be generated high biogas production from natural *Euphorbia tirucalli*. Because this plant species is only vegetative material is needed and can generate high biomass production. No need to wait up to flowering and fruit time production; when cut back, the plant rapidly grows back by itself, and plantation can easily be established by vegetative propagation. It also has large volume of cow dung generated from feedlot farming which is disposed into landfills or applied to the land without treatment. Anaerobic digestion provides an alternative option for biogas generating and waste treatment to decrease disposal costs. The biogas produced can be used as a source of renewable energy and the residue can be used as a soil conditioner (fertilizer).

Recently, peoples of the world have worried about whether fossil fuel is reliable global energy sources due to the ever-increment of vehicles and different industries that are not balanced with the supply of petroleum. In Ethiopia

also there are several indicators point out an energy crisis including: rapid deforestation, a biomass energy scarcity and deterioration in electricity generation and distribution systems. However, Ethiopia has considerable opportunities for energy development from hydro sources, wind, solar and biogas. Most of these energy sources have not been fully exploited. As such, wood is still the major source of energy for the population and imported petroleum products from foreign country. To solve this problem, the non-renewable natural fuel can be substituted by renewable plant based energy sources. The significance of this work may solve the energy scarcity of the country. It can also use to increase the access rate of modern energy resources such as new and renewable energies; produce large quantity and quality energy for urban and rural areas as improving security of electricity and petrol product supplies; and meet needs of domestic energy to protect environmental pollution. Therefore, this study was conducted with the following specific objective

- To evaluate biogas production from *euphorbia tirucalli*

MATERIALS AND METHODS

Description of Study Area

Sample that was utilized in this research work is *Euphorbia tirucalli* which was obtained from Tachgayint. It is located in South Gondar Zone, Amahra Region, Ethiopia. It is about 770 kms northeast of Addis Ababa and about 200 kms from Bahir Dar. The Woreda lies within the geographical grid coordinates of 11°22′N latitude and 37°41′E longitude. In terms of altitude, the Wereda ranges from 750 m to 2800 meters above sea level with highest and lowest temperature of 27^{o}C and 13^{o}C respectively. The rainfall ranges in mean annual amount between 900 mm to 1000 mm. The experiment was done in Bahir Dar and Haramaya University.

Materials and Chemicals

Drums of different volumes, plastic containers, graduated cylinders of different volumes, refluxing apparatus, vacuum filtering system with trap in line, desiccator, berzelius beakers, sintered glass crucibles (coarse porosity), electronic balance, digital pH meter, Plastic bags, get valve, rubber tube, vacuum pump machine, mixer grinder, $C_{12}H_{25}O_4S$, EDTA, $C_{12}H_{25}O_4S$, $Na_2B_4O_7.10H_2O$, Na_2HPO_4, $C_4H_{10}O_2$, muffle furnace, oven, H_2SO_4, boric acid solution, NaOH and HCl are the materials and chemicals used during the experiment.

Experimental Design

The experiment was conducted by using three factorial complete randomized designs (chemicals, water level and materials) with three replications. The experimental design for the anaerobic digestion of Euphorbia tirucalli was carried out at ambient temperature in one batch digesters as follow:

- Digester A: comprise 100% *Euphorbia tirucalli*

Procedure

To build this digester, a hole was cut in the lid of one of the larger drums, near the outer edge. The pipe was slide into the hole. Then, a smaller hole was cut near the opposite edge and another hole in the bottom of the medium drum. Pieces of plastic tubing was attached to the larger drum and run the tubing into the medium drum. All the connections were sealed with epoxy. A second hole was cut in the bottom of the medium drum and attaches the valve to the hole. The medium drum was inverted and the valve was opened and pushed it down into the large drum with water. The digester was filled with slurry and necessary chemicals in required quantity such as sodium carbonate, ash and lime were added. Then, anaerobic digestion was allowed to continue for different intervals of time. As gas is produced it was bubbled up through the water and filled the medium drum making it float. This floating drum collector was connected with gas collector (plastic container). Ambient temperature measurement was determined with a mercury bulb thermometer.

Chemical Analysis

Chemical analysis of the sample was carried out to determine their volatile matter, moisture content, total solid, pH, cellulose content and lignin content. The volatile matter was determined by dried a portion of these samples and ashed in a muffle furnace at 550°C. Moisture content and total solid was determined by drying a sample to a constant value in a drying oven at 105°C. The pH of the sample was determined by digital pH meter. The carbon content in the sample was determined according to the following procedure. Aluminum pan was dried in oven at 100°C for 15 to 30 minute. Then, the pan was cooled in desiccators, weighed and recorded. Samples were added and recorded weight of pan plus sample. Pan plus sample was dried in oven at 100°C for 12 hours and cooled in desiccators, weighed back, and recorded. Pan plus samples were placed in muffle furnace and ashed at 500°C for 3 hours. Then after pan plus samples were cooled in muffle for at least 8 h, and then in desiccators, weighed back, and recorded the weight. The neutral detergent fiber, acid detergent fiber and acid detergent lignin were determined using Van Soest procedure.

Methods of Data Collection

20 types of grab sample from *Euphorbia tirucalli* was collected randomly from Tachgayint. The matured shoot part of *Euphorbia tirucalli* was collected, chopped, grinding and stored in safe place. After mixing these grab samples and homogenized, a composite samples from the material was taken to laboratory for analysis. After that, the quantitative data obtained from experiment was measured using water displacement method in which the amount of tap water displaced was proportional to the volume of biogas produced. Finally, the average three replicate results of these samples were calculated and used for the statistical analysis.

Data Analysis

After comprehensive data collection and analysis, the overall result was presented in the form of tables, graphs, figures and maps to make things clear and understandable. The collected data was analyzed using SAS (statistical analysis software 2004).

RESULT AND DISCUSSION

Chemical Composition of *Euphorbia tirucalli*

Table 1. Fiber contents of *Euphorbia tirucalli*

Parameters	NDF	ADF	ADL
Euphorbia tirucalli (%)	42.42	30.31	4.24

NDF = Nutrient detergent fiber, ADF = Acid detergent fiber, ADL = Acid detergent fiber

The chemical composition of the slurry was present in table 1. The value of NDF, ADF and ADL content of *Euphorbia tirucalli* were found as 42.42, 30.31 and 4.24%, respectively. The NDF content of *Euphorbia tirucalli* was higher than the ADF and ADL contents. Whereas, the ADL content of *Euphorbia tirucalli* is greatly less than the value of NDF and ADF of *Euphorbia tirucalli*. This indicated that the lignin part (the insoluble parts of carbohydrate) of *Euphorbia tirucalli* is less and the soluble parts of *Euphorbia tirucalli* is high. The value of NDF (42.24%) content was found higher than the other. Indicated that *Euphorbia tirucalli* has high amount of soluble parts of carbohydrates followed by ADF (some parts insoluble) valued 30.31 percent.

Table 2. Characterization of *Euphorbia tirucalli* and cow dung

Parameters	*Euphorbia tirucalli*
Moisture content (%)	76.13
Total solid (%)	23.87
Total volatile solid (%)	20.67
Ash (%)	3.20
Carbon content	11.48
Total volatile solid/ Total solid (%)	86.59
Ash/total solid (%)	13.41

Determination for total solids of material is an effective way of finding out of the amount of nutrient that will be available for bacterial action during digestion. The amount of methane to be produced depends on the quantity of volatile solid that is the amounts of solids present in the material and their digestibility or degradability and the

volatile solids are within the range for biogas production. The total volatile solid content in the total solid of Euphorbia tirucalli used in this study were 86.59%. As the result shows, Euphorbia tirucalli have high percentage of volatile solid content relative to total solid. Euphorbia tirucalli has higher volatile solid content. This indicative that Euphorbia tirucalli has high value of cellulose content and lower value of lignin content in the case of this study. Accordingly, Euphorbia tirucalli is more considered as good substrates for anaerobic digestion and hence for biogas production.

Biogas Production

Biogas systems are those that take organic material (*Euphorbia tirucalli*) into an air-tight tank, where bacteria break down the material and release biogas, and a mixture of mainly methane with some carbon dioxide is produced. The biogas can be burned as a fuel, for cooking or other purposes, and the solid residue can be used as organic composite. Through this compact system, it has been produced biogas that by using *Euphorbia tirucalli* having high calorific and nutritive value to microbes, the efficiency of methane generation can be increased by several orders of magnitude. It is simple to use and apply. Conventional biogas systems using *Euphorbia tirucalli* required to produce some quantity of methane and CO_2 gases.

Table 3. Volume of biogas in liter produced per 2kg of *Euphorbia tirucalli*

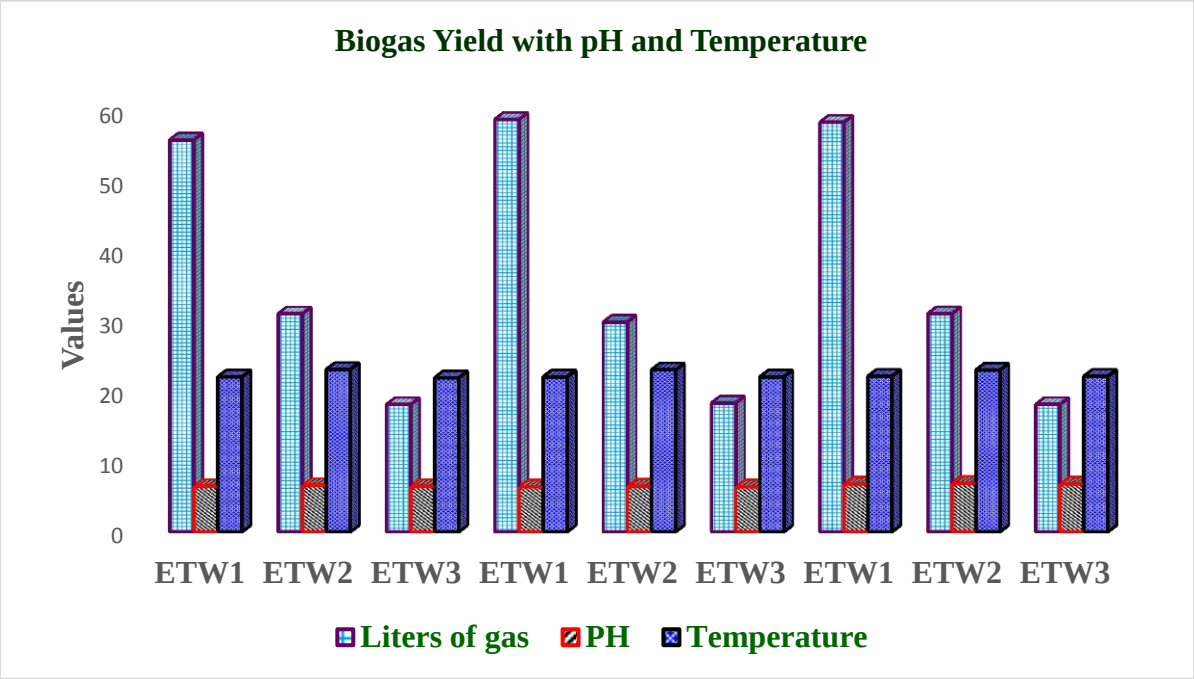
Treatment	**1:10WR**	**Std**	**1:15WR**	**Std**	**1:20WR**	**Std**	**SL**
Euphorbia tirucalli	55.70^{a}	4.68	30.97^{e}	1.15	18.07^{i}	0.25	***
Significance level= 0.01					Replication = 3		

WR = water ratio, Std = standard deviation, SL = significance level, *** = highly significance different

From the experiment performed in the laboratory, a set of results were obtained that contain cumulative biogas yields. Thus, the results of biogas production from *Euphorbia tirucalli*, documented in Table 3. The biogas production from *Euphorbia tirucalli* only in 1:10, 1:15 and 1:20 *Euphorbia tirucalli* to water ratio was 55.70, 30.97 and 18.07 liters respectively. This data indicated that the highest biogas production was observed in 1:10 *Euphorbia tirucalli* to water ratio (55.70 liters) when compared with 1:15 (30.97 liter) and 1:20 (18.07 liter) *Euphorbia tirucalli* to water ratios. This is due to the dilution and concentration effects of the material. Too much water will reduce the rate of biogas production per unit of volume within a certain time. There is highly significance difference among the biogas production from 1:10, 1:15 and 1:20 *Euphorbia tirucalli* to water ratio.

A digital pH meter was used to determine the pH of the slurry. The pH values for treatment pure *Euphorbia tirucalli* with 1:10, 1:15 and 1:20 *Euphorbia tirucalli* to water ratio were found 6.47, 6.59 and 6.47, respectively. This is around the neutral condition which was favorable for the growth of important microorganisms to support high biogas production.

Figure 1. Volume of biogas verses temperature and p^H value in water ratio



ETW1=Euphorbia tirucalli with 1:10 water ratio, ETW2=Euphorbia tirucalli with 1:15 water ratio, ETW3=Euphorbia tirucalli with 1:20 water ratio.

The digester was operated at ambient temperature and used thermometer to measure temperature of the slurry daily. The temperature of the slurry (*Euphorbia tirucalli* with the 1:10, 1:15 and 1:20 of *Euphorbia tirucalli* and water ratio) were found as 22.02, 23.06 and 21.99 ^oC, respectively. This temperature is known as mesophilic condition suitable for the growth of important microorganism that facilitate the biogas generation.

CONCLUSION AND RECOMMENDATION

The data gathered during this study showed that the NDF content of *Euphorbia tirucalli* was higher than the ADF and ADL contents. However, the ADL content of *Euphorbia tirucalli* is greatly less than the value of NDF and ADF of *Euphorbia tirucalli*. The volatile solid and carbon content of Euphorbia tirucalli also higher. This indicated that *Euphorbia tirucalli* has high amount of soluble parts of carbohydrates, amino acids and lower value of lignin content. Therefore, *Euphorbia tirucalli* is more considered as good substrates for anaerobic digestion and for biogas generation.

From the experiment performed in the laboratory, a cumulative biogas yields were obtained from *Euphorbia tirucalli* substrate loadings. *Euphorbia tirucalli* only without any chemical addition was produced the highest biogas production in 1:10 *Euphorbia tirucalli* to water ratio. The moisture content to slurry ratio also plays a great role to produce maximum biogas. A more concentrated organic material was typically produced biogas at a faster rate than

a more diluted organic material. Because too much water were reduced the rate of biogas production per unit of volume within a certain time. Therefore, *Euphorbia tirucalli* only in 1:10 slurry to water ratio without any chemical addition is more preferable for growth of microbial and generation of biogas. It is also economically visible, because the prices of chemicals like lime and sodium carbonate is reduced by hundred percent.

Reactor temperature and pH are also critical design parameters that must be maintained in order to achieve the desired anaerobic digestion. In this study, the experiment is carried out at mesophilic temperature which is suitable for the growth of important microorganism that facilitate the biogas generation. The pH of the slurry was around the neutral condition which was favorable for the growth of important microorganisms to support high biogas production. Euphorbia tirucalli is economically very important to produce sufficient amount of biogas to solve energy deficiency of the country and using this material for biogas production has not an impact on the deforestation. Euphorbia tirucalli does not need any chemicals to generate the biogas production.

A study conducted on synthesis of biogas from *Euphorbia tirucalli* has useful information to the government and voluntary organization. So, give attention to the plant in order to spread throughout the country specially to cultivate in areas which not favorable for crop production and plan for generations of biogas from *Euphorbia tirucalli.*

The societies in order to have, an opportunity to synthesis their own biogas by using simple technology from *Euphorbia tirucalli* and cultivate on their surroundings. Therefore, the researchers strongly recommend as the government should be given awareness to the society to produce their own biogas.

Other researchers should be involved concerning on further characterization and improvement the yield of biogas from *Euphorbia tirucalli.*

Acknowledgements

Certainly, this study called for the participation of many individuals and institutions without their help, financial, technical and moral support, we would not have completed it. First of all, we are very grateful to our University (Debre Tabor University) for giving us this chance and financial support.

It is our great pleasure to express our heartfelt thanks to Bahir Dar and Haramaya Universities for making their Laboratory available for the experiment. Finally, our greatest acknowledgement and gratitude goes to Ato Faska Kebede who, help us to do all the necessary activities in Bahir Dar University chemistry laboratory without any tiredness.

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