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Research article

IMPACTS OF SLURRY MIXTURES ON BIOGAS PRODUCTION FROM *EUPHORBIA TIRUCALLI* AND COW DUNG

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Abstract

The study was conducted to assess biogas production from the mixture of euphorbia tirucalli and cow dung, to determine the amount of biogas production from euphorbia tirucalli and cow dung. Biogas production from five batch digesters containing varying ratios of mixture of Euphorbia tirucalli and cow dung were studied at ambient temperature. The maximum biogas yield 34.43 liters was attained from 75% of Euphorbia tirucalli with 300g lime in 1:10 slurry to water ratio. There is highly significantly ($P<0.0001$) difference among the treatments of mixture of 75% Euphorbia tirucalli and 25% cow dung with ash in 1:10, 1:15 and 1:20 slurry to water ratio. Whereas, a significant ($P<0.001$) difference among the treatments of 50% Euphorbia tirucalli and 50% cow dung with ash, 75% Euphorbia tirucalli and 25% cow dung with lime, 50% Euphorbia tirucalli and 50% cow dung with lime, 75% Euphorbia tirucalli and 25% cow dung with sodium hydroxide in the 1:10, 1:15 and 1:20 Euphorbia tirucalli to water ratio. However, there is no significant difference was observed in the treatments of 50% Euphorbia tirucalli and 50% cow dung in the 1:10, 1:15 and 1:20 Euphorbia tirucalli to water ratio. 75% Euphorbia tirucalli and 25% cow dung with 300g lime in 1:10 slurry to water ratio is economically very important to produce sufficient amount of biogas to solve energy deficiency of the community.

Keywords: Biogas, Chemicals, Cow dung, Deforestation, Euphorbia tirucalli,Yield

INTRODUCTION

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 [1, 2 and 3].

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[4].

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 [5].

There is a great deal of environmental pressure in many parts of the world to ascertain how livestock waste can best be handled. Livestock manure, like cow dung in the absence of appropriate disposal methods can cause adverse environmental and health problems such as: pathogen contamination, odor, air born ammonia, greenhouse gases, etc [6]. Anaerobic digestion has been considered as waste-to-energy technology, and is widely used in the treatment of different organic wastes, for example: organic fraction of municipal solid waste, sewage sludge, food waste, animal manure, etc [7]. Anaerobic treatment comprises of decomposition of organic material in the absence of free oxygen and production of methane, carbon dioxide, ammonia and traces of other gases and organic acids of low molecular weight [8].

The chemical constituent of *Euphorbia tirucalli* and cow dung may vary significantly in nature. So, the need for combining *Euphorbia tirucalli* and cow dung from different sources may become imperative in biogas generation. Hence, the implication of combining *Euphorbia tirucalli* and cow dung for biogas production need to be properly assessed for successful implementation of such anaerobic process. Co-digestion was used by researchers such as (9, 10 and 11) to improve biogas yield by controlling the carbon to nitrogen ratio.

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 [12]. 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 and animal waste 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 determine the amount of biogas production from mixture of *Euphorbia tirucalli and* cow dung

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 m 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. fresh cow dung was obtained from a ranch of Bahir Dar 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, ash, lime, $NaCo_2$,$C_{12}H_{25}O_4S$, 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 and cow dung were carried out at ambient temperature in 3 batch digesters labeled A–C as follow:

- ✓ Digester A : comprise 75% *Euphorbia tirucalli* and 25% cow dung
- ✓ Digester B : comprise 50% *Euphorbia tirucalli* and 50% cow dung
- ✓ Digester C : comprise 25% *Euphorbia tirucalli* and 75% cow dung

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 these samples were carried out to determine their volatile matter, moisture content, total solid, pH, cellulose content, lignin content and carbon to nitrogen ratio. 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 min. 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 h and cooled in desiccators, weighed back, and recorded. Pan plus samples were placed in muffle furnace and ashed at 500°C for 3 h. 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 each material (*Euphorbia tirucalli* and cow dung) were collected randomly from Tachgayint and a ranch of Bahir Dar University. The matured shoot part of *Euphorbia tirucalli* was collected, chopped, grinding and stored in safe place. Cow dung without urine was collected from Bahir Dar ranch in the morning. After mixing these grab samples and homogenized, a composite samples from each 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

Table 1. Characterization of *Euphorbia tirucalli* and cow dung

Parameters	*Euphorbia tirucalli*	Cow dung
Moisture content (%)	76.13	82.93
Total solid (%)	23.87	17.07
Total volatile solid (%)	20.67	13.14
Ash (%)	3.20	3.93
Carbon content	11.48	7.30
Total volatile solid/ Total solid (%)	86.59	76.98
Ash/total solid (%)	13.41	23.02

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* and cow dung used in this study were 86.59% and 76.98%, respectively. As the result shows, both *Euphorbia tirucalli* and cow dung have high percentage of volatile solid content relative to total solid. Yet, *Euphorbia tirucalli* has higher volatile solid content than cow dung. 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.

From the experiment performed in the laboratory, a set of results were obtained that contain cumulative biogas yields for different substrate loadings. Thus, the results of biogas production from mixtures of *Euphorbia tirucalli and* cow dung are documented in Table 2.

Table 2. Volume of biogas in liter produced per 2kg of different substrate loading

Treatment		**1:10WR**	**Std**	**1:15WR**	**Std**	**1:20WR**	**Std**	**SL**
Cow dung + ET	$ETCDA_1$	28.90^{b}	0.62	23.20^{c}	0.30	9.53^{ef}	1.33	***
	$ETCDA_2$	16.20^{d}	0.60	6.00^{fgh}	0.30	2.43^{hi}	0.15	***
	$ETCDL_1$	34.43^{a}	0.42	11.97^{e}	0.06	8.17^{efg}	0.06	***
	$ETCDL_2$	27.20^{bc}	0.70	9.43^{ef}	0.35	8.00^{efg}	0.20	**
	$ETCDN_1$	12.00^{e}	0.20	6.00^{fgh}	0.20	2.17^{hi}	0.15	***
	$ETCDN_2$	4.00^{ghi}	0.20	2.00^{hi}	0.10	0.93^{i}	0.04	**

Significance level= 0.01 Replication = 3

WR = water ratio, Std = standard deviation, SL = significance level, *** = highly significance different, ** = significance different, ET = *Euphorbia tirucalli* only, $ETCDA_1$ = 75% *Euphorbia tirucalli* +25% cow dung + 300g ash, $ETCDA_2$ = 50% *Euphorbia tirucalli* + cow dung + 300g ash, $ETCDL_1$ = 75% *Euphorbia tirucalli* + 25% cow dung + 300g lime, $ETCDL_2$ = 50% *Euphorbia tirucalli* + cow dung + 300g lime, $ETCDN_1$ =75% *Euphorbia tirucalli* + 25 cow dung + 25g sodium carbonate and $ETCDN_2$ = 50% *Euphorbia tirucalli* + cow dung + 25g sodium carbonate.

There is a significant difference among the biogas generated from *Euphorbia tirucalli*, cow dung and mixtures of *Euphorbia tirucalli* and cow dung. Biogas production from 100% cow dung and mixture of the two materials (*Euphorbia tirucalli* and cow dung) were taken long period of time especially 100% cow dung stayed up to 40 days.

The biogas production from the mixtures of 75% *Euphorbia tirucalli*, and 25% cow dung and 300g ash in 1:10, 1:15, 1:20 slurry to water ratio were found 28.9, 23.2, 9.53 liters of gas, respectively. The highest biogas production was observed in 1:10 slurry to water ratio when compared with 1:15 and 1:20 slurry to water ratios. As the result

shows, there is highly significance difference between the biogas yielded from 1:10 and 1:15, and 1:10 and 1:20 slurry to water ratio. The biogas production from the mixtures of 50% *Euphorbia tirucalli*, and 50% cow dung and 300g ash in 1:10, 1:15, 1:20 slurry to water ratio were found 16.20, 6.00 and 2.43 liters respectively. The highest biogas production was observed in 1:10 slurry to water ratio when compared with 1:15 and 1:20 slurry to water ratios. As the result shows, there is highly significance difference between the biogas yielded from 1:10 and 1:15, and 1:10 and 1:20 slurry to water ratio.

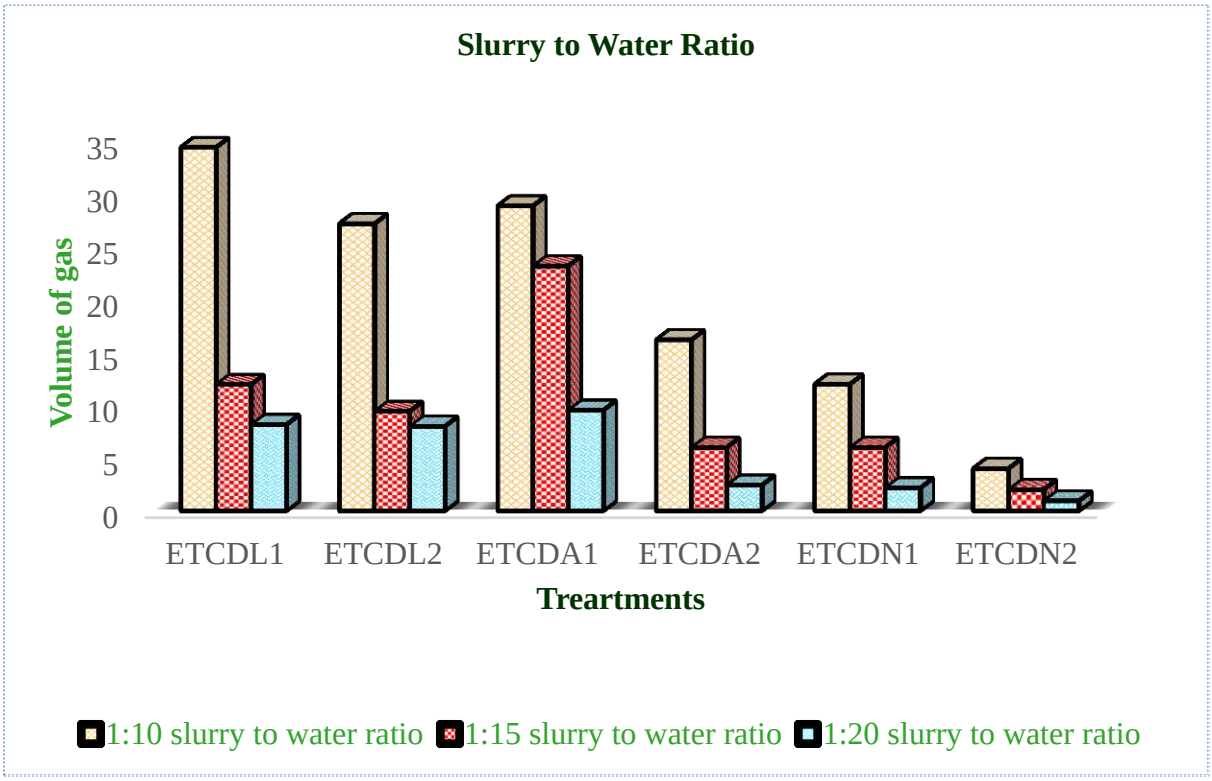
The biogas generated from the mixtures of 75% *Euphorbia tirucalli*, 25% and cow dung with 300g lime in 1:10, 1:15 and 1:20 slurry to water ratio were found 34.43, 11.97 and 8.17 liters, respectively. This indicated that the highest biogas production was recorded in 1:10 slurry to water ratio with 300g ash as compared with 1:15 and 1:20 slurry to water ratios. As the result shows, there is highly significant difference between the biogas produced from 1:10, 1:15 and 1:20 slurry to water ratio with 300g lime

The biogas generated from the mixtures of 50% *Euphorbia tirucalli and* 50% cow dung with 300g lime in 1:10, 1:15, 1:20 slurry to water ratio were attained 27.20, 9.43 and 8.00 liters, respectively. As the result indicated, the higher biogas yield were observed in 1:10 slurry to water ratio with 300g lime when compare with 1:15 and 1:20 slurry to water ratios. There is a significant difference between the values of 27.20 and 9.43, and 27.20 and 8.00 produced from 1:10 and 1:15, and 1:10 and 1:20 slurry to water ratio, respectively. But, there is no a significant difference with the values of 9.43 and 8.00 liters of biogas yielded from the mixture of 50% *Euphorbia tirucalli* and 50% cow dung in 1:15 and 1:20 slurry to water ratio, respectively with 300g lime.

The biogas production from the mixtures of 75% *Euphorbia tirucalli* and 25% cow dung with 25g sodium carbonate in 1:10, 1:15 and 1:20 slurry to water ratio were found 12.00, 6.00 and 2.17 liters, respectively. As the result shows, the highest biogas produced was achieved in 1:10 slurry to water ratio as compared with 1:15 and 1:20 slurry to water ratios. There is highly significant difference between the values of 12.00, 6.00 and 2.17 liters, respectively produced from 1:10, 1:15 and 1:20 slurry to water ratio.

The biogas production from the mixtures of 50% *Euphorbia tirucalli* and 50% cow dung with 25g sodium carbonate in 1:10, 1:15 and 1:20 slurry to water ratio were gained 4.00, 2.00 and 0.93 liters, respectively. As the result indicated, there is a significant difference between the values of 4.00 and 0.93 liters of biogas yield from the mixture of 50% *Euphorbia tirucalli* and 50% cow dung in 1:10 and 1:20 slurry to water ratio, respectively.

Figure 1. Volume of biogas in liter produced per 2kg different mixtures of substrate loading



Biogas production was slightly slow at the beginning and the end period of observation in the substrates of mixtures of Euphorbia tirucalli and cow dung. This is predicted because biogas production rate in batch condition is directly proportional to specific growth rate of methanogenic bacteria in the biodigester. Comparing with the 100% cow dung, the mixing *Euphorbia tirucalli* and cow dung generally increased biogas yield except the pure *Euphorbia tirucalli*.

CONCLUSION

From the experiment performed in the laboratory, a cumulative biogas yields were obtained from different substrate loadings. 75% *Euphorbia tirucalli* and 25% cow dung with 300g of lime produce high biogas in 1:10 slurry to water ratio. This indicated as substrate and moisture effects. Due to cow dung has high lignin content which is low soluble parts and ash has mineral effects may be harmed to the important microorganism to generate biogas. Pure cow dung was failed to produce any significant amount of biogas. Because ruminants extract much of the nutrients from the forage and the leftover is rich in lignin complexes.

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, 75%

Euphorbia tirucalli and 25% cow dung with 300g lime in 1:10 slurry to water ratio is more preferable for growth of microbial activities and generation of biogas. This is economically very important to produce sufficient amount of biogas to solve energy deficiency of the country.

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REFERENCE

[1] Emilia, S. R., 2009. Biogas composition and upgrading to biomethane, Jayvaskyla: University of Jayvaskyla, pp. 76.

[2] Ilaboya, I.R., F.F. Asekhame, M.O. Ezugwu, A.A. Erameh and F.E. Omofuma, 2010. Studies on Biogas Generation from Agricultural Waste; Analysis of the Effects of Alkaline on Gas Generation, World Applied Sciences Journal, Igbinedion University Okada, Nigeria, 9 (5): 537-545.

[3] Omolola A. M., 2007. Anaerobic digestion of ethanol distillery waste-stillage for biogas production, thesis research report in fulfilment of the award of M.Sc chemical engineering, University College of Boras School of engineering, Sweden.

[4] Uchida, H., K. Ohyama, M. Suzuki, H. Yamashita,T. Muranaka and K. Ohyama, 2010. Triterpenoid levels are reduced during Euphorbia tirucalli L. callus formation, Plant Biotechnology, Tokyo, Japan. 27, 105–109.

[5] http://www.worldagroforestry.org/treedb2/AFTPDFS/Euphorbia_tirucalli. Accessed 20 March 2011.

[6] Harikishan S. Sung S. 2003. Cattle waste treatment and class-A biosolid production using temperature phased anaerobic digester. Advances in Environmental Research. 7: 701-706.

[7] Li R., Chen S. and Li X., 2009. Anaerobic co-digestion of kitchen waste and cattle manure for methane production. Energy Sources. 31: 1848-1856.

[8] Lopes W. S., Leite V. D. and Prasad S. 2004. Influence of inoculum on performance of anaerobic reactors for treating municipal solid waste. Bioresource Technology. 94: 261-266.

[9] Callaghan F.J., Wase D.A.J., Thayanithy K., Forste C.F., 1999. Co-digestion of waste organic solids: batch studies. Bioresource Technology, 67: 117–122.

[10] Gelegenis J., Georgakakis D., Angelidak I., Marris V., 2007. Optimization of biogas production by co-digesting whey with diluted poultry manure. Renewable Energy, 32: 2147–2160.

[11] Chellapandi P., Prabaharan D., Uma L., 2008. A preliminary study on co-digestion of ossein industry waste for methane production. EurAsian Journal of BioSciences, 2: 110–114.

[12] Azene Bekele-Tesemma, 2007. Useful trees and shrubs of Ethiopia: identification, propagation and management for 17 agro-climatic zones; Technical manual number 6. World agro-forestry center.