Comparison of Sodium carbonate, Lime and Ash effects on Biogas Production

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Abstract - The study was conducted to evaluate biogas production from three batch digesters containing Euphorbia tirucalli and different chemicals. Biogas production from Euphorbia tirucalli with 600g ash in 1:10, 1:15 and 1:20 Euphorbia tirucalli to water ratio was attained 49.23, 27.20 and 14.13 liters, respectively. The production potential of Euphorbia tirucalli with 300 g lime in 1:10, 1:15 and 1:20 Euphorbia tirucalli to water ratio were 41.72, 29.57 and 9.77 liters, respectively. The yields of biogas from Euphorbia tirucalli with 25g Na2CO3 in 1:10, 1:15 and 1:20 Euphorbia tirucalli to water ratio were 20.33, 11.17 and 4.20 liters, respectively. There is highly significant difference among the biogas generated from Euphorbia tirucalli with 600 g ash, Euphorbia tirucalli with 300 g lime, Euphorbia tirucalli with 25g sodium carbonate in 1:10 slurry to water ratio. There is no significant difference among the treatments of Euphorbia tirucalli with 600g ash and Euphorbia tirucalli with 300g lime in 1:15 Euphorbia tirucalli to water ratio. Generating biogas from Euphorbia tirucalli is economically very significant to produce sufficient amount of biogas to solve energy deficiency.

Keywords: Biogas, Chemicals, Deficiency, Economically, Energy, Euphorbia tirucalli, yield

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I. 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 emission 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, 3, 4, 5 and 6].

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[7].

Euphorbia tirucalli is a type of Euphorbiaceae plant species. It is relatively easy to grow in different soil types, under diversified conditions, and does not require special management practices. This plant also 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 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 17,600kJ/kg [8]. So, *Euphorbia tirucalli* can uses for biogas generating using anaerobic digestion. The biogas produced can be used as a source of renewable energy and the residue can be used as a soil conditioner (fertilizer)[9,10, 11, 12 and 13].

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 natural *Euphorbia tirucalli* in the form of biogas. Because this plant is found in most part of the country specifically in Wollo, Gojam, Gonder, Shoa, Tigray, Harerge, Sidamo, Gamo gofa, Ilubabor and Bale [14]. The energy sources from *Euphorbia tirucalli* in the form of biogas 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. Therefore, this study was conducted to evaluate the amounts of biogas from *euphorbia tirucalli* using sodium carbonate, lime and ash.

II. 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, Amhara Region, Ethiopia. It is about 770kms northeast of Addis Ababa and about 200kms 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 Woreda ranges from 750m to 2800m above sea level with highest and lowest temperature of 27°C and 13°C, respectively. The rainfall ranges in mean annual amount between 900mm to 1000mm. The experiment was done in Bahir Dar and Haromaya University.

Sample collection

20 types of grab sample from *Euphorbia tirucalli* were 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 were 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 using SAS (statistical analysis software 2004).

Materials and Chemicals

drums of different volumes, plastic containers, graduated cylinders of different volumes, electronic balance, digital pH meter, Plastic bags, get valve, rubber tube, vacuum pump machine, mixer grinder, Na_2CO_3, ash and lime are the materials and chemicals used during the experiment.

Experimental Design

The experiment was conducted by using two factorial complete randomized designs (chemicals and water level) with three replications. The experimental design for the anaerobic digestion of Euphorbia tirucalli were carried out at ambient temperature in 3 batch digesters labeled A–C as follow:

- Digester A: comprise *Euphorbia tirucalli* with 600g ash
- Digester B: comprise *Euphorbia tirucalli* with 300g lime
- Digester C : comprise *Euphorbia tirucalli* with 25g sodium carbonate

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.

III. RESULT AND DISCUSSION

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 *Euphorbia tirucalli* with addition of chemicals were present in Table 1.

Table 1. Volume of biogas in liter produced per 2kg of slurry with different chemicals

Treatment	1:10WR	Std	1:15WR	Std	1:20WR	Std	SL
ETA + 600g ash	49.23^{a}	0.74	27.20^{c}	0.10	14.13^{e}	0.21	***
ETL + 300g lime	41.72^{b}	1.63	29.57^{c}	0.93	9.77^{ef}	0.42	***
ETN + 25g Na_2CO_3	20.33^{d}	0.68	11.17^{e}	0.15	4.20^{f}	0.19	***
Significance level= 0.01					Replication = 3		

WR = water ratio, Std = standard deviation, SL = significance level, *** = highly significance different, ** = significance different, ETA = *Euphorbia tirucalli* + 600g ash, ETL = *Euphorbia tirucalli* + 300g lime, ETN = *Euphorbia tirucalli* + 25g sodium carbonate,Duncan Grouping

In this study, biogas production from *Euphorbia tirucalli* with 600g ash in 1:10, 1:15 and 1:20 *Euphorbia tirucalli* to water ratio were 49.23, 27.20 and 14.13 liters, respectively. 1:10 *Euphorbia tirucalli* to water ratio with 600g ash has the highest biogas production potential, that is, 49.23 liter when compared with 1:15 and 1:20 *Euphorbia tirucalli* to water ratios. There is highly significance difference among the biogas production from 1:10, 1:15 and 1:20 *Euphorbia tirucalli* to water ratio. The difference is due to the dilution and concentration effect of the slurry.

Biogas production from *Euphorbia tirucalli* with 300 g lime in 1:10, 1:15 and 1:20 *Euphorbia tirucalli* to water ratio have a production potential of 41.72, 29.57 and 9.77 liters, respectively. The highest biogas production was observed in 1:10 *Euphorbia tirucalli* to water ratio with 300 g lime. In general, there is highly significant difference among the biogas production from 1:10, 1:15 and 1:20 *Euphorbia tirucalli* to water ratio with 300g lime.

The yield of biogas from *Euphorbia tirucalli* with 25g Na_2CO_3 in 1:10, 1:15 and 1:20 *Euphorbia tirucalli* to water ratio was 20.33, 11.17 and 4.20 liters, respectively. As shown in this result, the highest biogas production was observed in 1:10 *Euphorbia tirucalli* to water ratio when compared with 1:15 and 1:20 *Euphorbia tirucalli* to water ratios with 25 g Na_2CO_3. As the result indicated, there is highly significance difference among the biogas production from 1:10, 1:15 and 1:20 *Euphorbia tirucalli* to water ratio with 25g Na_2CO_3.

There is highly significant difference among the biogas generated from *Euphorbia tirucalli* with 600 g ash, *Euphorbia tirucalli* with 300 g lime, *Euphorbia tirucalli* with 25g sodium carbonate in 1:10 *Euphorbia tirucalli* to water ratio. The difference is due to the chemical effects.

There is no significant difference among the treatments of *Euphorbia tirucalli* with 600g ash and *Euphorbia tirucalli* with 300g lime in 1:15 *Euphorbia tirucalli* to water ratio. This is due to the dilution of the slurry. Because excess water in the feedstock leads to a fall in the rate of production per unit volume of feedstock and on the other hand, inadequate water leads to an accumulation of acetic acids which inhibit the digestion process and hence production.

IV. CONCLUSION AND RECOMMENDATION

From the data gathered during this work showed that biogas production from *Euphorbia tirucalli* with 600g ash in 1:10 *Euphorbia tirucalli* to water ratio was yielded 49.23, which is the highest biogas production. There is highly significant difference among the biogas generated from *Euphorbia tirucalli* with 600 g ash, *Euphorbia tirucalli* with 300 g lime, *Euphorbia tirucalli* with 25g sodium carbonate in 1:10 *Euphorbia tirucalli* to water ratio. The difference is due to the chemical effects and moisture contents of the slurry. Therefore, control of those factors determines the quality and quantity of biogas produced.

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* due to economically preferable.

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