# EVALUATION OF COW DUNG AND TALINUM TRIANGULARE AS A SEEDING AGENT FOR THE PRODUCTION OF BIOGAS FROM DOMESTIC WASTES IN WARRI METROPOLIS

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**Abstract:**
The evaluation of cow dung and talinum triangulare (water leaf) as a seeding agent for the production of biogas from organic domestic wastes was conducted in Warri metropolis, Nigeria. The experiments were conducted within a period of thirty seven days in a steel bio-digester. The biogas produced was dried, purified and transferred into a commercially available 7.5Kg gas cylinder using a compressor. The results obtained showed that the domestic wastes seeded with cow-dung and talinum triangulare produced 2.1Kg and 2.2Kg of biogas respectively. Overall, from the result obtained with cow-dung and talinum triangulare, it can be seen that talinum triangulare is as good as cow-dung and can be used as a substitute for cow dung (since it is readily available) in Warri metropolis, Nigeria.

**Keywords:** Cow-dung, Domestic wastes, Talinum triangulare, Seeding agent, Warri metropolis.

## 1. INTRODUCTION

The demand for energy in Nigeria has led to deforestation and excessive exploitation of crude oil that are not environmental friendly. There is need for the adoption of technologies that promote renewable energy and the conversion of organic wastes to biogas is a reliable option in this regard. The biogas technology is one of such systems and has been found to be cost effective and environmentally friendly (Brown, 2003). Biogas is a potential fuel and can be produced through an anaerobic digestion of organic material, such as biomass, municipal waste and sewage (Authayanun et al., 2013; Adeyosoye et. al., 2010). Biogas mainly consists of methane and carbon dioxide together with smaller amounts of other gases and vapours, such as hydrogen, nitrogen and hydrogen sulphide ($H_2S$) (Makaruk et al., 2010). The main component of biogas is methane; other combustible hydrocarbons of biogas do not contribute much to the calorific value of the gas (Hansson et al., 2002). Biogas is an odourless and colourless gas that burns with blue flame similar to LPG gas (EREC,1997) and has ignition temperature in range of $650^0$C to $750^0$C (FAO/CMS, 1996).

Seeding is an important factor that enhances biogas production. It has been shown that after feeding the digester with freshly prepared slurry, it takes some days before it starts producing gas. But when seeded, gas production starts immediately (Liu, 2003). The quality of biogas generated by organic waste materials does not remain constant but varies with the period of digestion (Khandewal and Mahdi, 1986). Practice shows that the gas yield with the highest seeding amount is eleven times more than the one with lowest amount of seeding material (Yadava and Hcssc, 1981). Outside seeding, other key operating factors which have a direct influence on the level and efficiency of biogas production include volatile solids loading rate, digester temperature, hydraulic retention time, pH and carbon/nitrogen ratio (Vetter et al., 1990). Song et al., (2004) pointed out that there are two conventional operational temperature levels for anaerobic digesters and these are determined by the species of methanogens inside the digester. These are mesophilic (i.e. $20^0$C-$45^0$C) with optimal performance around $36^0$C-$41^0$C and thermophilic which takes place at higher temperatures up to $70^0$C, although optimal digester performance is around $50^0$C-$52^0$C. According to Martin (2007) the methanogens involved in the biological process of methanogenesis which is the terminal stage of anaerobic digestion require a neutral or mildly alkaline environment, as a too acidic or too alkaline environment will be detrimental. FAO/CMS (1996) reported pH between 6.5 and 8 as best for methanogenesis. The pH value for a digester depends on the ratio of acidity and alkalinity and the carbon dioxide content in the digester. The determining factor being the density of the acids. The hydraulic retention time (HRT) in anaerobic digesters is determined by calculating the number of days required for displacement of the fluid volume of the culture. The retention time is also dependent on all the factors discussed above. Generally a retention time of between 30 and 45 days and in some cases 60 days is enough for substantial gas production (Clanton et al., 1985; Carcelon and Clark, 2002).

Imoh and Julia (2001) reported that talinum triangulare contains 81.9% of water, 14% of flavonoid, 3.4% of saponion, tannis 0.26% and traces of other nutrients 0.17%. The 81.9% of water suggests that talinum triangulare will be a good seeding agent to initiate the first process of digestion (Hydrolysis). Talinum triangulare (water leaf) is a common vegetable grown in Warri metroplolis and Sourthern Nigeria. It require rainy season to grow, however due to minimal dry season experienced in Warri metropolis, talinum triangulare can be grown all year around with less effort in watering. Talinum triangulare is propagated by seeds though in Warri metropolis/Southern Nigeria it can equally grow on its own and harvesting is all year. This makes it economically feasible a reliable seeding agent.

IEA (2005) reported that cow manure is an excellent substrate for the production of biogas when co-digested with other kinds of waste materials such as organic industrial waste, household waste and sewage sludge though its methane yield as a single substrate is low. But due to its high water content and high fraction of fiber, methane yield is low especially when used as the only substrate (Angelidaki and Ellegaard, 2003). However, cow manure serves as an excellent "carrier" substrate during the mixed digestion of wastes and allows anaerobic digestion of concentrated industrial waste, which would be difficult to treat separately. This suitability of manure to be used as "carrier" substrate is because of; its high water content, which act as solvent for dry waste materials, its high buffering capacity that regulate the optimum pH in the reactor, and the high level of nutrient, a requirement for optimal bacteria growth. Anaerobic digestion of cow manure gives approximately 63% of biogas. The advantages of co-digesting animal manure together with other kinds of waste materials have been reported in different research studies. Angelidaki and Ellegaard, 2003 also reported the increase in biogas yield due to co-digestion of cattle manure together with waste materials in anaerobic digestion process. With all these advantages there is still set back in using of cow-dung as a seeding agent because of the low quantities generated in Nigeria.

This paper is aimed at studying the performance evaluation of cow-dung and talinum triangulare as a seeding agent for biogas production. The objective of the work was to evaluate the biogas production potential from domestic wastes seeded with cow-dung manure and domestic wastes seeded with talinum triangulare.

**MATERIALS AND METHODS**

The digester and its accessories were: steel bio-digester, compressor, gas bottle, scrubber, thermometer, a plastic bucket, manometer, connecting hoses and weighing scale. The digester unit is made up of thin wall steel cylinder measuring 140mm x 395mm x 5mm. The scrubber is also a thin wall steel cylinder measuring 150mm x 400mm x 5mm. Iron filling and quicklime were used as the reagent in the scrubber unit. The gas bottle is 7.5kg in size and it carried a pressure gauge and inlet valve. The pressure gauge gives the actual pressure of the stored gas. Domestic wastes, cow-dung and talinum triangulare (water leaf) served as substrates. 25Kg of domestic wastes was measured into two different places (Sample 1&2); cut into pieces with knife to increase its surface area, 5Kg of talinum triangulare cut into pieces was mixed with the 25Kg (sample 1) of domestic wastes. Also 5Kg of cow-dung was mixed with 25Kg (sample 2) of domestic wastes. Both sample 1 & sample 2 were properly mixed with water and charged into steel bio-digester for

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anaerobic digestion to take place. The gas produced was properly purified. Quicklime was used to remove water and carbon dioxide while the Iron fillings were used to remove hydrogen sulphide.

## RESULTS AND DISCUSSION

The results obtained in charging sample 1 and sample 2 in the bio-steel digester is shown in Table 3.1 and Table 3.2

**Table 3.1: Results of Sample 1**

| S/N | Day | Time | Temp | $P_G$ | $P_{(mH20)}$ | Remark |
|---|---|---|---|---|---|---|
| **1** | 1 | 11.30am | 25$^0$C | - | - | No gas |
| **2** | 1 | 5.00pm | 28$^0$C | - | -1.3cm | No gas |
| **3** | 2 | 6.20am | 26$^0$C | - | 1.0cm | No gas |
| **4** | 2 | 5.00pm | 32$^0$C | - | 0.01cm | No gas |
| **5** | 3 | 6.20am | 25$^0$C | 5 mmHg | - | No flame |
| **6** | 3 | 4.30pm | 28$^0$C | 10mmHg | - | No flame |
| **7** | 4 | 7.00am | 27$^0$C | 8 mmHg | - | Yellow flame |
| **8** | 4 | 5.10pm | 32$^0$C | 15mmHg | - | Yellow flame |
| **9** | 5 | 6.10am | 28$^0$C | 10mmHg | - | Yellow flame |
| **10** | 5 | 4.00pm | 33$^0$C | 18mmHg | - | Yellow flame |
| **11** | 6 | 6.40am | 28$^0$C | 12mmHg | - | Blue flame |
| **12** | 6 | 4.50pm | 36$^0$C | 28mmHg | - | Blue flame |
| **13** | 7 | 6.25am | 28$^0$C | 20mmHg | - | Blue flame |
| **14** | 7 | 4.10pm | 36$^0$C | 35mmHg | - | Blue flame |
| **15** | 8 | 6.40pm | 28$^0$C | 25mmHg | - | Blue flame |
| **16** | 8 | 4.30pm | 36$^0$C | 50mmHg | - | Blue flame |
| **FIRST: EVACUATION** | | | | | | |
| **17** | 9 | 4.00pm | 30$^0$C | 25mmHg | - | Blue flame |
| **18** | 10 | 4.30pm | 36$^0$C | 40mmHg | - | Blue flame |
| **19** | 11 | 4.20pm | 37$^0$C | 50mmHg | - | Blue flame |
| **20** | 12 | 4.10pm | 36$^0$C | 48mmHg | - | Blue flame |
| **SECOND: EVACUATION** | | | | | | |
| **21** | 13 | 4.00pm | 35$^0$C | 25mmHg | - | Blue flame |
| **22** | 14 | 4.10pm | 36$^0$C | 30mmHg | - | Blue flame |
| **23** | 15 | 3.40pm | 37$^0$C | 45mmHg | - | Blue flame |
| **24** | 16 | 4.00pm | 36$^0$C | 50mmHg | - | Blue flame |
| **25** | 17 | 4.20pm | 36$^0$C | 49mmHg | - | Blue flame |
| **THIRD: EVACUATION** | | | | | | |
| **26** | 18 | 3.10PM | 35$^0$C | 28mmHg | - | Blue flame |
| **27** | 19 | 4.00PM | 36$^0$C | 35mmHg | - | Blue flame |
| **28** | 20 | 4.20PM | 36$^0$C | 38mmHg | - | Blue flame |
| **29** | 21 | 4.30PM | 36$^0$C | 43mmHg | - | Blue flame |
| **30** | 22 | 4.40PM | 37$^0$C | 38mmHg | - | Blue flame |
| **FOURTH: EVACUATION** | | | | | | |
| **31** | 23 | 4.20pm | 32$^0$C | 28mmHg | - | Blue flame |
| **32** | 24 | 4.25pm | 36$^0$C | 35mmHg | - | Blue flame |
| **33** | 25 | 4.10pm | 37$^0$C | 50mmHg | - | Blue flame |
| **34** | 26 | 4.20pm | 37$^0$C | 52mmHg | - | Blue flame |

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|---|---|---|---|---|---|---|
| **35** | 27 | 4.00pm | $37^{0}C$ | 50mmHg | - | Blue flame |
| **36** | 28 | 4.20pm | $36^{0}C$ | 48mmHg | - | Blue flame |
| **FIFTH: EVACUATION** | | | | | | |
| **37** | 29 | 4.00pm | $38^{0}C$ | 28mmHg | - | Blue flame |
| **38** | 30 | 6.40am | $28^{0}C$ | 20mmHg | - | Blue flame |
| **39** | 31 | 4.50pm | $36^{0}C$ | 35mmHg | - | Blue flame |
| **40** | 32 | 6.25am | $28^{0}C$ | 25mmHg | - | Blue flame |
| **41** | 33 | 4.10pm | $40^{0}C$ | 24mmHg | - | Blue flame |

**Table 3.2: Results of Sample 2**

| **S/N** | **Day** | **Time** | **Temp** | $P_G$ | $P_{(mH20)}$ | **Remark** |
|---|---|---|---|---|---|---|
| **1** | 1 | 12.25m | $28^{0}C$ | - | -1.4cm | No gas |
| **2** | 1 | 7.20pm | $30^{0}C$ | - | 1.00cm | No gas |
| **3** | 2 | 6.30am | $26^{0}C$ | - | 1.15cm | No gas |
| **4** | 2 | 4.30pm | $28^{0}C$ | - | 1.6cm | No gas |
| **5** | 3 | 6.25am | $25^{0}C$ | 10mmHg | - | No flame |
| **6** | 3 | 5.00pm | $30^{0}C$ | 20mmHg | - | Yellow flame |
| **7** | 4 | 6.30am | $28^{0}C$ | 15mmHg | - | Yellow flame |
| **8** | 4 | 5.20pm | $32^{0}C$ | 25mmHg | - | Yellow flame |
| **9** | 5 | 6.20am | $30^{0}C$ | 25mmHg | - | Blue flame |
| **10** | 5 | 6.00pm | $30^{0}C$ | 27mmHg | - | Blue flame |
| **11** | 6 | 6.30am | $25^{0}C$ | 28mmHg | - | Blue flame |
| **12** | 6 | 6.00pm | $32^{0}C$ | 30mmHg | - | Blue flame |
| **13** | 7 | 6.10am | $26^{0}C$ | 28mmHg | - | Blue flame |
| **14** | 7 | 5.00pm | $33^{0}C$ | 40mmHg | - | Blue flame |
| **15** | 8 | 6.25am | $27^{0}C$ | 35mmHg | - | Blue flame |
| **16** | 8 | 6.00pm | $35^{0}C$ | 50mmHg | - | Blue flame |
| **FIRST: EVACUATION** | | | | | | |
| **17** | 9 | 6.20am | $25^{0}C$ | 28mmHg | - | Blue flame |
| **18** | 9 | 6.00pm | $30^{0}C$ | 35mmHg | - | Blue flame |
| **19** | 10 | 6.00am | $28^{0}C$ | 30mmHg | - | Blue flame |
| **20** | 10 | 5.00pm | $35^{0}C$ | 48mmHg | - | Blue flame |
| **21** | 11 | 6.25am | $25^{0}C$ | 28mmHg | - | Blue flame |
| **22** | 11 | 5.00pm | $35^{0}C$ | 50mmHg | - | Blue flame |
| **SECOND: EVACUATION** | | | | | | |
| **23** | 12 | 6.40am | $28^{0}C$ | 28mmHg | - | Blue flame |
| **24** | 12 | 5.30pm | $32^{0}C$ | 32mmHg | - | Blue flame |
| **25** | 13 | 6.30am | $27^{0}C$ | 30mmHg | - | Blue flame |
| **26** | 13 | 5.40am | $32^{0}C$ | 40mmHg | - | Blue flame |

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|---|---|---|---|---|---|---|
| **27** | 14 | 6.20am | $28^{0}$C | 35mmHg | - | Blue flame |
| **28** | 14 | 6.20pm | $34^{0}$C | 52mmHg | | Blue flame |
| **THIRD: EVACUATION** | | | | | | |
| **29** | 15 | 3.10pm | $25^{0}$C | 28mmHg | - | Blue flame |
| **30** | 16 | 6.00am | $30^{0}$C | 43mmHg | - | Blue flame |
| **31** | 17 | 4.20pm | $28^{0}$C | 40mmHg | - | Blue flame |
| **32** | 18 | 6.10am | $35^{0}$C | 48mmHg | - | Blue flame |
| **33** | 19 | 6.20am | $30^{0}$C | 40mmHg | - | Blue flame |
| **34** | 20 | 6.00am | $33^{0}$C | 45mmHg | - | Blue flame |
| **35** | 20 | 5.40pm | $35^{0}$C | 50mmHg | - | Blue flame |
| **FOURTH: EVACUATION** | | | | | | |
| **36** | 21 | 6.00am | $25^{0}$C | 28mmHg | - | Blue flame |
| **37** | 21 | 6.20pm | $30^{0}$C | 35mmHg | - | Blue flame |
| **38** | 22 | 6.00pm | $30^{0}$C | 40mmHg | - | Blue flame |
| **39** | 23 | 6.00pm | $28^{0}$C | 42mmHg | - | Blue flame |
| **40** | 24 | 6.00pm | $30^{0}$C | 40mmHg | - | Blue flame |
| **FIFTH: EVACUATION** | | | | | | |
| **41** | 25 | 6.40am | $28^{0}$C | 28mmHg | - | Blue flame |
| **42** | 26 | 5.30pm | $32^{0}$C | 43mmHg | - | Blue flame |
| **43** | 27 | 6.30am | $25^{0}$C | 40mmHg | - | Blue flame |
| **44** | 28 | 5.40am | $30^{0}$C | 48mmHg | - | Blue flame |
| **45** | 29 | 6.20am | $28^{0}$C | 46mmHg | - | Blue flame |
| **46** | 30 | 6.20pm | $34^{0}$C | 42mmHg | - | Blue flame |
| **SIXTH:3 EVACUATION** | | | | | | |
| **47** | 31 | 6.00am | $25^{0}$C | 28mmHg | - | Blue flame |
| **48** | 32 | 6.20pm | $30^{0}$C | 35mmHg | - | Blue flame |
| **49** | 33 | 6.00pm | $30^{0}$C | 40mmHg | - | Blue flame |
| **50** | 34 | 6.00pm | $28^{0}$C | 42mmHg | - | Blue flame |
| **51** | 35 | 6.00pm | $30^{0}$C | 40mmHg | - | Blue flame |
| **52** | 36 | 6.00pm | $28^{0}$C | 38mmHg | - | Blue flame |
| **53** | 37 | 6.00pm | $30^{0}$C | 28mmHg | - | Blue flame |

Results of sample 1 and sample 2 shown that both domestic wastes seeded with cow-dung and talinum triangulare started yielding in day 5 and also stopped at about the same time (i.e. day 33 and 37 respectively). Domestic wastes seeded with talinum triangulare covered a period of 27 days for production while domestic wastes seeded with cow-dung covered a period of 32 days (Table 3.1 and Table 3.2). Therefore both covered almost the same period of production though domestic wastes seeded with cow-dung last longer with a period of five days. This implies that domestic wastes seeded with talinum triangulare digested faster. At the end of production domestic wastes seeded with talinum triangulare produced 2.2Kg of biogas when compared to 2.1Kg of biogas produced by domestic wastes seeded with cow-dung. Therefore a domestic waste with talinum triangulare is a better option. After evacuation, the rate of production is observed to increase rapidly. It can be observed that after the first and second evacuation, successive evacuation was frquent. This implies that evacuation is necessary once the pressure had build up to a reasonable level (50mmHg).

## 4. CONCLUSION

As indicated in Table 3.1 and 3.2, it may take up to three or four day evacuations to fill the gas bottle reasonably enough to be used for cooking. At this time the quantity of biogas collected can be used by a family of four for average cooking rate of fourteen (14) days. The only remarkable difference between sample 1 and sample 2 is the initial period before complete combustion/blue flame can be obtained. The result of this research work showed that talinum triangulare can adequately replace cow dung as a seeding agent. Moreover when the local population of Warri metropolis, Nigeria adopts the use of talinum triangulare for the production of biogas, deforestation for firewood may reduce drastically. Since this research work succeeded in Warri metroplolis, Nigeria, it can be extended to the whole of Southern Nigeria. The resulting multiplier effect will brings about positive impart in our economic, political and social life.



## 5. RECOMMENDATION

Considering the huge economic and ecological advantages associated with the use of talinum triangulare, government should apply its policy on renewable energy (Iloeje, 2002) and intervene, promote and encourage the research and use of talinum triangulare and domestic wastes for the production of biogas for our domestic purposes.

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