Nitin A.Wankhade, Dr.S.B.Thakre A.V.Dhote, P.S.Wankhade / International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com
Vol. 2, Issue 5, September- October 2012, pp.1383-1388

# Enhancement Of Biogas From Abattoir Cow Liquor Waste With Some Agro-Industrial Wastes

Nitin A.Wankhade [1], Dr.S.B.Thakre [2] A.V.Dhote[3] and P.S.Wankhade[4]

## Abstract

**An investigation was carried out on the production of biogas from abattoir cow liquor waste (CLW) on biogas production of some agro-industrial wastes. The wastes; brewery spent grain (BS), cassava waste water (CW) and carbonated soft drink sludge (CS) were combined with definite proportions of cow liquor waste to produce biogas under anaerobic digestion for a 25 day retention period. The wastes were combined in the ratios: CLW:BS (1:1), CLW:CS (3:1) and CLW:CW (1:3). The results obtained indicated increased biogas production when BS and CW were inoculated with CLW, while it had a negative effect on CS.The mean biogas production of BS and CS were 8.72 and 8.12 L, respectively, while CW had no biogas production. When inoculated with CLW, the mean biogas production of BS increased to 24.28 L. CW experienced gas production with mean biogas yield of 8.36 L while the gas production of CS reduced to 2.84 L. The CLW:BS blend had the shortest time lag from gas production to onset of gas flammability of 7 days while CLW:CW and CLW:CS had time lag of 10 and 11 days respectively. The retention times for the CLW:CW and CLW:CS was 17 and 21 days, respectively. Overall results indicated that while the low biogas and/or flammable biogas production of brewery spent grain could be enhanced significantly in the presence of cow liquor waste. Cassava waste water which could not produce biogas could be made to be a cheap source of biogas by inoculating it with cow liquor waste.**

**Keyword:** **Agro-Industrial wastes, waste combination, flammable biogas production, biogas yield, biogas production**

## INTRODUCTION

Biogas is a mixture produced by anaerobic bacteria (acidogens and methanogens) in the presence of little or no molecular oxygen, comprises 50-70% methane, 30-40% carbon dioxide and low amount of other gases (hydrogen, ammonia, water vapor, nitrogen, hydrogen sulfide, etc). However, the composition of the mixture depends on the source of biological waste and management of digestion process (Yadav and Hesse, 1981; Wantanee and Sureelak, 2004).The effluent of this process is a residue rich in essential inorganic elements needed for healthy plant growth known as biofertilizer which when applied to the soil enriches it with no detrimental effects on the environment (Energy Commission, 1998). The methanogens that finally convert the free energy present in the organic substrate into the end product methane are obligate microbes and are very sensitive to pH and temperature changes (Hashimoto et al., 1980). Originally, anaerobic digestion occurred naturally in swamps, digestive systems of termites and ruminant animals such as cow. Cow dung is a good source of bacteria (Fulford, 1998). An inoculums is a biological active liquid or partially digested organic waste medium rich in micro-organisms (Maishanu and and Maishanu, 1998). Addition of inoculum to organic wastes in anaerobic digestion process has advantages such as establishment of anaerobic microbial flora, elimination of lag phase and hence increased biogas production and methane contents of the biogas especially where the synergy existed (Kanwar and Guleri, 1994). Different sources of inocula contain different colonies of biogas microbes and each type of colony acts upon some particular substrates most efficiently. Ramasamy et al. (1990),reported that abundant proteolytic organisms was found to be present in cow dung-fed biodigesters and other animal waste-fed digesters while Preeti et al. (1993),observed that while cow dung-fed digesters have higher amylolytic microbes, poultry-fed digesters showed higher proteolytic population. Research findings have shown that rumen liquor can be used as a seed or inoculum to optimize biogas production. Ezeonu et al. (2002) reported the use of fresh cow rumen liquor as inoculum to initiate fermentation of Brewer's spent grain biomethanation. Maishanu and Maishanu, (1998) reported that addition inoculum

**Table 1.** Physico–chemical properties of undigested brewery spent grain (BS), cassava waste water (CW) and carbonated soft drink sludge (CS).

| Parameter | BS | CW | CS |
|---|---|---|---|
| Moisture (%) | 14.10 | 93.50 | 71.35 |
| Ash (%) | 7.20 | 1.00 | 3.10 |
| Fibre (%) | 4.20 | 0.00 | 1.50 |
| Fat (%) | 7.30 | 0.70 | 3.60 |
| Crude nitrogen (%) | 1.82 | 0.21 | 0.07 |
| Crude proteins (%) | 11.38 | 1.31 | 0.44 |
| Total solids (% slurry) | 67.30 | 60.89 | 47.50 |
| Carbon (%) | 47.00 | 0.79 | 1.67 |
| C/N ratio | 25.9 | 3.80 | 23.90 |
| Carbohydrate (%) | 28.60 | 3.50 | 21.00 |
| pH | 5.00 | 3.20 | 5.60 |

to biogas digesters enhan-ced gas generation, concluding that the age of inoculum was found to be influential especially in specific gas production, cumulative gas production,retention time and percentage degradation of solid particles.In all these reports of investigation using cow dung inoculum, the inocula were prepared from cow dung mass prior to the anaerobic digestion process or collected from a digester slurry already producing flammable gas. Cow liquor waste (CLW) which is a mixture of waste water and blood from the activities of slaughtering a cow has constituted a nuisance in terms of the putrefying odour to areas where abattoirs are sighted and hence utilizing them for biogas production could be a major means of disposing the waste water and consequent source of energy generation. The agro-industrial wastes; brewery spent grain (BS) cassava waste water (CW) and carbonated soft drink sludge (CS) are readily available as a result of manufacturing activities in the country. However, thir yield of flammable biogas when subjected to anaerobic digestion is very poor. This has been attributed majorly to their low pH (acidic) (Uzodinma et al., 2007).The present study tried to investigate the effect of abattoir cow liquor waste as an inoculum on the biogas yield of these agro-industrial wastes. The cow liquor waste (CLW) was added to the agro-industrial wastes (BS, CW and CS) in the ratios of CLW:BS (1:1), CLW:CW (1:3) and CLW:CS (3:1), respectively.

## MATERIALS AND METHODS

Fresh abattoir cow liquor waste was collected from a local market in the Amravati town of Maharastra state and was used without further preparations. The brewery spent grain (BS) was collected from Amravati breweries limited while the carbonated soft drink sludge (CS) was collected from bottling company limited,Amravati.. The cassava wastewater (CW) was procured from a local garri processor at the Amravati town. The biodigesters used for the study were of 1 m3 capacity *constructed* locally at the Prof .Ram Meghe Institute of Technology and Research,Badnera. Other materials used include top loading balance (50 kg capacity, “Five goats” model no Z051599), thermometer (-10 to 110°C), pH meter (Universal Inventory Data Base), welding hose pipes, water trough, graduated plastic white buckets for measuring daily volume of gas production and a biogas burner (fabricated locally) for checking the combustibility of the gas.

### The digestion studies

The single agro-industrial wastes (BS, CW and CS) were digested separately after collection using biodigesters of capacity of 1 $m^3$ and with the combination of CLW.The CLW was added to the BS waste and water in the ratio of 1:2:2. The ratio of CLW to CW was 1:3 (no water was added to this blend which are mainly liquids) and that of CLW with CS and water were 1:1:2. The moisture contents of the agro-industrial wastes determined the waste to water ratios used for charging the digesters while the pH levels of the single wastes formed the basis for the blending ratio (pH of CW was 3.2 while BS and CS had pH of 5.00 and 5.6, respectively).The digestion for both the control and the variants were batch operated within a 25 day retention time.

### Analysis of wastes

**Proximate analysis:** Ash, moisture and fiber contents of the undigested agro-industrial wastes were determined using AOAC method of 1990. Carbon content of the undigested wastes was also carried out using Walkey and Black (1934) method. Fat, crude protein and nitrogen contents were determined using soxhlet extraction and micro-kjedhal method described in Pearson (1976). Total and volatile solids of the wastes were determined using Meynell (1982) method. Carbohydrate content of the undigested agro-waste was also determined by difference (Onwuka, 2005).

**Microbial analysis:** The total viable count (TVC), of micro-organisms in each digester during the anaerobic digestion process was carried out using Miles and Misra (1938) method as described in Okore (2004).

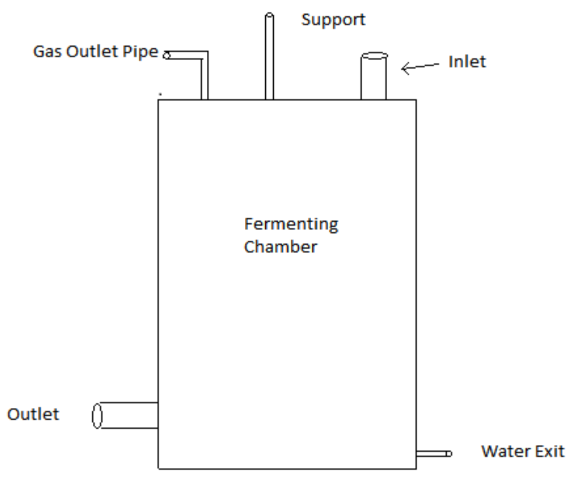


**Figure 1.** Schematic diagram of a biodigester.

## RESULTS AND DISCUSSION

The anaerobic fermentation study was investigated within the mean daily ambient temperature range of 25 to 32$^0$c and slurry temperature range of 26 to 42°C for both the control and the variants. The result of the performance of the wastes as a function of daily biogas yield for both control and the variants are shown in Figure 1.For the single wastes, the brewery spent grain (BS) commenced biogas production within 36 h while the carbonated soft drink sludge (CS) started production after 36 h post-charging period as shown on the same figure. The cassava waste water (CW) did not produce any bio- gas.This is as a result of the low pH of the system (3.2). The brewery spent grain had lag period of 22 days while the carbonated soft drink sludge had lag period of 10 days.Flammable gas production from the CS system stopped after one and half weeks. This is attributed to the drop in pH from 5.60 to 5.20 resulting to high acidity of the system.

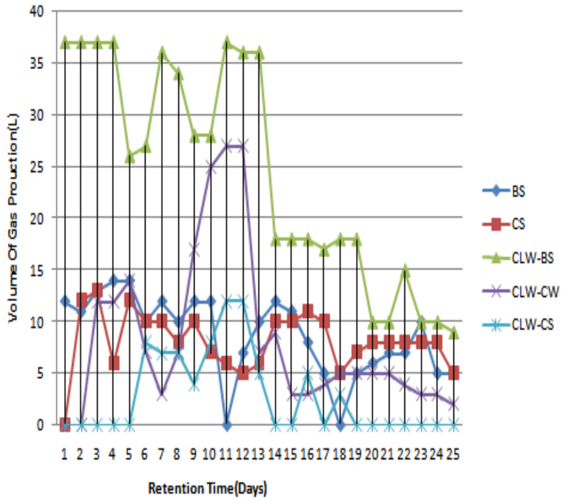


**Figure 2.** Daily biogas yield of agro-industrial wastes supplement with abattoir cow liquor. BS = brewery spent grain, CW = cassava waste water, CS = carbonated soft drink sludge, and CLW = cow liquor waste. The wastes were combined in the ratios: CLW:BS (1:1), CLW:CS (3:1) and CLW:CW (1:3).

**Table 2.** Physico-chemical properties of undigested agroindustrial wastes blended with cow liquor waste.

| Parameter | CLW:BS | CLW:CW | CLW:CS |
|---|---|---|---|
| Total solids (%) | 93.06 | 97.45 | 92.51 |
| Volatile solids (%) | 12.14 | 10.26 | 12.75 |
| Carbon (%) | 5.70 | 3.00 | 2.66 |
| Crude nitrogen (%) | 0.22 | 0.10 | 0.130 |
| Crude protein (%) | 1.38 | 0.63 | 0.813 |
| C/N ratio | 26.00 | 30.00 | 20.50 |
| pH | 6.43 | 4.57 | 6.50 |

BS = brewery spent grain, CW = cassava waste water, CS = carbonated soft drink sludge, and CLW = cow liquor waste. The wastes were combined in the ratios: CLW:BS (1:1), CLW:CS (3:1) and CLW:CW (1:3).

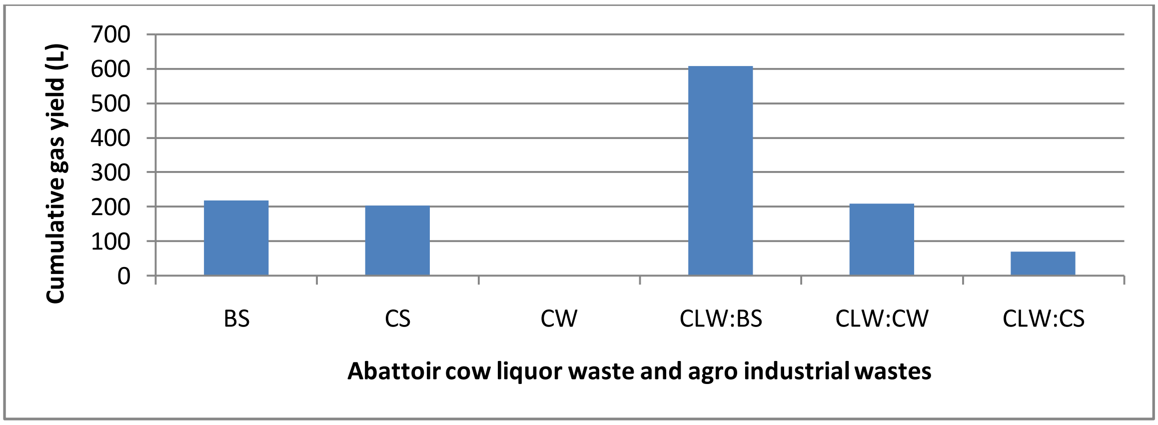


**Figure 3**.Cumulative gas yield from abattoir liquor waste and agro industrial wastes

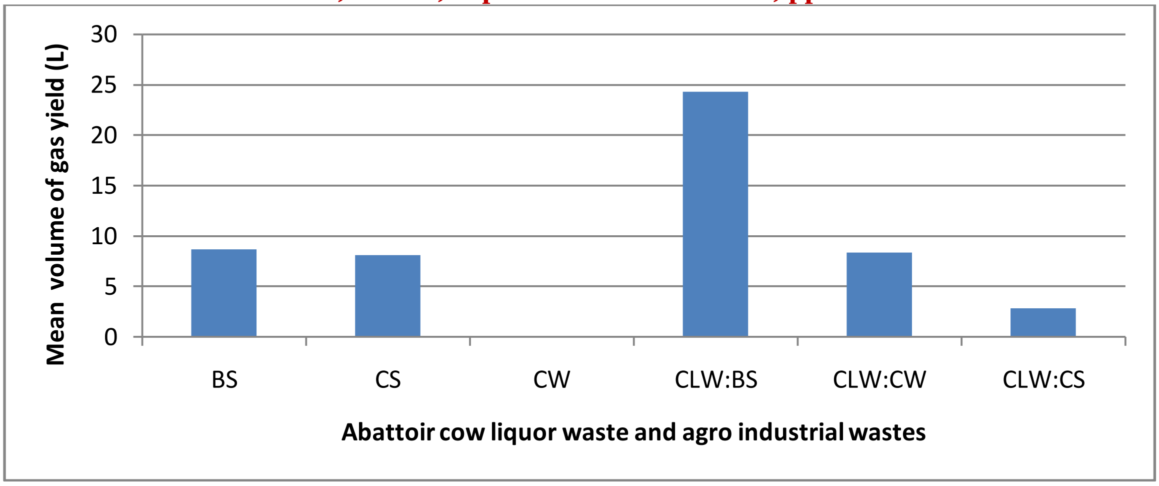


**Figure 4.**Mean volume of gas yield from abattoir cow liquor waste and agro industrial wastes

The mean volume and cumulative biogas yield of the systems used for the control is shown in Table 3 and figure 3 and 4.The CS system stopped flammable gas production due to unfavorable environment for the methane producing bacteria. The methanogens are slow growth obligate anaerobes that are highly pH sensitive and survive optimally within the pH range of 6.5 to 7.5 and in some instances up to 8.5 (FAO/CMS, 1996). The pH of a digester system is a function of the volatile fatty acid concentration, bicarbonate alkalinity of the system and amount of CO2 produced (Chawla, 1986). Research report of Sahota and Singh (1996) indicated that gas production was significantly affected when pH of slurry decreased to 5.0 due to reduction in methanogenic activity of the digester system. Their observation supported the trend that was obtained in this study for the CS digester system. Blending the CS waste with the CLW having a pH of 8.10significantly improved the pH (6.5) to enable the anaerobic digestion to take place (Table 2). For the waste blends, gas production commenced within 36 h of charging CLW:BS while CLW:CW blend started gas production after 48 h and CLW:CS blend commenced gas production 5 days post charging period. The blending of CLW with CS was expected to reduce the lag period since the pH was increased from 5.60 to 6.5. The lag period for BS, CW and CS blended systems were 7,10 and 9 days respectively,while their cumulative biogas yields are as shown in Table 3. The CLW:BS blend had the shortest lag period with highest amount of cumulative gas volume (Table 3). The apparent good performance of CLW:BS blend during the anaerobic digestion could be accounted for by the results of the physico-chemical properties (Table 2). Those properties such as volatile solids (which are the biodegradable portion of the waste), carbon to nitrogen ratio (C/N ratio) and pH at charging (6.43) were high enough for the bioactive microbes to start the digestion process. Carbon and nitrogen source affect the growth of micro-organisms and consequently biogas production. Table 4 also shows that the total via-ble microbial count was the highest for that blend during the digestion period. The C/N ratio of the CLW:BS and CLW:CW was at the upper limit of the optimum C/N ratio suggested by (Kanu, 1988; Anonymous, 1989), to be in the range of 20 to 30:1. The CLW:CW undigested waste blend had lower carbon content and the lowest pH at the point of charging which may have contributed to the lower value of cumulative gas yield and shorter retention time. This system produced flammable gas on the 9th day of the digestion period and was at the peak by the 10th to 12$^{th}$ day after which flammable gas production stopped from 15th day (Figure 2).There was consequent reduction in volume of biogas yield (at pH 5.40 ) on daily basis till the end of the digestion study. The CLW:CS blend had the shortest retention time (biogas production stopped completely on the 19th day). (Figure 2), it also had the lowest cumulative volume of gas production. The pattern of gas production indicated that CLW was not a good inoculum for CS waste since; commencement of gas production for the system delayed up to the 5th day after charging the digester. Again, the volume of gas produced was low until at the point of gas flammability when gas production became relatively high (10th to 12th day). After this day, it started reducing until the death of the methanogens by the 19th day of the digestion process. The pH at this point was reduced to 5.0. This performance may be attributed to the low level of carbon, C/N ratio, other nutrients like protein (Tables 2)

.

**Table 3.** Lag periods, cumulative and mean volume of gas yield for single organic wastes and cow liquor waste blends.

| Parameters | BS | CS | CW | CLW:BS | CLW:CW | CLW:CS |
|---|---|---|---|---|---|---|
| Lag period (days) | 22 | 10 | Nil | 7 | 10 | 9 |
| Cumulative gas yield (L) | 218 | 203 | Nil | 607 | 209 | 71 |
| Mean volume of gas yield (L) | 8.72 | 8.12 | Nil | 24.28 | 8.36 | 2.84 |

## CONCLUSION

The addition of abattoir cow liquor waste to the agro industrial wastes had significant effect on the brewery spent grain. Cassava waste water which could not produce biogas alone was able to produce when inoculated with the CLW. This suggests that improving the initial pH at the point of charging could further enhance the rate of biogas production. However, the effect on the carbonated soft drink sludge was negative in terms of cumulative gas yield, onset of gas flammability, retention time and. Overall results indicate that cow liquor waste is a very good inoculum for BS waste in the enhancement of flammable gas production. The inoculum- treated brewery spent grain can therefore be a rich source of energy generation to brewery industries for heating/ lighting purposes and electricity supply in their various factories. Further work on the optimal blending ratio of CLW with CS to achieve the right pH for anaerobic digestion of this blend will constitute a separate report.

## REFERENCES

[1] Anonymous (1989). A handbook of the Asian -pacific regional biogas research-Training center, Chengdu, China. Operating conditions of Biogas fermentation. pp. 58–59.
[2] AOAC (1990). Official Methods of Analysis: Association of Analytical Chemists. 14th Ed; Washington, USA, 22209.Chawla OP (1986). Advances in Biogas Technology. Indian Council of Agricultural Research, New Delhi, p. 144.
[3] Energy commission of Nigeria (1998). Rural renewable energy needs and five supply technologies. pp. 40 -42.
[4] Ezeonu FC, Udedi SC, Okonkwo CJ, Okaka ANC (2002). Studies on brewers spent grain bio-methanation: 1. Optimal conditions for anaerobic digestion. Nig. J. Renewable Energy. 10: 53– 57.
[5] FAO/CMS (1996). A system approach to biogas technology; From “Biogas technology a training manual for extension”. p. 5-9.
[6] Fulford D (1998). Running a biogas program: A hand book. Intermediate technology publications, .Southampton Row, LondonWCIB 4HH, UK. pp. 30-31.
[7] Hashimoto AG, Chen YR, Varel VH (1980). Theoretical aspects of methane production: State-of-the-Art. In proceedings “Livestock waste: A renewable resource. 4th International symposium on livestock wastes. ASAE. pp. 86–91.
[8] Kanu C (1988). Studies on Biogas production of fuel solid waste. Nig. J. Biotechnol. 6: 90-96.
[9] Kanwar S, Guleri RL (1994). Influence of recycled slurry filtrate on biogas production in anaerobic digestion of cattle dung. Biogas Forum 57: 21- 22.
[10] Maishanu SM, Maishanu HM (1998). Influence of inoculum age on biogas generation from cow dung. Nig J. Renewable Energy, 6 (1& 2): 21 -26.
[11] Meynell PJ (1982). Methane. Planning a digester. Prison Stable Court.Clarington, Dorset. Sochen Books, p.3
[12] Okore VC (2004). Surface viable count. A standard laboratory technique in Pharmaceutics and Pharmaceutical microbiology. 2nd Edition. El’ Demark publishers. Pp 24 – 26.
[13] Onwuka GI (2005). Food analysis and instrumentation (Theory and practice). Naphathali prints, Nigeria, pp.95-96.
[14] Pearson D (1976). The chemical analysis of foods. 7th Edition. Churchill Livingstone. New York. pp. 11-12, 14-15.
[15] Preeti RP, Shivaraj D, Seenayya G (1993). Indian J. microbial. 33: 185 -189.
[16] Ramasamy K, Nagamani B, Sahul HM (1990). Tech Bull; fermentationlaboratory, Tamil Nadu Agricultural University, Coimbatore, 1: 91.
[17] Sahota P, Singh A (1996). Res. Dev. Rep. 13: 35-40.Uzodinma EO, Ofoefule AU, Eze JI, Onwuka ND (2007). Biogas production from blends of agro-industrial wastes. Trends in Appl. Sci. Res. 2(6): 554–558.
[18] Walkey A, Black LA (1934). An Examination of the Degtjareff method for determining soil organic matter and proposed chromic acid titration method. J. Soil Sci. 37: 29-38.
[19] Wantanee A,Sureelak R (2004), Laboratory Scale experiments for biogas production from cassava tubers.The Joint international

conference on Sustainable Energy and Enviornment (SEE). 1-3 December,Hua Hin,Thailand.

[20] Yadav L.S.and P.R.Hesse (1981),The development and use of biogas technology in rural areas ( A status report 1981).Improving soil fertility through organic recycling,FAO/UNDP Regional Project RAS/75004.Project field Document No.10.

,

**Nitin A.Wankhade [1]**

[1] Research Scholar, Department of Mechanical Engineering ,Prof.Ram Meghe Institute of Technology and Research Badnera(Amravati) Maharashtra, India

**Dr.S.B.Thakre [2]**

[2] Professor , Department of Mechanical Engineering ,Prof.Ram Meghe Institute of Technology and Research Badnera(Amravati) Maharashtra, India

**A.V.Dhote[3]**

[3] Professor , Department of Mechanical Engineering ,Prof.Ram Meghe Institute of Technology and Research Badnera(Amravati) Maharashtra, India

**P.S.Wankhade[4]**

[4]Lecurer,. Department of Mechanical Engineering Badnera Polytechnique,Badnera.,