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# Bioconversion of Vegetable and Agricultural Waste in Biogas using Cow Dung as Co-substrate

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**A 21 days batch experiment was conducted for production of biogas using cow dung alone (T1) and with vegetable waste (T2) and agricultural waste (T3) at mesophilic conditions. At every 3 days interval, total gas, methane and substrate degraded were measured. The partitioning of carbon to total gases is measured in terms of gas produced per unit of substrate loss. The total gas production reached its maxima at day 3 with 30ml in T2 giving a cumulative biogas production of 91 ml at the end of the 21st day of the experiment followed by T1 (69ml) and T2 (61ml). The maximum methane production per unit of total gas (0.60) as well as per unit substrate degraded (0.32) was also observed for T2. From the results it is concluded that the wastes can be managed through conversion into biogas, which is a source of income generation for the society.**

**Key words:** Waste, Anaerobic Fermentation, gas, methane.

The amount of solid wastes including cattle dung and agricultural waste generated in developing countries such as India has steadily increased over the last two decades as a result of population explosion and continuous growth of industries and agricultural practices. In agriculture, particularly cattle rearing, large quantities of cow wastes are generated, which could be used as biogas inputs to compliment the fuel usage alternative. In addition, a large number of university campuses generate heavy wastes in the kitchen on a daily basis, which could be converted to economic benefits such as production of biogas. Biogas is a term used to represent a mixture of different gases produced as a result of the action of anaerobic microorganisms on domestic and agricultural waste [(Mclnerney and Bryant, 1981), (Ezeonu *et al*.2005)]. It usually contains 50% and above methane and other gases in relatively low proportions namely, $CO_2$, $H_2$, $N_2$ and $O_2$ [(Milono *et al*.1981), (Kalia *et al*.2000)]. The mixture of the gases is combustible if the methane content is more than 50% [Agunwamba 2001]. Biogas production involves a) Hydrolysis of organic polymers into monomers, b) Acid (acetate, propionate and others) and gas ($CO_2$, $NH_3$ and $H_2$) formation from monomers, and c) Methane formation from simple compounds.

Co-digestion, simultaneous digestion of more than one type of waste in the same unit offers advantages such as better digestibility, enhanced biogas production/methane yield arising from availability of additional nutrients, as well as a more efficient utilization of equipment and cost sharing [(Agunwamba 2001), (Mshandete and Parawira 2009), (Parawira *et al*.2004)]. A wide variety of substrates, animal and plant wastes, as well as

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industrial wastes such have been used for biogas production [(Mackie and Bryant 1995), (Zhang and Zhang 1999), (Nagamani 2007), (Uzodima *et al*.2008)]. In these studies, the rate of biogas production was found to depend on several factors such as pH, temperature, C:N ratio, retention time, etc.

The need for more research into biogas production as a renewable energy source alongside the added benefit of solving major environmental problems posed by the wastes used as substrates is well established. Given the large scale production of vegetable produced in MMU campus and agricultural waste and the level of cattle rearing in Mullana and surroundings, large quantities of cow dung are dumped. Therefore, this work was carried out to explore the potential of biogas production from co-digestion of vegetable waste and agricultural waste with cow dung.

## MATERIALS AND METHOD

**Substrate**

For lab-scale experimental purpose, 1 L mineral water bottle were used as an anaerobic digester. The bottles were filled with PVC Pall Ring to create fixed film inside the reactor. Different combinations of the wastes were formulated:

a) T1: Cow dung: 500g
b) T2: Cow dung: Vegetable waste (1:1), 250 g each
c) T3: Cow dung: Agricultural waste (1:1), 250 g each

The fresh cow dung was collected from nearby village where the animals were fed with roughage diet. The vegetable waste contained peels of onion, potato, tomato and banana; while the agricultural waste contained the dried leaves and twigs. T3 yielded no biogas production due to less moisture content therefore, a 10 ml of distilled water was added to T3. After charging the different combinations of cow dung inside the bottle digester were sealed. A thermometer and a pH probe was inserted in the cap of the bottle for measurement of pH and temperature. All the experiments were done in triplicates.

**Analysis**

**Collection of gas**

The gas formed after an incubation at different intervals was measured using water displacement assembly as per Archimedes Principle i.e. The volume of water displaced is equals to the volume of gas produced and then weight of biomass is measured using a weighing balance.

**Methane measurement**

A 10 ml of biogas was collected in a syringe, followed by addition of 4 ml of 10 molar NaOH through the silicon tube. Sealed the nozzle of the syringe and shaken the contents to enable the $CO_2$ to be absorbed into the hydroxide. The syringe was then turned upside down for the reading of $CH_4$ level.

**Organic Matter loss**

Loss in organic matter at different time intervals was measured by difference in the weight of the treatment bottle

**Calculations**

For the extent of methane production, the methane produced of the total gas produced (on volume basis), and methane produced per unit of substrate degraded were considered. The measurement of total gas, methane and substrate loss was used for calculation of methane produced per ml of total gas and methane production per mg of substrate degraded. The proportion of methane in total gas (NMP) was calculated as: NM/NG. The methane produced per unit substrate degraded was calculated as: Net methane/ Net loss in substrate.

## RESULTS AND DISCUSSION

The biogas production with time from treatments, T1, T2 and T3 are shown in Fig 1. T2 (cow dung: vegetable waste, 1:1) was observed to produce the highest quantity of cumulative biogas (91 ml) during a period of 21 days of incubation, followed by T1 (69 ml) and T1 (61ml). The maximum metabolic activity was observed after 3 days of incubation with a gas production of 30ml and substrate loss of 14%. The total gas volume for T1 and T3 were almost similar, this might be due to the fact that T3 has the agricultural waste as the substrate which was not given any pre-treatment so as to expose the substrate for microbial attack. Also, it is well known that the composition of biogas as well as biogas yields depend on the substrates owing to differences in material characterization in each feed material [(Calzada *et al*.1984), (Cuzin *et al*.1992), (Kalia *et al*.2000), (Zhang and Zhang 1999)]. Given the high cellulose and lignin content of agricultural waste, it is not surprising that it is resistant to enzymatic degradation and hence, biogas production [Pillaier 1988]. Usually, it is observed that biogas production from cow waste should be higher than that of kitchen waste probably because cow waste have undergone initial digestion in the animals' stomach. However, we observed higher production when vegetable waste was added to cow waste. The reason could be more accessible sugars in their simpler form the vegetable waste (banana peel, potato peel etc.) and higher moisture levels (not determined in the present study). The percentage of substrate loss possessed the similar trend to the gas production during the incubation period. Maximum substrate loss was observed for T2 followed by T1 and T3, respectively. The substrate loss was linear in case of T1 as the fermentable substrate gets limited as the incubation proceeds further.

As shown in Figure 1, the initial anaerobic digestion process that produced a maximum of 30 ml of biogas on the 3rd day and is followed by decline, this inactivity is probably due to the methanogens undergoing a methamorphic growth process by consuming methane precursors produced from the initial activity [(Lalitha *et al.* 1994), (Bal and Dhaghat 2001)]. It is generally agreed that at the initial stages of the overall process of biogas production, acid forming bacteria produce Volatile Fatty Acids (VFA) resulting in declining pH and diminishing growth of methanogenic bacteria and methagogenesis [(Vicenta *et al*.1984), (Cuzin *et al*.1992)]. That is, a low pH value inactivated microorganisms responsible for biogas production. The mesophilic temperature (30°C – 32°C) was recorded during the period of study. The pH of all the experimental bottles varied from 6.0 to 7.5 towards to end of the fermentation.

Fig 2, represents the methane production on volume basis and on the basis of substrate degraded. The former parameter is useful in knowing the effect of treatment as a direct effect on methane production. On the other hand, the latter gives the partitioning of the substrate carbon to methane carbon, since the proportion of organic matter digested that leads to methane formation is of relevance and the production of methane per unit of organic matter digested represents the true efficacy of a treatment. Similar to the pattern observed for total gas production, the maximum methane per unit of total gas as well as per unit substrate degraded was observed for T2 after an incubation of 12 days. This mobilization of substrate to biogas gives an indication that vegetable waste when supplemented to cow dung results in partitioning of substrate carbon to the gases efficiently as compared to T1 and T3. Recent studies also reported lower biogas production when agrowaste were co-digested with cow dung [(Bagudo *et al* 2011), (Vivekanandan and Kamraj 2011), (Patil *et al*.2011)].

The outcome of this research suggests that vegetable waste could be easily converted to biogas economically, however, the agricultural waste without any pre-treatment does not have the potential for biogas production at the temperature range of 26 - 29°C. Shredding allows for better and more contact between the active

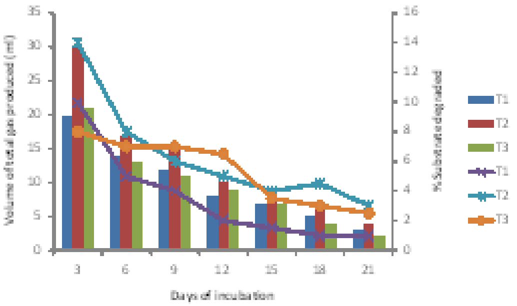


**Fig. 1.** Biogas production and loss in substrate in different treatments at incubation of 21 days, T1: Cow dung; T2: Cow dung: Vegetable waste (1:1); T3: Cow dung: Agricultural waste (1:1)

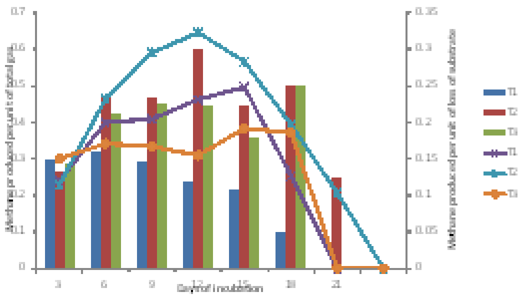

**Fig. 2.** Methane production per unit of total gas and per unit of substrate loss
T1: Cow dung; T2: Cow dung: Vegetable waste (1:1); T3: Cow dung: Agricultural waste (1:1)

microorganisms and the slurry, and improves the bacterial population's ability to obtain nutrients, which in turn increases biogas production. The vegetable waste could be economically utilized for production of biogas. From the results of this work, it can be concluded that the wastes generated from domestic and agricultural activities could be converted into useful products (methane and manure) with the help of anaerobic digestion technology.

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GG planned and compiled the research data, MR, SK and VKB executed and analysed the research data. There is no conflict of interest

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