

## Production of Biogas from Poultry Waste

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### ABSTRACT

It is inevitable that with large volume and high density poultry productions, there will be large quantities of poultry waste produced in Kathmandu and throughout Nepal. Poultry waste produced as the daily feeding of chicken both from broilers and layers in the country is largely used as organic manure for agricultural purposes. The poultry industry is growing day by day concentrated within the urban as well as rural community. The intent of this paper is to show that the chicken waste used as feed material to produce biogas can tap additional energy from the otherwise wasted energy and make the poultry industry co-exist with the environment of the neighbors. This research will identify and evaluate the economic feasibility to produce biogas from poultry waste. The research is of particular interest to the poultry farmers and to the community in the Kathmandu valley as the people are becoming very conscious of environmental impact due to pollution. The study has focused on various parameters relating to physico-chemical characteristics of the substrates, fertilizing value of digested poultry waste, assessment of odour level in and around poultry farm and cost-benefit aspects of biogas production from poultry wastes. It has been concluded that biogas can be generated in Nepal with a huge probability of energy for use in households as well as industrial use which can also cut the supply of non-conventional fuels and balancing the environment aspects using poultry waste digestion in Nepal.

**Keywords:** *Biogas, Poultry Waste, Renewable Energy, Slurry*

### 1. INTRODUCTION

Based upon estimates, with the country's poultry population of 28.6 million and availability of poultry waste of 1,575.5 million kg per year, the biogas yield would be 116.6 million m<sup>3</sup>/year [2]. This can generate 648 GWh of thermal energy per year. If the thermal energy is converted into electric energy, assuming 15 percent conversion loss in conversion of thermal energy to electric energy, approximately 550 GWh of electric energy can be obtained annually.

As the research in biogas production from poultry waste has been a new area for biogas technology as well as Nepalese poultry industry, Centre for Energy Studies (CES) of the Institute of Engineering (IOE), Tribhuvan University, Nepal, has initiated a research to study various parameters of biogas production from poultry waste in Kathmandu.

However, the specific objectives of the research were to:

- Install a 10 m<sup>3</sup> GGC-2047 model fix dome bio-digester to conduct experiments on biogas generation from poultry waste.
- Record various parameters such as pH, temperature, retention time, and consistency of slurry, total solids content, Carbon: Nitrogen ratio (C/N ratio) and volatile solids content.
- Evaluate the production of biogas in normal condition.
- Assess odour level of poultry waste in the neighbourhood before and after biodigestion.

- Assess and analyze the fertilizing value of slurry from poultry waste.
- Analyze financial viability of generating biogas in the poultry industry.

The bio-digester for the research was constructed 10 m<sup>3</sup> GGC- 2047 Model fixed dome plant (this design is approved by Biogas Support Program – Nepal (BSP-Nepal) at Great Himalayan Poultry Farm in Ward No. 16, Chhauni, Kathmandu in November 2003. This bio-digester requires daily feeding of 42 kg of poultry waste, which is mixed with 84 litres of water.

## 2. TEST RESULTS

**Chemical Analysis:** With the support from Biogas Support Program – Nepal (BSP-Nepal), chemical analysis of the fermenting slurry was done at Agricultural Technology Centre, Pulchowk, Lalitpur. The format for the chemical tests is shown in the Appendix I. Various parameters included in the analysis were: pH, nitrogen, potassium, phosphorus, temperature, retention time, organic matter content, C/N ratio, total solids and volatile solids. According to analytical result, the pH value obtained was 6.5 at an average, which is not optimum for the methanogenesis process thereby affecting production of methane. The poultry waste was diluted with water at 5 to 12 percent of the total solids content for feeding into the biodigester and the average C/ N ratio of fermenting slurry was found to be 14, which is considered optimum [3] and [5]. The volatile solids content of the slurry was found to range from 35.6 percent to 80.7 percent, the average value being 61.10 percent.

**Effect of Odour due to Poultry Waste in the Neighbour:** The nearest neighbour was located at least 20 metres away from the poultry farm. The odour level of poultry waste in the neighbourhood was assessed by interviewing neighbours at every direction nearest to the farm before and after the establishment and operation of bio-digester with poultry waste. They all reported that the level of odour is not perceived. On the other hand, farmhouse dwellers reported that they have been inhaling offensive smell produced from putrefying poultry waste. The study also found that the odour level of poultry waste is perceived more in wet condition than when it is in fresh and dry form. This is attributed to the emission of ammonia gas, which has offensive odour. Furthermore, it is to be noted that there is no protest as yet from the public against the poultry farm odour.

**Fertilizing Value of the Slurry :** The chemical tests of the slurry showed that the concentration of Potassium was increased. The concentration of Phosphorus and Nitrogen were decreased. The percentage of N in the raw poultry waste was 2.01. It decreased gradually to 2.00 during the first two weeks of fermentation and then to an average of 1.79 percent finally. The P content of the raw material was reported to be 6.66 percent. It was decreased to 4.37 percent after two weeks' digestion and finally 5.85 percent was recorded as the average value. As for K, it increased from 3.45 percent to 4.15 percent after two weeks' digestion process with final average value of 5.51 percent.

**Gas Production:** The feeding was done in batch and left aside for study of the daily production of gas. Large volume of the biogas is generated from feeding of the waste mixed with green grasses, green vegetable wastes, potato pills and other kitchen wastes. Evaluation of biogas production was done at the ambient temperature. The average daily biogas production as recorded from April 25, to May 4, 2005 was found to be 3,000 litres. The retention time was found to be 65 days which is longer compared to cow dung.

## 3. DISCUSSIONS

With recommendation of the above thesis, Further research could be done to produce combustible gas by feeding poultry waste with some volume of other degradable organic matters for example kitchen wastes, cow dung etc. to produce biogas in the same plant, the plant is again fed with some degradable kitchen waste like potato pills, green grasses, etc. the final result was combustible biogas production.

## Financial Analysis

In the context of Nepal, biogas is known more as a technology for meeting household energy requirements than its other utilities. In financial analysis all costs and benefits are valued from the point of view of the user for whom this is being done. Though this analysis should have been undertaken before making a decision to install the plant, it is ensured that all costs and benefits are estimated most likely to be realized by the user after the plant installation. Benefits and costs of a biogas plant vary depending upon the use of inputs and outputs by the particular user. However, in this case the poultry farm has many workers living in the farm house. They are helping daily feed into the digester in that the labour charge is not allowed additionally as it is considered the part of their job in turn of providing shelter and monthly salary in the farm. The water is available from the well just few meters away from the digester. So the labour cost for obtaining water and feeding poultry waste including collecting it from the poultry farm floor (litter) is neglected in this case.

The financial analysis indicated that the venture of bio-digester programme with poultry waste is thus feasible in Kathmandu weather for the production of biogas generated<sup>1</sup>. It can be used as a substitute for cooking fuel.

### Value of Cooking Fuel Saved

- The result average generation of gas is 3,000 litres (i.e. 3.0 m<sup>3</sup>). We assume that it is combustible and could be used in cooking or space heating. It is estimated that 20 MJ [1] or 5.56 kWh of thermal energy can be produced from 1 m<sup>3</sup> of biogas. Therefore with 3.0 m<sup>3</sup> of biogas the amount of energy generation is 20.56 kWh. In this session it is assumed that all gas produced is fully consumed. And it is based upon the following assumption.
- 50 Kg of poultry waste produced 3.0m<sup>3</sup> biogas per day per plant.
- 1 m<sup>3</sup> of biogas is equivalent to 20 MJ [1] or 5.56 kWh of thermal energy.
- 1 lb of LPG contains 21,200 Btu of energy<sup>2</sup> [4].

From above the thermal energy content of 14.2 kg LPG is 194.1 kWh. Therefore 194.1kWh energy is contained in one cylinder of 14.2 kg LPG which costs Rs. 1,100<sup>3</sup>. Therefore 1 kWh of thermal energy of LPG cost Rs. 5.67. So, comparing with LPG the generation of 3.0 m<sup>3</sup> or 16.68 kWh the biogas could save Rs. 92.74 per day. Table 1 shows the cost estimation of LPG in terms of cooking gas. The simple payback period was found to be 2 years.

**Table 1 Cost Estimation of LPG in terms of Cooking Gas**

| Reqd. Qty. of poultry waste | Gas produced/day   | Gas Produced/year   | Annual Cost Savings in LP Gas @ Rs. 5.67/kWh | Total Cost of Plant | Simple Pay Back Period <sup>i</sup> |
|-----------------------------|--------------------|---------------------|--|---------------------|-------------------------------------|
| 42 kg                       | 3.0 m <sup>3</sup> | 1,095m <sup>3</sup> | Rs. 34,500                                   | Rs. 70,000          | 2 years                             |

<sup>1</sup> Average Kathmandu temperature which is most important factor for biodegradation is the lowest average of 5<sup>0</sup>C to the highest average of 28<sup>0</sup>C

<sup>2</sup> Source: Unit Conversion obtained from LP Gas company.

<sup>3</sup> Price as of August 1<sup>st</sup>, 2004 Source: Nepal Gas Industry.

#### **4. CONCLUSION**

The bio-digester required daily feeding of 42 kg of poultry waste mixed with nearly the same volume of water. The poultry farm was capable of producing 255 kg/day of poultry waste which indicated that it was possible to run a bio-digester of much greater capacity.

As regards chemical analyses of bio-slurry, various parameters included in the research were: pH, nitrogen, potassium, phosphorus, temperature, retention time, organic matter content, C/N ratio, total solids and volatile solids. All the results showed the normal value for methanogenesis which thus produced biogas. The retention time was 82 days which was longer than cow dung digestion time which generally is around 40 to 50 days.

The study also found that the odour level of poultry waste was perceived more in wet condition than when it was in dry form. This attributed to the emission of ammonia gas, which was offensive in odour level. Furthermore, it was to be noted that there was no protest so far from the public against the poultry farm odour.

The financial analysis showed that the venture of bio-digester programme with poultry waste was feasible in Kathmandu weather. In substitution for cooking gas the simple payback period was found 2 years which indicated that the project was financially viable.

With the daily feed of 42 kg poultry waste 3,000 litres of biogas was produced per day. This could be an additional benefit for poultry industries in Kathmandu and also the whole Nepal in suitable environment. At the present poultry waste producing capacity of the farm of 93,075 kg per year the biogas generation could be estimated to 6,648 m<sup>3</sup> per year. This could generate 36.96 MWh of thermal energy per year.

Based upon estimates, the country's poultry population being 28.646 million and availability of poultry waste being 1,575.475 million kg per year, it could be concluded that the biogas yield per year would be 116.585 million m<sup>3</sup>. This could generate 648<sup>4</sup> GWh of thermal energy per year. If the thermal energy was converted into electric energy, assuming 15 percent conversion loss upon conversion of thermal energy to electric energy it was obtained approximately 550 GWh of electric energy per year.

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<sup>4</sup> Estimating 1 m<sup>3</sup> of biogas generate 20 MJ of thermal energy or 5.56 kWh of thermal energy.

**List of Plates**



**Fig. 1** Chicken in the farm house



**Fig. 2** Plant under Construction and a Visit by Professors/ Supervisors



Fig. 3 Mixing Feed Material in Mixer



Fig. 4 Agitating the Slurry



Fig. 5 Sample Taken for Test



Fig 6 Gas Meter in Kitchen

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### **List of Abbreviations & Units**

|           |                                     |
|-----------|-------------------------------------|
| FAO       | = Food and Agriculture Organization |
| CMS       | = Consolidated Management Services  |
| GGC       | = Gobar Gas Company                 |
| CES       | = Centre for Energy Studies         |
| IOE       | = Institute of Engineering          |
| BSP-Nepal | = Biogas Support Program – Nepal    |
| LPG       | = Liquidified Petroleum Gas         |
| GWh       | = Gega Watt hour                    |
| MWh       | = Mega Watt hour                    |
| KWh       | = Kilo Watt hour                    |
| MJ        | = Mega Joule                        |
| Btu       | = British Thermal Unit              |
| C/N ratio | = Carbon Nitrogen Ratio             |

