



## Investigation for the sensitivity of biogas production on the biomass volume in a batch type biogas mild steel plant

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### Abstract

Biogas plants are biggest source of renewable energy. Any biomass available on earth can be converted into thermal energy, CNG and electricity generation by using biogas plants. In this research, a batch type biogas plant of two different volumes is used for biogas production and biomass used is paddy straw mix with cow dung. The main objective is to calculate the biogas production depending upon the volume of plant. The biogas plants used are made up of mild steel installed on the ground having dimensions of plant 1 (6 feet x 8 feet) with 600 kg capacity (450 kg paddy straw + 150 kg cow dung) and plant 2 have dimensions (10 feet dia x 10 feet height) and capacity is 2000 kg (1600 kg paddy straw + 400 kg cow dung). The data obtained is based on three months working of plant. Once the plant filled, it produces gas for three months regularly. The results found after complete working of plants are: plant-A produces biogas 1.5-2 cubic meter daily and total 106.578 cubic meters and plant-B produces 4-5 cubic meter of biogas daily and total of 400 cubic meters.

**Keywords:** anaerobic digestion, paddy straw biogas technology, two biogas plants made up of mild steel with dimensions (6 feet x 8 feet) and 10 feet x 10 feet), paddy straw husks, biogas generation

### Introduction

In India, million tons of biomass available and can be utilized as a renewable source of energy. There is great potential in this field of power generation from biomass. This biomass conversion into renewable energy can be a game changer and become alternatives of non-renewable sources which are load on Indian government. Paddy straw husks after harvesting are available in farmer fields in the form of millions of tons. North India is struggling to overcome this situation and developed various machines, installed projects to overcome this. Biogas plants are also available to divide this problem. In the background, cattle dung biogas plants are available to reduce the waste of cattle, animals etc. Various designs are available for this management. For paddy straw least work is done in the past. Stubble burning is problem, but if this is converted into useful biogas generation, CNG plants, power generation, it becomes the source of income as well as an option for country as a another fuel or form of energy which can be utilized to satisfy the needs of people. A less work is done for production of biogas from paddy straw as well as on designing of paddy straw biogas plants. Only few government projects are available. CNG generation from paddy straw is the future scope in this field. Some private companies invested in CNG generation from paddy straw. There are various studies conducted in past on batch type systems for biogas production. The anaerobic digestion of organic materials is useful producing useful renewable source of energy such as biogas, which is by product of anaerobic digestion. Biogas is useful in cooking, power generation, lighting, CNG production and this will reduce the loads in energy generation sector for countries like

India, China and Bangladesh. In addition co-digestion of organic waste with sludge or cow dung has been done for improvement of biogas production <sup>[1]</sup> biogas production potential of paper waste (PW-A) and its blend with cow dung (PW: CD) in the ratio 1:1 was investigated <sup>[2]</sup>. characterization of the residual materials found in fruit and vegetable markets and their adaptability to be treated by anaerobic digestion with the aim of generating biogas as a new and renewable energy source <sup>[3]</sup>. Effects of waste paper on biogas production from co-digestion of fixed amount of cow dung and water hyacinth in batch reactor was studied at room temperature in 5 batch reactor for over 60 days <sup>[4]</sup>.

### Energy Recovery from paddy straw:

In Asia paddy straw is major residue and total 668 tonnes could produce theoretically 187 gallons of bioethanol (Kim and Dale 2004). In India, this paddy straw undergoes field burning. This waste of energy seems inapt, given the high fuel prices and the great demand for reducing greenhouse gas emissions as well as air pollution. As climate change is extensively recognized as a threat to development, there is a growing interest in alternative uses of field-based residues for energy applications. Punjab produces around 23 million tonnes of paddy straw and 17 million tonnes of wheat straw annually. More than 80% of paddy straw (18.4 million tonnes) and almost 50% wheat straw (8.5 million tonnes) produced in the state is being burnt in fields <sup>[5]</sup>. From the data obtained in this paper, if 2000 kg can produce 5 cubic meters than this 23 million of paddy straw produce million cubic meter of biogas, further converted into large amount of electricity, CNG production. This will produce a source of income as well as reduce the petroleum, non-renewable

sources which are the biggest problem of any country due to its cost and availability. This will produce thousands of green jobs also.

### Biogas generation from paddy straw by anaerobic digestion

A series of biological processing steps with the core conversion using the anaerobic digestion technology, converts the complex organic matter in waste products to simple monomers by using a consortia of micro-organisms. The AD technology facilitates organic decomposition and reduction in inorganic matter in the absence of oxygen [6]. These organic materials are converted into final products, which are mainly biogas, digestate and a combination of solid and liquid effluents derived from digestate treatments. Using biogas in power generation (when compared to fossil fuels) avoids additional GHG emissions [7]. With regard to beneficial uses of biogas generated from anaerobic digestion. Paddy straw biogas generation is a batch type process. The material once filled in a digester by mixing it with cow dung in the absence of oxygen in leakage proof digester made up of mild. This process is anaerobic digestion. It starts producing biogas after a period of 7-8 days. Once it starts producing biogas, it can produce biogas up to 3-4 months. No other substrates or any other kind of material is required to be feeded during the working of biogas generation. Main components of biogas produced are methane, carbon dioxide, hydrogen sulphide. The paddy straw feeded in digester after 3-4 months gets converted into bio-digested slurry used as manure in farm fields and the water obtained is also bio- liquid compost used in farming.

### Objective of this project

Anaerobic digestion of paddy straw is viable process. Paddy straw utilization for producing biogas is new concept and least work done in the past. There is need to develop techniques, which produces energy for useful purposes. This batch type experiment in two digesters of different volume is a totally new. There is least scientific data available and the pressure to overcome the problem of paddy straw management is very high. The quality of biogas produced from this batch type is to be tested. The main objectives are to:

- Evaluate the capacity of material to produce biogas.
- Optimize the comparison between two different volumes of plants.
- To develop scientific information of biogas production from paddy straw.
- Effects on environment.

### Methods and Materials

In this work two paddy straw plants are tested. The plants consists of two parts i) digester ii) gas holder for gas storage. The plants used are made up of mild steel and these plants are on the ground. Plants are directly in contact with sunlight, which is advantage during biogas production because the best temperature for biogas production is above 25degree Celsius. Both plants are leakage proof and air tight and biogas comes out from an outlet available on the top of plant cover. The methods and arrangements follows under this work is described as follow:

**a) Paddy straw arrangements:** The paddy straw was arranged from the fields of PAU Ludhiana. The material

was collected and then chopped with fodder chopper (toka machine) and chopped paddy straw filled in digester. The cow dung was also arranged from the dairy farms of university. The composition of paddy straw with cow dung for both plants is shown in Table 1.

**Table 1:** Composition of feeding material

Composition for Plant A	450 kg paddy straw crop residue+150 kg cow dung = 600 kg
Composition for Plant B	1600 kg paddy straw crop residue+4000 kg cow dung =2000 kg

**b) Paddy straw plants arrangements:** In this work mild steel plants were developed and new kind of designs was used to conduct the testing. Both plants were designed by scientists of PAU Ludhiana and fabricated by a local vendor. Both plants are leakage proof and for feeding material the cove was available on the top of plant and for removing the digested paddy straw an outlet cover having diameter three feet is available on the bottom of the plant. The plant – A and B are used for digestion of paddy straw which are shown in Figures 1 & 2 respectively. The specifications of these plants have been shown in Table 2 and 3 respectively. The plants



**Fig 1:** PLANT-A



**Fig 2:** PLANT-B

**Table 2:** Specification of Plant-A

Dimensions	6 feet diameter x 8 feet height
Quantity of feeding material	450 kg paddy straw + 150 kg cow dung
Testing temperature	20 to 45 degree Celsius
Material of plant	Mild steel

**Table 3:** Specification of Plant-B specifications

Dimensions	10 feet diameter x 10 feet height
Quantity of feeding material	1600 kg paddy straw + 4000 kg cow dung
Testing temperature	20 to 45 degree Celsius
Material of plant	Mild steel

Both the plants were tested for a period of three months and the work was carried out at PAU, Ludhiana. The biogas produced was measured by gas flow meter and produced biogas was utilized for various cooking purposes.

**Batch operation:** Paddy straw is a solid biomass so that batch system is perfect for biogas generation for its utilization. Initially both plants were filled with required paddy straw and cow dung. Once filled, the cover on the top of plants was tightly closed. Under closed environment in the absence of oxygen, the dry fermentation of paddy straw starts and biogas production was started on the 7<sup>th</sup> day after filling of paddy straw. Once it starts producing biogas, it produced biogas for a period of three months continuously.

**Testing:** The working for biogas production of both the plants was tested under observation of researchers. The volume of biogas was measured daily and the side effect (if any) on the body structure of the plants was also observed on daily basis. There was not any side effect on the structure of the plants.

### Results and Discussions

The volume of the Plant – A was 600 kg. A total 106.578 cubic meter of biogas was produced in the Plant – A during a period of three months. The volume of the Plant – B was 2000 kg. A total of 400 cubic meters of biogas was produced in the Plant – B during a period of three months. The total LPG equivalent of biogas produced from both the plants has been shown in Tables 4 and 5 respectively.

**Table 4:** LPG equivalent of biogas produced from PLANT – A.

Period	1 <sup>st</sup> month	2 <sup>nd</sup> month	3 <sup>rd</sup> month	Total
Monthly biogas production	46.340 m <sup>3</sup>	39.350 m <sup>3</sup>	20.888 m <sup>3</sup>	106.578 m <sup>3</sup>
LPG equivalent	19.926 kg	16.925	8.974 kg	45.825 kg

Total No. of LPG cylinders produced =  $45.825/14.2 = 3.22$  Cylinders

**Table 5:** LPG equivalent of biogas produced from PLANT – B.

Period	1 <sup>st</sup> month	2 <sup>nd</sup> month	3 <sup>rd</sup> month	Total
Monthly biogas production	160.340 m <sup>3</sup>	140.50 m <sup>3</sup>	99.16 m <sup>3</sup>	400 m <sup>3</sup>
LPG equivalent	68.946 kg	60.415 kg	42.63 kg	172 kg

Total cylinder produced =  $172/14.2 = 12.11$  Cylinders

### Discussions

It is clearly observed that biogas produced by Plant-A per kg of paddy straw is more from biogas plant (Plant – B).

### Future Scope

- By scaling up the size of biogas plant, large quantity of paddy straw can be utilized for the production of biogas which controls its burning at farmer's field.
- With this the environmental pollution can be controlled at a large extent.

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