Production of Bio-Energy and Organic Fertilizer Using Canteen and Kitchen Waste

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Abstract - The use of renewable energy sources are becoming very necessary due to the limited reserves of fossil fuels and global environmental concerns for the production of electrical power generation and utilization. In remote areas, villages, rular areas it is easy to get more amount of biomass. Hence by the use of these systems consisting of Biomass to generate methane gas and electrical energy in these remote areas canbe more economical and commercial.

Kitchen waste (food waste can be collected from different hostels, mess; homes can feed to reactor which works as aerobic and anaerobic digester system to produce biogas energy. In College campuses by utilizing the hostels (mess) food waste and other biomass residues can be utilized for better purposes. Biogas production requires anaerobic digestion. This paper will gives an analysis on how Kitchen food waste can be converted into biogas and its utilization for daily utilization.

Key Words: Biogas, Kitchen food waste, Environment, Anaerobic digestion.

1. INTRODUCTION

Biomass energy, or “Bioenergy”, is energy produced from recently living organisms. There are three forms of Bioenergy available with today’s technology: heat, fuels, and electrical power. Farmers are potentially in a good position to utilize Bioenergy because they are already knowledgeable and well-equipped for the production of biomass, including that which can produce energy. As consumers of energy, farmers can produce and utilize Bioenergy at the same location. iomass is organic, meaning it is made of material that comes from living organisms, such as plants and animals. The most common biomass materials used for energy are plants, wood, and waste. These are called biomass feedstocks. Biomass energy can also be a nonrenewable energy source.

Biomass contains energy first derived from the sun: Plants absorb the sun’s energy through photosynthesis, and convert carbon dioxide and water into nutrients (carbohydrates). The energy from these organisms can be transformed into usable energy through direct and indirect means. Biomass can be burned to create heat (direct), converted into electricity (direct), or processed into biofuel (indirect). Bioenergy, primarily in the form of heat, has been produced for thousands of years, providing a good precedent to build upon in planning for its use in agriculture. This burning of the biomass or products from it is known as direct combustion. Direct combustion is a comparatively efficient means of using Bioenergy, due to its minimal processing needs, the diversity of feedstock that can be used, relatively simple equipment needs, and a relatively high rate of energy recovery. For most operations, direct combustion is the only practical means of harnessing Bioenergy. For some select types of farming operations, anaerobic digestion and gasification of biomass are also practical Bioenergy technologies for on-farm use. On-farm production of biodiesel from oil crops is also possible. This fact sheet willtherefore focus primarily on direct combustion and secondarily on anaerobic digestion, gasification, and biodiesel production.

1.1 Generating biomass from kitchen waste food

Anaerobic digestion (AD) is a microbial decompositionof organic matter into methane, carbon dioxide, inorganic nutrients and compost in absence of oxygen. This process is also known as bio-Methanogenesis. In the generalized scheme of the anaerobic digestion, the feedstock is collected, coarsely shredded and placed into a reactor with active inoculums of methanogenic microorganisms. Generally three main reactions occur during the entire process of the anaerobic digestion to methane: hydrolysis, acid forming and methanogenesis. Although AD can be considered to take place in three stages all reactions occur simultaneously andare interdependent.

1.2 Anaerobic Digester Set-Up

The batch type anaerobic digesters used for the study were made up of the following materials and specifications:

- **Digester**: A 25 litre (base: 400 mm x 230 mm; height: 275 mm) plastic keg serves as the digester.
- **Water collector**: A 5 litre transparent plastic (base:170 mm x 130 mm; height: 240mm).
- **Rubber Hoses**: The hose is about 1 meter in length and 7 mm inner diameter. It was used to convey gas from the digester to the water tank and to the water collector.
- **Digital Thermometer with thermocouple probe**: to read temperatures. The thermometer was in the range of 0 °C to 100 °C.

Optimization of gas production

Comparison with conventional plants will depends on different parameters:

* Temperature
* PH
* Total & volatile solid concentration
* Alkalinity
* Additives Nutrients
* Nitrogen source

Precautions while collecting sample kitchen waste:

- A separate container for coconut shells, egg shells, peels and chicken mutton bones. These will be crushed separately by mixer grinders.
- Different containers of volumes 5l to collect the wet waste, stale cooked food, waste milk products. The vegetables refuse like peels, rotten potatoes coriander leaves collected in bags.
- **BIO Energy** Bio-energy is produced by bacteria through the bio- degradation of organic material under anaerobic conditions. Natural generation of biogas is an important part of bio-geochemical carbon cycle. It can be used both in rural and urban areas

1.3 INSTALLATIONS:

Important aspect in smoother running of plant by avoidingthe choking of the plant. This occurs due to thick biological waste that not reaches to the microorganisms to digest. The easy answer to this problem is to convert solid wastes into liquid slurry. Mixer can be used to convert solid into slurry.

1.3.1 Composition of biogas observed as:

component	Concentration (by volume)
Methane (CH_4)	55-60%
Carbon dioxide (CO_2)	35- 40%
Water (H_2O)	2- 7%
Hydrogen Sulphide (H_2S)	20-20.000 ppm (2%)
Ammonia (NH_3)	0-0.05%
Nitrogen (N)	0-2%
Oxygen (O_2)	0-2%
Hydrogen (H)	0-1%

Table 1.1 Composition of biogas

1.3.2 Analytical methods & calculations:

Total Solids (Ts %) –

It is the amount of solid present in the sample after the water present in it is evaporated. The sample, approximately 10 gm is taken and poured in foilplate and dried to a constant weight at about 105 0C in furnace

TS % = (Final weight/Initial weight) * 100

Volatile Solids (Vs %) –

Dried residue from Total Solid analysis weighed and heated in crucible for 2hrs at 500 0C in furnace. After cooling crucible residue weighed.

VS % = [100-(V3-V1/V2-V1)] * 100

V1= Weight of crucible.
V2= Weight of dry residue & crucible.
V3= Weight of ash & crucible (after cooling)

Volatile Fatty Acid (Vfa):

Volatile fatty acids (VFA's) are fatty acids with carbon chain of six carbons or fewer. They can be created through fermentation in the intestine. Examples include: acetate , propionate , butyrate. There are many titration methods forVFA measurement.

Method 1

1. Take 100 ml sample in beaker
2. Filter the sample.
3. Check pH of filterate.
4. Take 20 ml of filterate and add 0.1M HCl until pH reaches 4
5. Heat in the hot plate for 3 mins
6. After cooling titrate with 0.01M NaOH to take pH from 4 to 7.
7. Amount of HCl&NaOH recorded
8. Total VFA content in mg/l acetic acid = (Volume of NaOH titrated) * 87.5
9.

Method 2:
Titration procedure for measurements of VFA andalkalinity according to Kapp :

x Before analysis, the sample needs to be filtered through a 0.45µm membrane filter.
VFA = (131340 * N * B / 20) - (3.08 * Alk) – 10.9

VFA = Volatile fatty acids [mg/l acetic acid equivalents].N = Normality [mmol/l]
B = Consumption of sulphuric acid (H_2SO_4 , 0. 1N) to titrate sample from pH 5.0 to pH 4.0 [ml], due to HCO_3/CO_2 buffer.

B = A2 + A3 [ml]

SV = Initial sample Volume
Alk = Alkalinity [mmol/l]

The A/TIC-method was developed at the Federal Research Institute for Agriculture (FAL) in Braunschweig, Germany. Used as an indicator of the process stability inside the digester, it expresses the ratio between Volatile Fatty Acids and buffer capacity (alkalinity), or in other words the amount of Acids (A) compared to Total Inorganic Carbon

$$\frac{A[\frac{mg}{l} = VFA[\frac{mg}{l}]}{TIC[\frac{mg}{l} = Alkalinity[\frac{mg}{l}]}$$

2. TECHNICAL REPORT OF BIOMASS ENERGY

In the past few years, there have been significant improvements in renewable energy technologies along with declines in cost. The growing concern for the environment and sustainable development, have led to worldwide interest in renewable energies and bio-energy in particular. Biomass can be converted into modern energy forms such as liquid and gaseous fuels, electricity, and process heat to provide energy services needed by rural and urban populations and also by industry. This mini project explains the different ways of extracting energy from biomass and a comparison is made among them and also explains about the potentiality of biomass energy in GIET campus, analyses current situation compares bio-energy and other options for promoting development, brings out the advantages over the other renewables putting forth the drawbacks to be overcome to make it still more successful.

2.1 Technical assessment

To understand technical and economical features of Kitchen waste based biogas plant the below example will gives an approach for 1 cum family size bio waste treatment plant:

Waste Treatment Capacity - 2 Kg Solid waste 20 – 30 Liters Waste Water

Volume of Digester - 1000 Liters Suitable for - 3-5 member family

Space required for the installation - 1.25 Sq Mtrs. Gas generation per day - 1 Cum Biogas

Liquid fertilizer - 20 Liters per day1 Cum Biogas - 0.5 Kg. LPG

Annual income in the form of gas &manure - Rs. 12,000/- Annual Biogas generation - 365 Cum

Generation of 365 Cum Biogas - Emission reduction of 3.5tone CO_2

Revenue from CDM - 3.5 credits /year

Various characteristics of bigger size biogas plant of 1m^3 andSmaller size biogas plant of 0.5 m^3 has shown in Table Table 2.1: characteristics of various biogas plants with kitchen waste

Characteristics	**Bigger size biogas plant**	**Smaller size biogas plant**
Size	1 m^3 digester	0.5 m^3 digester
Capacity	up to 2 kg kitchen waste	up to 1 kg kitchen waste
Quantity of gas produced	up to 1 kg biogas, capable of replacing 250 gm of LPG	up to 0.5 kg biogas, capable of replacing 100 gm of LPG.
Uses under cooking purposes	either breakfast or one meal can be cooked entirely on biogas.	about 15-20 min of cooking (tea, snakes, etc.) can be done.

Table 2.1 characteristics of various biogas plants with kitchen waste

2.2 Production of Energy (Heat, Light, Electricity)

The calorific value of biogas is about 6 kWh/ m^3; which is equal to about half a liter of diesel oil. The net calorific value of fuel also depends on the efficiency of the burners or appliances. Methane is the main important component under the aspect of using biogas as a fuel. The se of biogas can replace various conventional fuel like kerosene or firewood and protect the environment. Biogas is the best substitute of firewood in rural households. The biogas generated from small and medium sized units (up to 6 m^3) is generally used for cooking and lighting purposes. If we use a 8 kg (1:2 ratio) kitchen waste for biogas production, we cansave various fuel sources which can be used as alternatives. Total biogas production from 8 kg (1:2 ratio) kitchen waste of volume capacity 0.018 m3 biogas plant was 0.258157 m^3 during whole retention period.

The amount of other fuel sources which we can save by the use of 8 kg (1:2 ratio) kitchen waste in respect of ICAR data. Women spend 2-4 hours per day in searching and carrying the firewood. Once a biogas is installed, they will have much extra time for herself and her children. This will help in improving their quality. They will get more time for education and interesting activities outside the home. Biogasplants also improve health conditions in the homes. The annual time saving for firewood collection and cooking average to almost 1000 hours in each household provided with a biogas plant.

TABLE2.2: The amount of other fuel sources which can saveby the use of 8 Kg (1:2 ratio) Kitchen waste in respect of ICAR data

S.N.	**1 m3 biogas (approximately 6 kWh/ m3) is equivalent to:**
1	Diesel, Kerosene (approx. 12kWh/kg) 0.5 kg
2	Wood (approx. 4.5 kWh/kg) 1.3 kg
3	Cow dung (approx. 5 kWh/kg dry matter) 1.2 kg
4	Plant residues (approx. 4.5 kWh/kg dry matter) 1.3 kg
5	Coal (approx. 8.5 kWh/kg) 0.7 kg
6	City gas (approx. 5.3 kWh/ m3) 0.24 m3

TABLE2.2: The amount of other fuel sources which can saveby the use of 8 Kg (1:2 ratio) Kitchen waste in respect of ICAR data

Source:

According to ICAR paper (report issued by Indian Council of Agricultural Research, New Delhi)

Winrock International, Nepal Biogas Support Program (BSP) Nepal

In all these measurement if the different ratios of kitchen waste were compared under aluminium made biogas plant.

Aluminium is also better alternative on the basis of biogas production and also safe for the environment becauseit can easily be disintegrated by microorganism but plastic creates a lot of environmental problem due to its non biodegradable nature. In overall observation, we got, metal absorbing more sunlight to increase the temperature inside the digester in comparison to plastic made biogas plant. Aluminium made biogas plant is comparatively costly and even its life is half than a plastic made biogas plant. But if we compare biogas production and carbon credit, it will be better than plastic made biogas plant. We can also save the life of metal made biogas plant and increase the biogas production by black paint coat, which we have done duringexperimentation. In that way, black painted aluminium made biogas plant will be the best alternative under a communitylevel biogas production from kitchen waste.

2.3 Biogas plant with Kitchen waste in GIET campus

According to the purpose of mini project; a proposal has been made to design reactors of 200 kg for central mess GIET campus. (at the backyard of the mess, using kitchen waste directly as a feedstock) Hence there is a possibility of produce 650 lit of biogas daily in 200 kg reactor, under ideal conditions (like maintaining pH , VFA , Alkalinity, etc.).

Capacity of the Central Mess	No. of LPG Cylinders required per year (per day usage × no. of days	cost of each cylinder (19 Kg)	Total cost (in INR)
2370	6×250 = 1500	1731 Rs/-	2596500

Table 2.3: LPG consumption at targeted Central Mess

Daily kitchen waste from Central mess, Staff quarters and other areas	Total availability of Biogas with Kitchen waste	Equivalent to LPG gas	Equivalent to LPG cylinders	cost of each cylinder (19 Kg)	Total cost (in INR)
200 Kgs per day ×250 days in year = 50, 000 Kgs	25,000 Kgs	6,250 Kgs	329 cylinders	1731 Rs/-	569499

Table 2.4: Kitchen waste based biogas plant comparison with LPG

2.4 Payback analysis:

Payback analysis of Proposed Kitchen waste based biogas plant has shown in table:3.5. To understand the technical analysis of kitchen waste based plant the following example will gives an idea to calculate the payback analysis.

ANALYSIS 1 :

- Calorific value of Biogas = 6 kWh/m3
- Calorific value of LPG = 26.1 kWh/m3
- Let us assume; need to boil water sample of 100 gm
- Energy required to boil 100 gm water = 259.59 kJ
- Hence, need of the Biogas to boil 100 gm water = 12.018 lit
- And, we need LPG to boil 100 gm water = 2.76 lit.
- Therefore, amount of water which can be boiled using this much Biogas = 5.408 lit/day Now, amount of LPG required to boil 5.408 lit of water per day = 149.26 lit So. Hence, savings are up to 10 cylinders of LPG per day.

3. CONCLUSIONS:

By utilizing the hostels food waste and other biomass residues can be utilized for better purposes in college campuses. Biogas production requires anaerobic digestion. This paper has analyzed a biogas process and how it can be replace the LPG. A 200 Kg food waste per day in a college campus can replace 329 cylinders for 250 working days in a year.

From my experiment I am able to produce around 10 lit of biogas daily in a 20 lit reactor (digester). According to our purpose of our project we were trying to design reactors of 1000 lit for each and every canteen in Collage (at the backyard of the mess, using kitchen waste directly as a feedstock) Hence I can conclude that we can produce 650 lit of biogas daily in 1000 lit reactor, under ideal conditions (like maintaining pH , VFA , Alkalinity, etc.)

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