**Report Number:** R01

A

REPORT

ON

**BIOGAS PRODUCTION FROM KITCHEN WASTE**

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**DEPARTMENT OF SCIENCE AND HUMANITIES**

**PULCHOWK CAMPUS**

PULCHOWK, LALITPUR

BHADRA 15, 2072

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**PREFACE**

In many developing countries like Nepal, so many people do not access to

modern energy resources. The reserve of fossil fuels is depleting continuously

thereby making the issue of energy security more critical. In Nepal, energy use is

characterized by high use of fuel wood. Deforestation has reduced Nepal’s forest

to a few scrubby trees and causing extreme fuel shortage in rural areas. Biogas

technology is expected to play a vital role in this regard.

This report describes about biogas, its composition, its properties and its role in

energy planning. This technology can be used for cooking and heating system

also. This report mainly includes about biogas production process and factors

affecting biogas production. Biogas is a developing technology and many

researches have been conducted and are being conducted for further

development of this technology.

This report was designed with the intent of making people aware of biogas

generation methods and the factors affecting biogas generation. This report also

includes the scope of biogas in Nepal and its capacity to reduce LPG

consumption.

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**ABSTRACT**

Biogas production requires anaerobic digestion. Project was to Create an

Organic Processing Facility to create biogas which will be more cost

effective, eco-friendly, cut down on landfill waste, generate a high-quality

renewable fuel, and reduce carbon dioxide & methane emissions. Overall by

creating a biogas reactors on campus in the backyard of our hostels will be

beneficial. Kitchen (food waste) was collected from different hostels of Central

Campus Pulchowk’s Mess as feedstock for our reactor which works as

anaerobic digester system to produce biogas energy. The anaerobic digestion of

kitchen waste produces biogas, a valuable energy resource anaerobic digestion

is a microbial process for production of biogas, which consist of primarily

methane (CH4) & carbon dioxide (CO2). Biogas can be used as energy

source and also for numerous purposes. But, any possible applications

requires knowledge & information about the composition and quantity of

constituents in the biogas produced. The continuously-fed digester requires

addition of sodium hydroxide (NaOH) to maintain the alkalinity and pH to 7.

For this reactor we have prepared our Inoculum than we installed batch

reactors, to which inoculum of previous cow dung slurry along with the

kitchen waste was added to develop our own Inoculum. A combination of these

mixed inoculum was used for biogas production at 37°C in laboratory(small

scale) reactor (20L capacity) In our study, the production of biogas and

methane is done from the starch-rich and sugary material and is determined

at laboratory scale using the simple digesters.

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**INTRODUCTION**

Due to scarcity of petroleum and coal it threatens supply of fuel throughout the

world also problem of their combustion leads to research in different corners to

get access the new sources of energy, like renewable energy resources. Solar

energy, wind energy, different thermal and hydro sources of energy, biogas are all

renewable energy resources. But, biogas is distinct from other renewable energies

because of its characteristics of using, controlling and collecting organic

wastes and at the same time producing fertilizer and water for use in

agricultural irrigation. Biogas does not have any geographical limitations nor does

it requires advanced technology for producing energy, also it is very simple to use

and apply.

Deforestation is a very big problem in developing countries like Nepal, most of

the part depends on charcoal and fuel-wood for fuel supply which requires cutting

of forest. Also, soil erosion leads to decrease the fertility of land. Use of dung,

firewood as energy is also harmful for the health of the masses due to the smoke

arising from them causing air pollution. We need an ecofriendly substitute for

energy.

Kitchen waste is organic material having the high calorific value and nutritive

value to microbes, that’s why efficiency of methane production can be increased

by several order of magnitude as said earlier. It means higher efficiency and size

of reactor and cost of biogas production is reduced. Also in most of cities and

places, kitchen waste is disposed in landfill or discarded which causes the

public health hazards and diseases like malaria, cholera, typhoid. Inadequate

management of wastes like uncontrolled dumping bears several adverse

consequences: It not only leads to polluting surface and groundwater through

leachate and further promotes the breeding of flies, mosquitoes, rats and other

disease bearing vectors. Also, it emits unpleasant odour & methane which is a

major greenhouse gas contributing to global warming.

Mankind can tackle this problem(threat) successfully with the help of methane,

however till now we have not been benefitted, because of ignorance of basic

sciences – like output of work is dependent on energy available for doing that

work.

This fact can be seen in current practices of using low calorific inputs like cattle

dung, distillery effluent, municipal solid waste (MSW) or sewage, in biogas plants,

making methane generation highly inefficient. We can make this system extremely

efficient by using kitchen waste/food waste. In 2003, **Dr. Anand Karve[2][4]**

(President ARTI) developed a compact biogas system that uses dstarchy or sugary

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feedstock material and the analysis shows that this new system is 800 times more

efficient than conventional biogas plants.

Why this type of plant?

The proper disposal of Central Campus Pulchowk’s Hostel kitchen waste will be

done in ecofriendly and cost effective way. While calculating the cost effectiveness

of waste disposal we have to think more than monetary prospects. The dumping

of food in places and making the places unhygienic can be taken good care of. It

adds to the value of such Biogas plants. Using the natural processes like

microorganisms kitchen waste & biodegradable waste viz paper, pulp can be

utilized.

Anaerobic digestion is controlled biological degradation process which allows

efficient capturing & utilization of biogas (approx. 60% methane and 40% carbon

dioxide) for energy generation. Anaerobic digestion of food waste is achievable but

different types, composition of food waste results in varying degrees of methane

yields, and thus the effects of mixing various types of food waste and their

proportions should be determined on case by case basis.

Anaerobic digestion (AD) is a promising method to treat the kitchen wastes. While

Anaerobic digestion for treatment of animal dung is common in rural parts of

developing countries, information on technical and operational feasibilities of the

treatment of organic solid waste is limited in those parts. There are many factors

affecting the design and performance of anaerobic digestion. Some are related to

feedstock characteristics, design of reactors and operation conditions in real time.

Physical and chemical characteristics of the organic wastes are important for

designing and operating digesters, because they affect the biogas production and

process stability during anaerobic digestion. They include, moisture content,

volatile solids, nutrient contents, particle size, & biodegradability. The

biodegradability of a feed is indicated by biogas production or methane yield and

percentage of solids (total solids or total volatile solids) that are destroyed in the

anaerobic digestion. The biogas or methane yield is measured by the amount of

biogas or methane that can be produced per unit of volatile solids contained in the

feedstock after subjecting it to anaerobic digestion for a sufficient amount of time

under a given temperature which is taken to be laboratory temperature in our

case.

In recent times varied technological modifications and improvements have been

introduced to diminish the costs for the production of biogas. Different Methods

have been developed to increase speed of fermentation for the bacteria gas

producers, reduction of the size of the reactors, the use of starchy, sugary

materials for their production , the modification of the feeding materials for

fermentation and the exit of the effluent for their better employment, as well as

compaction of the equipments to produce gas in small places like back-yard,

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among others.

Larger facilities operating costs can be reduced, per unit, to the point that,

in the current economic framework, very large Anaerobic Digestion facilities can

be profitable whereas small ones are not this is what is Economics of scale. If

energy prices continue to rise and the demand for local waste treatment, and

fertilizers increases, this framework may change.

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**PROPERTIES OF BIOGAS**

BIOGAS 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.

**Table-1**. Composition of biogas.

**Component Concentration (by volume)**

Methane (CH4) 55-60 %

Carbon dioxide (CO2) 35-40 %

Water (H2O) 2-7 %

Hydrogen sulphide (H2S) 20-20,000 ppm (2%)

Ammonia (NH3) 0-0.05 %

Nitrogen (N2) 0-2 %

Oxygen (O2) 0-2 %

Hydrogen (H) 0-1 %

Composition of biogas depends upon feed material also. Biogas is about 20%

lighter than air has an ignition temperature in range of 650 to 750 0C.An odorless

& colourless gas that burns with blue flame similar to LPG gas. Its caloric value is

20 Mega Joules (MJ) /m3 and it usually burns with 60 % efficiency in a

conventional biogas stove.

Biogas digestor systems provides a residue organic waste, after its anaerobic

digestion(AD) that has superior nutrient qualities over normal organic fertilizer, as

it is in the form of ammonia and can be used as manure. Anaerobic biogas digesters

also function as waste disposal systems, particularly for human wastes, and can,

therefore, prevent potential sources of environmental contamination and the

spread of pathogens and disease causing bacteria. Biogas technology is

particularly valuable in agricultural residual treatment of animal excreta and

kitchen refuse (residuals).

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PROPERTIES:

1. Change in volume as a function of temperature and pressure.

2. Change in calorific value as function of temperature, pressure and water

vapour content.

3. Change in water vapour as a function of temperature and pressure.

FACTORS AFFECTING BIOGAS PRODUCTION

The quantity and nature of organic matter

The temperature

Acidity and alkanity (PH value) of substrate

The flow and dilution of material

TABLE 2:- GENERAL FEATURES OF BIOGAS

Energy Content 6-6.5 kWh/m3

Fuel Equivalent 0.6-0.65 l oil/m3 biogas

Explosion Limits 6-12 % biogas in air

Ignition Temperature 650-750 \*C

Critical Pressure 75-89 bar

Critical temperature -82.5 \*C

Normal Density 1.2 kg/m3

Smell Bad eggs

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**PRODUCTION PROCESS**

A typical biogas system consists of the following components:

(1) Manure collection

(2) Anaerobic digester

(3) Effluent storage

(4) Gas handling

(5) Gas use.

Biogas is a renewable form of energy. Methanogens (methane producing bacteria)

are last link in a chain of microorganisms which degrade organic material and

returns product of decomposition to the environment.

PRINCIPLES FOR PRODUCTION OF BIOGAS

Organic substances exist in wide variety from living beings to dead organisms .

Organic matters are composed of Carbon (C), combined with elements such as

Hydrogen (H), Oxygen (O), Nitrogen (N), Sulphur (S) to form variety of organic

compounds such as carbohydrates, proteins

& lipids. In nature MOs (microorganisms), through digestion process breaks the

complex carbon into smaller substances.

There are 2 types of digestion process:

Aerobic digestion.

Anaerobic digestion.

The digestion process occurring in *presence of Oxygen* is called **Aerobic digestion**

and produces mixtures of gases having carbon dioxide (CO2), one of the main

“greenhouses” responsible for global warming.

The digestion process occurring *without (absence) oxygen* is called **Anaerobic**

**digestion** which generates mixtures of gases. The gas produced which is mainly

methane produces 5200-5800

KJ/m3 which when burned at normal room temperature and presents a viable

environmentally friendly energy source to replace fossil fuels (non-renewable).

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**ANAEROBIC DIGESTION**

It is also referred to as biomethanization, is a natural process that takes place in

absence of air (oxygen). It involves biochemical decomposition of complex organic

material by various biochemical processes with release of energy rich biogas and

production of nutrious effluents.

BIOLOGICAL PROCESS (MICROBIOLOGY)

1. HYDROLYSIS

2. ACIDIFICATION

3. METHANOGENESIS

**HYDROLYSIS:** In the first step the organic matter is enzymolyzed externally by

extracellular enzymes, cellulose, amylase, protease & lipase, of microorganisms.

Bacteria decompose long chains of complex carbohydrates, proteins,

& lipids into small chains. For example, Polysaccharides are converted

into monosaccharide. Proteins are split into peptides and amino acids.

**ACIDIFICATION:** Acid-producing bacteria, involved this step, convert the

intermediates of fermenting bacteria into acetic acid, hydrogen and carbon

dioxide. These bacteria are anaerobic and can grow under acidic conditions. To

produce acetic acid, they need oxygen and carbon. For this, they use dissolved

O2 or bounded-oxygen. Hereby, the acid-producing bacteria creates anaerobic

condition which is essential for the methane producing microorganisms. Also,

they reduce the compounds with low molecular weights into alcohols, organic

acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane.

From a chemical point, this process is partially endergonic (i.e. only possible with

energy input), since bacteria alone are not capable of sustaining that type of

reaction.

**METHANOGENESIS:** (Methane formation) Methane-producing bacteria, which

were involved in the third step, decompose compounds having low molecular

weight. They utilize hydrogen, carbon dioxide and acetic acid to form methane and

carbon dioxide. Under natural conditions, CH4 producing microorganisms occur

to the extent that anaerobic conditions are provided, e.g. under water (for example

in marine sediments), and in marshes. They are basically anaerobic and very

sensitive to environmental changes, if any occurs. The methanogenic bacteria

belongs to the archaebacter genus, i.e. to a group of bacteria with

heterogeneous morphology and lot of common biochemical and molecularbiological

properties that distinguishes them from other bacterias. The main

difference lies in the makeup of the bacteria’s cell walls.

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**FLOW CHART FOR ANAEROBIC DIGESTION**

Fig. 1 Flow chart of anaerobic digestion

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**CONCLUSIONS**

Energy crisis is a major issue of 21st Century and it can be solved using

alternative sources of energy. Biogas, are likely to play an increasing role in

meeting ever-increasing power demands. Because of their efficiency and

environmental advantages, biogas technologies are viewed as an attractive 21st

century solution to energy problems. To sum up, biogas can be expected to find

their applications in several sectors in Nepal. Deployment of biogas technologies

will help not only to produce clean and sustainable power but also to reduce

country’s over-dependence on imported petroleum products.

**RECCOMENDATIONS**

**KITCHEN WASTE:**

1. A separate container for coconut shells, egg shells, peels and chicken

mutton bones. These will be crushed separately by mixer grinders.

2. 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.

In case of installation, important aspect in smoother running of plant by avoiding

the choking of the plant. This occur 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.

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