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Generation of Bioenergy using Wet Feedstock Waste

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Abstract: World's vegetable production is strongly concentrated in Asia. India is next to China in area and production of vegetables in the world. Vegetable waste is produced in huge quantities during the harvesting, poor and inadequate transportation, storage facilities, marketing practices and processing of vegetables. These serve as source of nuisance. The present methods used to dispose the vegetable wastes are inappropriate and cause environmental pollution. In this project, we prepared a model' WET FEEDSTOCK WASTE' to prepare the biogas which produce bio energy for the everyday requirement. In addition, using the stirrer, we are mixing the slurry which in turn makes process faster. Also, by adding the chemicals like lactic acid and lacto bacillus we had made the rapid increase in the duration of forming bio gas.
Keywords: wet feedstock waste, lactic acid, lacto bacillus, rapid increase, stirrer.

I. INTRODUCTION

Anaerobic digestion (AD) is the breakdown of organic material (also known as biomass) by naturally occurring micro-organisms in the absence of oxygen. The process produces biogas which can subsequently be burned to produce heat. Alternatively, it can be fed into a combined heat and power (CHP) generator to produce both heat and electricity or it can be cleaned and used in the same way as natural gas or as a vehicle fuel. The material leftover after digestion, called digestate, can be used as a fertiliser and soil improver. The air-tight tank in which this process takes place is called a bio digester (also known as an anaerobic digester or fermenter).

Biogas can be produced from a variety of feedstocks, commonly manure or slurry from livestock. The advantage of using manure as a feedstock is that it reduces the gaseous releases compared to conventional storage and field application of manure. However, as it has already been digested by the livestock, gas output is relatively low. To boost gas production, it is usually necessary to add energy crops such as maize or silage. This is worthwhile if the cost of production is sufficiently low. Food processing or catering waste can also be added, which not only boosts the gas output but may generate a gate fee which contributes to the profit. Adding food wastes will increase the administrative complexity of the plant as well as adding to the capital cost. Around 57% of biogas in Europe is produced from agricultural waste, 31% from landfill and 12% from wastewater treatment plants. Elsewhere in the world, biogas is produced primarily by landfill-based plants or small-scale family digesters.

A. 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.

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 (N)	0-2 %
Oxygen (O2)	0-2 %

Table-1. Composition of biogas.

B. Characterstics of Biogas

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 &colorless 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.

This gas is useful as fuel to substitute firewood, cow-dung, petrol, LPG, diesel, & electricity, depending on the nature of the task, and local supply conditions and constraints.

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.

C. Properties Of Biogas

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.

D. Factors Affecting Yield And Production Of Biogas

Many factors affecting the fermentation process of organic substances under anaerobic condition are,

1) The quantity and nature of organic matter
2) The temperature
3) Acidity and alkanity (PH value) of substrate
4) The flow and dilution of material

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

TABLE 2: - General features of biogas

E. Problem Statement

There is an increase in production and consumption of fruits and vegetables, resulting in accumulation of fruits and vegetable wastes on Ghanaian markets.

This is as result of;

1) Inadequate containers or equipment for storing and transporting solid waste, and
2) Lack of definite schedule for collecting waste from storage to disposal sites.

Waste collectors may show up every week, every three weeks or even after one month. Such irregular waste collection programme leads to overflow of waste at storage points. Consequently when these wastes are being conveyed in trucks to the dumpsites, due to their overflowing nature, they end up falling off the trucks and litter the very place they are trying to keep clean. This situation not only create uncomfortable condition in the markets but also, since fruit and vegetable wastes are quickly degraded when not attended to, poses serious environmental problems such as soil and groundwater pollution, being washed into streams and other water bodies when it rains, thereby contaminating the water bodies and also adds to the accumulation of greenhouse gases. Therefore an appropriate method to treat waste is needed to overcome the problems caused by accumulation of fruit and vegetable waste at market sites.

F. Justification

Energy could be derived from the fruit and vegetable wastes in the form of biogas and also the by product could be used for soil amendment, which would be beneficial from the view point of both environmental protection and economic development.

G. Objectives

1) Main Objective: To enhance the management of fruit and vegetable wastes by converting it into biogas.
2) Specific Objective
a) To find the carbon and nitrogen contents of some selected fruits and vegetables.
b) To determine the yield of biogas from the selected fruit wastes, vegetable wastes and a mixture of the fruit and vegetable wastes

II. LITERATURE REVIEW

ARTI – appropriate rural technology of India, pune (2003) has developed a compact biogas plant which uses waste food rather than any cow dung as feedstock, to supply biogas for cooking. The plant is sufficiently compact to be used by urban households, and about 2000 are currently in use – both in urban and rural households in Maharashtra. The design and development of this simple, yet powerful technology for the people, has won ARTI the Ashden Award for sustainable Energy 2006 in the Food Security category.

Dr. Anand Karve [1] [2] et al. (2006) (ARTI) developed a “compact biogas system that uses starchy or sugary feedstock”.

waste grain flour, spoilt grain, overripe or misshapen fruit, nonedible seeds, fruits and rhizomes, green leaves, kitchen waste, left-over food, etc. Just 2 kg of such feedstock produces about 500 g of methane, and the reaction is completed with 24 hours. The conventional biogas systems, using cattle dung, sewerage, etc. use about 40 kg feedstock to produce the same quantity of methane, and require about 40 days to complete the reaction. Thus, from the point of view of conversion of feedstock into methane, the system developed by Dr. Anand Karve [1][2] is 20 times as efficient as the conventional system, and from the point of view of reaction time, it is 40 times as efficient. Thus, overall, the new system is 800 times as efficient as the conventional biogas system.

Hilkiah Igoni [3] et al. (2008) studied “The Effect of Total Solids Concentration of Municipal Solid Waste on the Biogas Produced in an Anaerobic Continuous Digester”.

The total solids (TS) concentration of the waste influences the pH, temperature and effectiveness of the microorganisms in the decomposition process.

They investigated various concentrations of the TS of MSW in an anaerobic continuously stirred tank reactor (CSTR) and the corresponding amounts of biogas produced, in order to determine conditions for optimum gas production. The results show that when the percentage total solids (PTS) of municipal solid waste in an anaerobic continuous digestion process increases, there is a corresponding geometric increase for biogas produced. A statistical analysis of the relationship between the volume of biogas produced and 20 the percentage total solids concentration established that the former is a power function of the latter, indicating that at some point in the increase of the TS, no further rise in the volume of the biogas would be obtained.

Kumar [4] et al., (2004) investigated “The Estimation method for national methane emission from solid waste landfills”.

Atmospheric Environment.

They concluded that it has more than 20 times the global warming potential of carbon dioxide and that the concentration of it in the atmosphere is increasing with one to two per cent per year. The article continues by highlighting that about 3 to 19% of anthropogenic sources of methane originate from landfills.

Shalini Singh [5] et al. (2000) studied “The increased biogas production using microbial stimulants”.

They studied the effect of microbial stimulant aquasan and teresan on biogas yield from cattle dung and combined residue of cattle dung and kitchen waste respectively. The result shows that dual addition of aquasan to cattle dung on day 1 and day 15 increased the gas production by 55% over unamended cattle dung and addition of teresan to cattle dung: kitchen waste (1:1) mixed residue 15% increased gas production.

Lissens [6] et al. (2004) studied “Thermal wet oxidation improves anaerobic biodegradability of raw and digested biowaste”.

Completed a study on a biogas operation to increase the total biogas yield from 50% available biogas to 90% using several treatments including: a mesophilic laboratory scale continuously stirred tank reactor, an up-flow biofilm reactor, a fiber liquefaction reactor releasing the bacteria Fibrobacter succinogenes and a system that adds water during the process. These methods were sufficient in bringing about large increases to the total yield; however, the study was under a very controlled method, which leaves room for error when used under varying conditions. However, Bouallagui et al. (2004) did determine that minor influxes in temperature do not severely impact the anaerobic digestion for biogas production

III. COMPONENTS

A. Frame
B. Inlet
C. Gas line
D. Pressure gauge
E. Flexible hoses
F. Motor
G. Shaft
H. Bearing
I. Outlet

IV. PLAN OF WORK

For the good results and expected output, proper planning is required. Planning is the thinking before doing. While planning, each steps and processes to be analysed carefully with all the factors to avoid the error and difficulties.

A. Design And Drawings

The design factor should be carefully considered. Detail drawings are necessary for designing and also fabricating the project. Development and modification of the system should be in the simplest form.

B. Selection Of Components

The mechanical components to be selected according to the requirement of the mechanism. It is difficult to manufacture all the components required for fabrication in the machine shop itself. The decision about particular component whether to be purchased or manufactured is decided after making a study of relative merits and demerits of direct purchase and self-manufacture.

C. Fabrication

Next step of the project is to select the best method of manufacture, so that the wastage of materials, man power, machine power and time can be reduced to a 5 greater extent. By comparing various methods, the best method of manufacturing is to be selected. The purpose of necessity of operation and machine tools used to do the jobs are considered while selecting the best method of manufacture.

D. Assembly of The Parts

The fabricated and purchased components are assembled together to complete the fabrication process.

E. Cost Estimation

Cost estimation to be calculated by considering all the components and other fabricated charges and other charges.

1) Material cost
2) Labour cost
3) Transportation cost

F. Result And Discussion

The result of the project to be analyzed and the detailed report to be prepared with the challenges and the drawbacks of the project.

V. PRODUCTION PROCESS

A typical biogas system consists of the following components

1) Vegetable 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.

A. 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:

1) Aerobic digestion.
2) 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 "green houses" 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).

VI. 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.

A. Hydrolysis

In the first step the organic matter is enzymolysed 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.

B. 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.

C. Methanogenesis

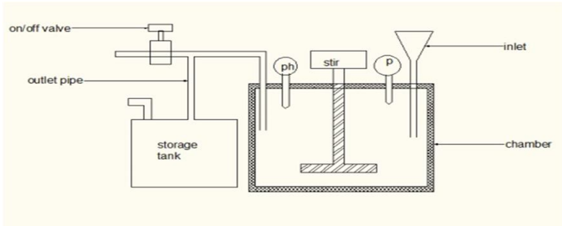
(Methane formation) Methane-producing bacteria, which were involved in the third step, decompose compounds having low molecular weight. They utilize hydrogen, carbon dioxide and acetic acid to form methane and carbon dioxide. Under natural conditions, CH4 producing microorganisms occur to the extent 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 belong to the archaebacter genus, i.e. to a group of bacteria with heterogeneous morphology and lot of common biochemical and molecular-biological properties that distinguishes them from other bacteria's. The main difference lies in the makeup of the bacteria's cell walls.

1) *Factors That Influence Anaerobic Digestion:* There are some factors that can influence the anaerobic digestion process. The factors include the following:
2) *Temperature:* Small changes in temperature can cause significant decrease in activity of microbial and gas production up to 30%; therefore, the temperature should be kept exactly in the range of +/-2ºC (Deublein, 2008). The involved bacteria are active within limited range of temperature, especially methanogens that are the methane-producing bacteria (Özmen and Aslanzadeh, 2009).
3) *Substrate:* Substrate is material and energy source for the microorganism which is consumed by microorganism and converted to methane as well as the use for growth. Types of substrate determine the rate of the digestion process, and lack of substrate ends the metabolism of the microorganism as well as determining the time of digestion, since more complex substrate will take longer time for degradation by microorganism (Anti, 2012).

4) Ph: pH is an important factor that affects microbial activity and control the anaerobic digestion process as the pH of the substrate influences the growth of methanogenic bacteria.eg. Anti (2012) indicated that, anaerobic digestion operated in a pH below 6.5 decreases the organic acid production by hydrolytic bacteria, as well as decreases the methane production. Generation of wastes

Fruit and vegetables are quickly degraded by contaminating microorganisms and this takes place faster when they show signs of mechanical damage or are excessively ripe (Efisio*et al.,* 2014). According to FAO UN (2011), the main fruit and vegetable waste stream originates from agricultural production which include the losses due to improper harvest operation, postharvest handling and storage, processing which produces waste composition such as peels, seeds, waste pulp, distribution which involves losses during transportation from storage to market or retailers and consumption which includes waste from consumption of fresh fruit in the household.

VII. DESIGN DIAGRAM



VIII. WORKING

Biogas is a clean and renewable fuel that you can make yourself. The main part of a biogas system is a large tank, or digester. Inside this tank, bacteria convert organic waste into methane gas through the process of anaerobic digestion. Each day, the operator of a biogas system feeds the digester with household by-product as market waste. The methane gas produced inside biogas system may be used for cooking, lighting and other energy needs. Waste that has been fully digested exists the biogas system in the form of organic fertilizer.

A. Organic input materials such as foodstuff remnants, fats or sludge can be fed into the biogas digester.
B. Vegetable wastage are a fed into the biogas digester. Also by adding the chemicals like lactobacillus and lactic acid.
C. We closed tightly the chamber, the substrate is decomposed by the microorganisms under the absence of oxygen.
D. The biogas generated is stored in the roof of the tank and from there it.
E. In addition, using the stirrer, we are mixing the slurry which in turn makes the process more faster.
F. In more amount biogas generated from the chamber and we have made rapidly increased in the duration of forming biogas.

IX. CONCLUSION

Vegetable wastes have high carbohydrate and high moisture content and thus are a good substrate for the production of biogas through biomethanation process. Several researchers have studied biogas production from mixture of vegetable waste. Biogas yield reported by researchers is in the range of 0.360 L/g of VS to 0.9 L/g VS added. The temperature, pH and organic loading rates have a pronounced effect of vegetable waste biomethanation. The reactors of different designs also influence on the biogas yield. The use of appropriate catalysts is found to increase the biogas yield from anaerobic digestion of vegetable waste. Thus, biomethanation appears to be an eco-friendly technology for the treatment of vegetable waste.

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PHOTOGRAPHY