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# Biogas production from potato waste and cow dung mixture

**Suman Chandra Roy**

Abstract

Potato is one of the most important food crops in Bangladesh .In our country potato waste is available. Biogas is one of the most vital sources of energy. Biogas is the renewable energy source. In our country biogas is produced from animal manure .Usually cow dung is the common raw material for the production of biogas. If biogas is obtained from potato waste or potato waste is used along with cow dung for biogas production then this will ensure the proper use of potato waste.



- ***Objectives***

The overall objective of the research is to ensure the proper use of potato waste. It is one kind of solid waste management .If we can produce biogas from potato waste ,this will be the proper use of potato waste.

**The specific objectives are as follows:**

- To produce biogas from potato waste.
- To use potato waste with cow dung for biogas production and observe the rate of biogas production.
- To disseminate new knowledge and technology developed through research in the field of biogas.
- To make entrepreneurs aware about opportunities in the field of biogas in the developing countries.

- To use biogas as an alternative source instead of natural gas for engine operation.

***Importance of the study:***

Bangladesh like other developing countries is facing a huge shortage of energy and power that caused slowing down the economic development as well as GDP growth. Although biogas program will have not a large impact on solving these problems, development of a large number of commercial biogas plants at rural and semi urban areas can reduce the government's pressure for further expansion of natural gas in country wide by gas distribution networks for households and small industries in rural and semi urban areas.

Biogas programs started in Bangladesh from early 1972[4]. Dr. M.A. Karim, a professor of Bangladesh Agriculture University (BAU) first set up a 3$m^3$ biogas plant at the university campus. Still now only approximately 34,000 biogas plants have been installed allover Bangladesh[5]. Different government, nongovernment organizations and developing partners are now involved in the promotion and dissemination of households and large scale biogas plants in Bangladesh. The Infrastructure Development Company Limited (IDCOL) is implementing the National Domestic Biogas and Manure Program (NDBMP) with support from GoB, SNV Netherlands and Kfw. Under the project a total of 37,269 domestic sized biogas plants will be financed.

Under the SED program, the target was to install over 2000 large size commercial biogas plant by 2009[7].Up to May 2010 total 1250 biogas plants have been installed under thisprogram.
There are some researches on impact and financial viability has been done for the domestic biogas plants. But this research has analyzed socio-economic impact and financial viability of large scale biogas plants. Different Organizations and the poultry and dairy farm owners hesitate to invest in the large biogas plants because of past failure of domestic biogas plants as stated in chapter 1.1. This study comprises the some very useful findings of the functioning status, impact on conventional fuel savings, slurry management, income generating, environmental impact and financial viability by explaining case studies. This study will help the future planner to further invest in commercial biogas plants and to remove the barriers which cause negative impact.

- ***Summary of Literature review***

The first biogas plant was introduced by one professor of Bangladesh Agricultural University (BAU) Dr. M. A. Karim in 1972 in the University campus. (Wim J. van Nes and et. al,august

2005).Ekkehard Kürschner (2009) studied that regarding access to biomass is becoming more expensive and scarce due to high demand. The infrastructure for energy generation and distribution is deficient and is not sufficiently extended to match the high demand. Electricity is unreliable because of insufficient power generation capacities.

Prakash C. Ghimire (2005) study explained that the interest in Biogas technology in Bangladesh is growing due to the increasing awareness of the importance of the renewable energy sources and their potential role in decentralized energy generation in rural areas. The rate of growth of biogas technology is expected to accelerate in future and realization of the importance of biogas in enhancing rural livelihoods. Implementation plan 2010-2012 of National Domestic Biogas and Manure Program of IDCOL mentioned that total technical potential of domestic biogas plants is 3 million. "Mobilizing market for the biogas technology" of GTZ study explained that the large potential market for the biogas digester in 100,000 poultry farms could benefit from the technology through the savings of traditional cooking fuel as well as prevention of disease and pathogen free fertilizer.



Prakash C. Ghimire (2005) study containing a sample of 66 biogas plants in different districts showed that the majority of the plants were under-fed. 47 % were functioning full capacity, 22% were functioning partly and 14 % not functioning at all. This study also showed that the average fuel savings was 156 kg/household/month. DPC group study showed that 88.5 % of plants constructed by BCSIR during phase I were functional and 97.2 % of the plants were functional for phase II Monsof Ali showed that 50% of biogas plants were not functioning at all. 16 % were well functioning, 19 % well functioning with some rare interruptions and 15 % functioning with many interruptions.

**Biogas:**

First Biogas plant was installed in Bangladesh in 1972 for an experimental basis. Now many organizations are involved for installing biogas plants in Bangladesh. Up to 2005 only 23,784 biogas plants were installed by Government, NGO's, and Research organizations[25]. Currently IDCOL is implementing National domestic biogas and manure program. IDCOL biogas program started from 2006 and it has already installed more than 10,000 domestic biogas plants. According to IDCOL, it is possible to install 3 million[26] domestic biogas plants. IDCOL's target is to install 37,269 biogas plants within 2012[27]. GTZ is also providing technical and financial assistant to its Partner Organizations to install commercial and institutional biogas plants. Up to May 2010 GTZ implemented 1250 commercial and institutional biogas plants. GTZ is also providing technical assistant for electricity generation from biogas.

## Use of Biomass Fuels

Biomass fuels play an important role (about 65% of primary energy ) in meeting total energy need of the country. But they are now being consumed beyond their regenerative limits. Unplanned and uncontrolled use of biomass fuels is causing environmental degradation.
In the foreseeable future there are limited prospects of increasing the supply of biomass fuels. On the other hand, it is not economically viable to substitute all the biomass fuels by commercial fuels. From environmental consideration there is aneed to maintain the supply of biomass fuels within the regenerative limits and the demand of biomass fuels in excess of sustainable limits is to be met by commercial fuels.



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## *Biogas technology and its potential in Bangladesh*

### Biogas Technology

Biogas fermentation is the process by which organic materials such as human or animal excreta, domestic wastage, agricultural wastage etc, are degraded, by huge quantities of various microbes of different functions, under anaerobic conditions, to yield methane (about 55-70% content), carbon dioxide (about 30-45% content) and low amount of other gases (i.e. Hydrogen, Nitrogen, Water vapor, Hydrogen Sulphide) in the end[37].
The whole process of conversion has three phases,

- The hydrolysis phase

- Acidic phase and
- Methanogenic phase

- Manure of human being, animals and poultry are easily biodegradable. They are nutrimental for microbes and with high nitrogen content, especially for the manure of chicken and pigs. The daily production of manure depends on the feeds and body weight of animal and poultry. The TS%, C/N ratio, daily gas yield per kg TS and CH4 content from different manures are as follows

**Table 2. The TS%, C/N ratio, daily gas yield per kg TS and $CH_4$[38]**

| Manure source | Body Weight(Kg | Manure yield (Kg/day) | TS% | C/N ratio | Gas yield (m3/ kg TS) (at 25-35$^0$C ambient temp.) | CH4% |
|---|---|---|---|---|---|---|
| Chicken | 1 | 0.1 | 25 | 9.65:1 | 0.33 | 60-65 |
| Pig | 50 | 5 | 18 | 13:1 | 0.27 | 50-77 |
| Cattle | 500 | 35 | 17 | 25:1 | 0.25 | 50-77 |
| Human | 50 | 0.5 | 20 | 2.9:1 | 0.30 | 69-74 |

Biogas is about 20% lighter than air and has ignition temperature in the range of 650to 750$^0$C[39]. It is an odorless and colorless gas that burns with clear blue flame similar to that of LPG gas. Its calorific value is 20 MJ/$m^3$and burns with 60% efficiency in a conventional biogas stove[40].

**Potential of Biogas in Bangladesh**

Most of the rural people of Bangladesh get energy from fuel wood, agricultural residues, cow dung, and kerosene. Only 3% of the people enjoy natural gas facilities connected to their home through pipelines mostly in eastern part of the country in big cities and 47% people has access to electricity[41]. The electricity is not reliable in Bangladesh. Moreover in the rural areas households are scattered. As a result, the electricity grid extension and gas through pipeline may not be cost effective to every village of Bangladesh. 83% of the electricity produced in the country is natural gas based which reserve is limited and will be exhausted in near future. To face this worst situation decentralized energy system like solar, biogas could be the best option for rural energy supply.

Early stage history of biogas technology in Bangladesh was not good. Several efforts had been taken by different Government organizations and NGO's for the dissemination of biogas technology from 1972 to 1990. But these efforts were not successful as desired. An important dissemination push and the considerable number biogas plants were delivered by the Biogas Pilot Plant (1$^{st}$phase) project which was implemented by BCSIR during the period July 1995 to June 2000. Under this project total 4,664 fixed dome biogas plants were installed all over Bangladesh. After successfully completed 1$^{st}$ phase, BCSIR started 2$^{nd}$ phase in July 2000 and continue up to June 2004. Total target was to install 20,000 biogas plants out of which 17,194 biogas plants were installed during this time. In parallel, another large biogas project was implementing by LGED during the time 1998 to 2003. Under this project the target was to install 5000 biogas plants. But during this time they could install 1120 plants. Annex1provides an overview of the history of biogas plants in Bangladesh.

Bangladesh climate is favorable for biogas production. The ideal temperature for biogas production is $30^0$ to $45^0$C[42]. The Normal minimum and maximum temperature in Bangladeshis illustrated in the following table 3.

**Table 3: Month wise maximum and minimum temperature in Bangladesh[43]**

| Month | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEPT | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Max. Temp. | 25.2 | 27.8 | 31.6 | 33.2 | 32.9 | 31.9 | 31.1 | 31.4 | 31.5 | 31.5 | 29.5 | 26.4 |
| Min. Temp. | 12.5 | 15.1 | 19.6 | 23.1 | 24.5 | 25.6 | 25.6 | 25.7 | 25.4 | 23.6 | 19.2 | 14.2 |

From above table normal temperature of Bangladesh varies from $12.5^0$ to $32^0$C. But the inside temperature of biogas digester remain $22^0$ to $30^0$C[44]. This temperature is near to ideal temperature. More over raw material for biogas digester is available and cheap in everywhere in Bangladesh. Hazardous materials such as poultry liter, cow dung, human excreta which pollutes environment, spread bad smell and diseases are the raw materials for biogas plants. Biogas is formed through fermentation in an anaerobic condition. So, all the harmful bacteria are killed by this process.

## Potential of Electricity Generation from Biogas

There are 96,987 registered poultry farms in Bangladesh as mentioned above. The farm size varies from 100 birds to 50000 birds. According to Dr. MahbuburRahman, Consultant, Department of Livestock, Ministry of Fisheries & Livestock a more detail estimate of the farm sizes which are given in table 8.

**Table 8: Farm size in terms of no of birds[52]**

| Size (No of birds) | No. of farms (approximate) |
|---|---|
| 100 – 249 | 15,000 |
| 250 – 499 | 35,000 |
| 500 – 999 | 45,000 |
| 1,000 – 4,999 | 12,000 |
| 5,000 – 9,999 | 8,000 |
| 10,000 – 50,000 | 1,200 |
| > 50,000 | 50 |

The farm having 1000 or more than 1000 are potential to generate electricity. The average farm size has been calculated from table 9 which shows about 20,000 poultry farms are potential for electricity generation.

Table 9: **Average farm size calculated from table 13**

| Average Size (No of birds) | No. of farms (approximate) |
|---|---|
| 175 | 15,000 |
| 375 | 35,000 |
| 750 | 45,000 |
| 3,000 | 12,000 |
| 7,500 | 8,000 |
| 30,000 | 1,200 |
| >50,000 | 50 |

According to Dr. Khurshidul Islam, Sr. Advisor of SED, 1kWh energy can be generated from $0.71m^3$ of biogas. Approximate electricity generations from the different size of farmsare shown in table 10.

**Table 10: Potential of electricity generation from different size of farms[53]**

| Size (No of birds) | No. of farms (approximate) | Biogas production per farm(m3/day) | Electricity Generation per farm(kWh/day) | Total electricity generation(kWh/day) | Total electricity generation(GWh/year |
|---|---|---|---|---|---|
| 3000 | 12000 | 21.3 | 30 | 360000 | 131.4 |
| 7500 | 8000 | 53.25 | 75 | 600000 | 219 |
| 30000 | 1200 | 213 | 300 | 360000 | 131.4 |
| >50000 | 50 | 355 | 500 | 25000 | 9.125 |
| | **Total** | **642.55** | **905** | **1345000** | **490.925** |

Therefore, poultry sector alone can produce about 490 GWh energy per year which is nearly 2%of total electricity generation 26603.95 GWh of the country in 2008-2009 financial years.

## Advantages of biogas technologies

The production and utilization of biogas from AD provides environmental and socioeconomic benefits for the society as a whole as well as for the involved farmers. Utilization of the internal value chain of biogas production enhances local economic capabilities ,safeguards jobs in rural areas and increases regional purchasing power. It improves living standards and contributes to economic and social development.

**Benefits for the society**

**Renewable energy source**

The current global energy supply is highly dependent on fossil sources (crude oil, lignite, hard coal, natural gas). These are fossilized remains of dead plants and animals, which have been exposed to heat and pressure in the Earth's crust over hundreds of millions of years. For this reason, fossil fuels are non-renewable resources which reserves are being depleted much faster than new ones are being formed The World's economies are dependent today of crude oil. There is some disagreement among scientists on how long this fossil resource will last.



Unlike fossil fuels, biogas from AD is permanently renewable, as it is produced on biomass, which is actually a living storage of solar energy through photosynthesis. Biogas from AD will not only improve the energy balance of a country but also make an important contribution to the preservation of the natural resources and to environmental protection.

**Warming**

Utilization of fossil fuels such as lignite, hard coal, crude oil and natural gas converts carbon, stored for millions of years in the Earth's crust, and releases it as carbon dioxide ($CO_2$) into the atmosphere. An increase of the current $CO_2$ concentration in the atmosphere causes global warming as carbon dioxide is a greenhouse gas (GHG). The combustion of biogas also releases $CO_2$. However, the main difference, when compared to fossil fuels, is that the carbon in biogas was recently up taken from the atmosphere, by photosynthetic activity of the plants.

The carbon cycle of biogas is thus closed within a very short time (between one and several years). Biogas production by AD reduces also emissions of methane ($CH_4$) and nitrous oxide ($N_2O$) from storage and utilization of untreated animal manure as fertilizer. The GHG potential of methane is higher than of carbon dioxide by 23 fold and of nitrous oxide by 296 fold. When biogas displaces fossil fuels from energy production and transport, a reduction of emissions of CO2, CH4 and N2O will occur, contributing to mitigate global warming.

**Reduced dependency on imported fossil fuels**

Fossil fuels are limited resources, concentrated in few geographical areas of our planet. This creates, for the countries outside this area, a permanent and insecure status of dependency on import of energy. Most European countries are strongly dependent on fossil energy imports from regions rich in fossil fuel sources such as Russia and the Middle East. Developing and implementing renewable energy systems such as biogas from AD, based on national and regional biomass resources, will increase security of national energy supply and diminish dependency on imported fuels.



**Contribution to EU energy and environmental targets**

Fighting the global warming is one of the main priorities of the European energy and environmental policies. The European targets of renewable energy production, reduction of GHG emission, and sustainable waste management are based on the commitment of the EU member states to implement appropriate measures to reach them. The production and utilization of biogas from AD has the potential to comply with all three targets at the same time.

**Waste reduction**

One of the main advantages of biogas production is the ability to transform waste material into a valuable resource, by using it as substrate for AD. Many European countries are facing enormous problems associated with overproduction of organic wastes from industry, agriculture and households. Biogas production is an excellent way to comply with increasingly restrictive national and European regulations in this area and to utilize organic wastes for energy production, followed by recycling of the digested substrate as fertilizer. AD can also contribute to reducing the volume of waste and of costs for waste disposal.

**Job creation**

Production of biogas from AD requires work power for production, collection and transport of AD feedstock, manufacture of technical equipment, construction, operation and maintenance of biogas plants. This means that the development of a national biogas sector contributes to the establishment of new enterprises, some with significant economic potential, increases the income in rural areas and creates new jobs.

**Flexible and efficient end use of biogas**

Biogas is a flexible energy carrier, suitable for many different applications. One of the simplest applications of biogas is the direct use for cooking and lighting, but in many countries biogas is used nowadays for combined heat and power generation (CHP) or it is upgraded and fed into natural gas grids, used as vehicle fuel or in fuel cells.

**Low water inputs**

Even when compared to other bio fuels, biogas has some advantages. One of them is that the AD process needs the lowest amount of process water. This is an important aspect related to the expected future water shortages in many regions of the world.



**Benefits for the farmers**

Additional income for the farmers involved

Production of feedstock in combination with operation of biogas plants makes biogas technologies economically attractive for farmers and provides them with additional income.

The farmers get also a new and important social function as energy providers and waste treatment operators.

**Digestate is an excellent fertilizer**

A biogas plant is not only a supplier of energy. The digested substrate, usually named digestate, is a valuable soil fertilizer, rich in nitrogen, phosphorus, potassium and micronutrients, which can be applied on soils with the usual equipment for application of liquid manure. Compared to raw animal manure, digestate has improved fertilizer efficiency due to higher homogeneity and nutrient availability, better C/N ratio and significantly reduced odors.

**Closed nutrient cycle**

From the production of feedstock to the application of digestate as fertilizer, the biogas from AD provides a closed nutrient and carbon cycle (Figure 1.2). The methane (CH4) is used for energy production and the carbon dioxide (CO2) is released to the atmosphere and re-up taken by vegetation during photosynthesis. Some carbon compounds remain in the digestate, improving the carbon content of soils, when digestate is applied as fertilizer. Biogas production can be perfectly integrated into conventional and organic farming, where digestate replaces chemical fertilizers, produced with consumption of large amounts of fossil energy.

**Flexibility to use different feedstock**

Various types of feedstock can be used for the production of biogas: animal manure and slurries, crop residues, organic wastes from dairy production, food industries and agro industries, wastewater sludge, organic fraction of municipal solid wastes, organic wastes from households and from catering business as well as energy crops. Biogas can also be collected, with special installations, from landfill sites.



One main advantage of biogas production is the ability to use “wet biomass” types as feedstock, all characterized by moisture content higher than 60–70% (e.g. sewage sludge, animal slurries, flotation sludge from food processing etc.). In recent years, a number of energy crops (grains, maize, rapeseed), have been largely used as feedstock for biogas production in countries like Austria or Germany. Besides energy crops, all kinds of agricultural residues, damaged crops, unsuitable for food or resulting from unfavorable growing and weather conditions, can be used to produce biogas and fertilizer. A number of animal by-products, not suitable for human consumption, can also be processed in biogas plants

**Veterinary safety**

Application of digestate as fertilizer, compared to application of untreated manure and slurries, improves veterinary safety. In order to be suitable for use as fertilizer, digestate is submitted to a controlled sanitation process. Depending of the type of feedstock involved, sanitation can be provided by the AD process itself, through a minimum guaranteed retention time of the substrate inside the digester, at thermophilic temperature, or it can be done in a separate process step, by pasteurization or by pressure sterilization. In all cases, the aim of sanitation is to inactivate pathogens, weed seeds and other biological hazards and to prevent disease transmission through digestate application.

### *Economic and Operational Consideration*

There are different basic situations out of which the use of biogas for the generation of mechanical or electric energy may be considered.

a) Biogas availability or potential

- A biogas plant already exists and the gas yield is larger than what is already consumed in other equipment or the yield could be increased.
- Organic matter is available and otherwise wasted; the boundary conditions allow for anaerobic digestion.
- Environmental laws enforce anaerobic treatment of organic waste from municipalities, food industries, distilleries, etc.

b) Demand for mechanical power

- Other fuels are practically not available.
- Other sources of energy or fuels are more expensive or their supply is unreliable.
- Having a fuel at one's own disposal is of specific advantage.

c) Possible revenue through selling mechanical power, electric power or related services to other customers (e.g. the public electricity supply company).

In all cases it is essential to combine the modes of the generation of the fuel and its consumption. While the biogas is produced in a continuous mode, the demand for power, hence fuel, is often discontinuous. Biogas, unlike liquid fuels, can be stored in larger quantities either in a compressed form requiring special efforts or in large, low pressure storage tanks. However, both ways are costly. This provides an incentive to avoid extensive storage through a well-balanced production and consumption of biogas. One way of equalizing the demand profile is the continuous operation of the engine, hence continuous fuel consumption. Instead of operating a powerful machine and engine for a short period per day the same service can often be obtained by a smaller system operating for a longer period. A similar effect is reached by the operation of different equipment in a sequence rather than at one time, e.g. water is pumped overnight while grains are milled during the day. The smaller system not only requires lower investment itself, but it also requires smaller or no gas storage capacities. The planning of the operational schedule of the equipment has a considerable effect on the economics and feasibility of biogas engine projects. In cases where biogas is used for electricity generation, the mode of operation, i.e. in an isolated grid or in parallel to an existing larger grid (e.g. public utility), further influences the power demand situation and the choice of the gen-set's power class.

***Biogas for Vehicles***

The use of biogas in vehicles requires a method of compact storage to facilitate the independent movement of the vehicle for a reasonable time. Larger quantities of biogas can only be stored at small volumes under high pressure, e.g. 200 . . . 300 bar, or purified as methane in a liquid form at cryogenic conditions, i.e. -161°C and ambient pressure. The processing, storage and handling of compressed or liquefied biogas demand special and costly efforts. Compression is done in reciprocating gas compressors after filtering of $H_2S$. At a medium pressure of about l5 bar the $CO_2$ content can be "washed out" with water to reduce the final storage volume. Intermediate cooling and removal of the humidity in molecular sieve filters are essential as the storage containers should not be subjected to corrosion from inside. The storage cylinders, similar to oxygen cylinders known from gas welding units, can be used on the vehicle as "energy tank" and in larger numbers as refilling store. One cylinder of 50l volume can store at a pressure of 200 bar approximately- 15 $m^3$ un-purified biogas ($CH_4$ = 65% Vol.) with an energy equivalent of 98 kWh or diesel fuel, or- 13 $m^3$ purified biogas ($CH_4$ = 95% Vol.) with an energy equivalent of 125 kWh or diesel fuel.

The storage volume thus required on the vehicle is still five times more than is required for diesel fuel. Purification of biogas to $CH_4$ increases the storage efficiency by 25 to 30% but involves an extra gas washing column in the process .Purified biogas, i.e. methane, has different combustion features than biogas because of the lack of the $CO_2$ content. It combusts faster and at higher temperatures; this requires different adjustments of ignition timing. Dual fuel methane engines are prone to increased problems with injector nozzle overheating and have to operate on higher portions of diesel fuel (about 40%) to effect sufficient cooling of the jets. Liquefaction of biogas requires drying and purification to almost 100% $CH_4$ in one process and an additional cryogenic process to cool the $CH_4$ down to -161°C where it condenses into its liquid form. Storage is optimal at these conditions as the volume reduction is remarkable, i.e. 0.6 $m^3n$ with an energy content of 6 kWh condense to one lifer of liquid with an energy equivalent of 0.61 diesel fuel. The required tank volume is only 1.7 times the volume needed for diesel fuel. This advantage is opposed by a more sophisticated multistage process, the handling of the liquid in specially designed cry-tanks with vacuum insulation and the fact that for longer storage it has to be kept at its required low temperature in order to prevent evaporation. This requires additional energy and equipment. Data on the economic viability are not yet available. The use of biogas as a fuel for tractors on farms has been elaborately researched.

The processing of the gas does not only require about 10% of the energy content of the gas, mainly for compression, but also involves considerable investment. The tractor itself needs to carry four gas cylinders at least for a reasonable movement radius. A 40kW tractor can then operate for about six to seven hours at mixed or medium load. The modification of the tractor has to include a three-stage pressure reduction system as the fuel gas is fed to the mixer at low pressure, i.e. about 50 mbar. Modification into an Otto gas engine includes the risk of non-availability of the tractor at biogas shortage. It therefore needs LPG as spare fuel or another diesel tractor standby. Dual fuel tractor engines, on the other hand, are difficult to control, especially because of their frequent speed and load changes during operation in the field. Biogas for road service has become an issue in Brazil lately. It must however be seen in connection with the specific situation in this country.

The main issue is to utilize the large natural gas resources for substitution of diesel fuel, which is scarce. Purified biogas is therefore integrated into a larger" methane program", for which the government may decide to give specific economic preferences because of energy-political reasons. The biogas will furthermore be obtained and processed in larger units, e.g. municipal sewage plants and sugar factories, which reduce the cost per $m^3$ considerably. With the current (political) price of fuel in industrialized countries the equivalent price for "vehicle biogas" is about two or three times higher than for diesel fuel. It is therefore presently not economic though technically feasible to use biogas in vehicles on a larger scale. The infrastructure for processing and filling however must also be developed accordingly.

# Methodology

**Raw Materials:-** Potato waste is the main raw material. It is collected from local market.

**Preliminary Treatment:-** Potato waste collected from local market is not suitable for the work. Because there are some dirt, soil along with potato waste. So after collecting potato waste is washed properly with water. Then it is dried in the open air.

**Table:- Characteristics of Potato Waste**

| Parameters | Value | |
|---|---|---|
| | Potato Waste -01 | Potato Waste -02 |
| pH | 5.74 | 6.64 |
| Total solid | 21.94% | 20.37% |
| Total Phosphate/OrthoPhosphate | 0.085g/l | 0.049g/l |
| Total Kjeldahl nitrogen | 0.0414% | 0.066% |
| Organic carbon | 8.514% | 10.85% |



**Moisture Content:-** For biogas production moisture content is very important. Usually for biogas production 8% total solid is maintained. so, due to this moisture content calculation is very important.

**Experiment no 1:** For experiment no -1 only potato waste is used for biogas production .For biogas production at first moisture content of potato waste is calculated.

**Calculation of moisture content for potato waste:-**

Weight of crucible = 18.23g

Weight of crucible with potato waste = 30.93g

Weight of potato waste = (30.93-18.23)g

=12.7g

After drying in oven at 105˚c for 3 hrs

Weight of crucible with potato waste = 23.62g

Weight of potato waste = (23.62-18.23)g

= 5.39g

Weight of moisture = (12.7-5.39) g

= 7.31 g

Moisture content = $\frac{7.31}{12.7} \times 100\%$

= 57.55%

So, potato waste contains around 58% moisture. Total solid = (100-58) %

= 42%

For the experiment 500g potato waste is used. In 500g potato waste 210g is total solid and 290g is moisture.

For 8% total solid $92 \times \frac{210}{8}$ ml or 2415 ml water is required. But in 500g potato waste there are 290g moisture. So extra (2415-290) ml or 2125 ml water should be added.

**So in sample 1 there are:-**

| | |
|---|---|
| Potato waste | 500g |
| water | 2125ml |
| Cow dung slurry | 60ml. |

**<u>Co-digestion</u>:-** Co-digestion of mixed organic waste involves the mixing various substrates in varying proportions. If all other factors, such as physical parameters, are kept constant, the methane yield (I/g volatile solids (VS) added or removed) and the percentage VS degradation are functions only of the proportions used. It is way for the production of biogas. For the experiment here co-digestion is done. For the co-digestion of potato waste here cow dung is used in varying proportion. Potato waste and cow dung are mixed properly. Then total solid is measured. Total solid is maintained 8%.For calculation of total solid moisture content of the co-digestion mixture is calculated

**Table:- Characteristics of cow dung**

| | |
|---|---|
| pH | 7.35 |
| Total Phosphate (g/l) | 1.12% |
| Orthophosphate (g/l) | 2.89% |
| Total Kjeldahl nitrogen (% TS) | 1.23% |
| Amonia-nitrogen | 0.89% |
| Organic carbon (%TS) | 17.03% |
| C/N ratio | 15.205 |
| Amount of Ca | 809.336 ppm |
| Amount of Mg | 1344.8 ppm |
| Amount of Zn | 27.696 ppm |
| Amount of K | 529.84 ppm |
| Amount of P | 1320 ppm |

**Experiment no-2:** At first 50% potato waste and 50% cow dung are mixed and moisture content is measured for determining total solid.

## Calculation of moisture content:-

Weight of crucible = 18.23g.

Weight of crucible with co-digestion mixture = 21.42g

Weight of co-digestion mixture = (21.42-18.23)g

=3.19g

After drying in oven at 105˚c for 3 hrs

Weight of crucible with co-digestion mixture =19.104g

Weight of co-digestion mixture = (19.104-18.23)g

= 0.874g

Weight of moisture = (3.19-0.874)g

=2.316g

Moisture content = 2.316/3.19×100%

= 72.60%

So, moisture content of co-digestion mixture is around 72% and total solid is 28%. In 500g co-digestion mixture there is 140g total solid and moisture is 360g.

For 8% total solid 140×92/8 ml or 1610 ml water is required. But in 500g co-digestion mixture there is 360g moisture. So, extra (1610-360) ml or 1250 ml water should be added.



**So, sample-2 contains**

| | |
|---|---|
| Potato waste | 250g |
| Cow dung | 250g |
| water | 1250 ml |
| Cow dung slurry | 60 ml |

**Experiment no-3:** Another co-digestion mixture is prepared .Here 75% potato waste and 25% cow dung are mixed properly. Then moisture content is measured to determine total solid of the co-digestion mixture.

## Calculation of moisture content:

Weight of crucible =18.23g

Weight of crucible with co-digestion mixture =23.23g

Weight of sample = (23.23-18.23)g

= 5g

After drying in the oven at $105^0$ c for 3 hours

Weight of crucible with co-digestion mixture =19.83g

Weight of sample = (19.83-18.23)g

= 1.6g

Weight of moisture = (5-1.6) g

=3.4g

So moisture content of the co-digestion mixture = 3.4/5 ×100%

= 68%

So total solid = (100-68) %

= 32%

Here 500g co-digestion mixture is used. Total solid of this mixture is 32%. So in 500g mixture there is 160g total solid and 340g moisture.

For 8% total solid 92×160/8 ml or 1840 ml water is required. But in 500g mixture there is 340 ml moisture. So extra (1840-340) ml water should be added.

## So sample-3 contains

| | |
|---|---|
| Potato waste | 375g |
| Cow dung | 125g |
| Water | 1500 ml |

| | |
|---|---|
| Cow dung slurry | 60 ml |

**Experiment no-4:** Here 75% cow dung and 25% potato waste are mixed properly for preparing another co-digestion mixture .It is the first step to calculate moisture content of the mixture and determine total solid of the co-digestion mixture.

## Calculation of moisture content:

Weight of crucible = 25.25g

Weight of crucible with co-digestion mixture = 26.25g

Weight of co-digestion mixture = (26.25-25.25) g

= 1 g

After drying in the oven at $105^0$ c for 3 hours

Weight of crucible with co-digestion mixture = 25.53 g

Weight of co-digestion mixture = (25.53-25.25) g

= 0.28 g

Weight of moisture = (1-0.28) g

= 0.72 g

Moisture content = 0.72/1×100%

= 72%

So total solid = (100-72)%

= 28%

Here 500 g co-digestion mixture is used for biogas production. In 500 g mixture 140 g is total solid and 360g is moisture.

For 8% total solid 92×140/8 ml or 1610 ml water is required. But in 500g mixture 360g is moisture. So extra (1610-360) ml or 1250 ml water is added.

## So sample-4 contains

| | |
|---|---|
| Potato waste | 125g |
| Cow dung | 375g |
| Water | 1250 ml |
| Cow dung slurry | 60 ml |

**Experiment no-5:** Here 90% cow dung and 10% potato waste are mixed properly as a result a co-digestion mixture is obtained .At first moisture content of this mixture is calculated.

**Calculation of moisture content**

Weight of crucible = 20.25g

Weight of crucible with co-digestion mixture = 23.75g

Weight of co-digestion mixture = (23.75-20.25)g

= 3.5g

After drying in oven at $105^0$c for 3 hours

Weight of crucible with co-digestion mixture = 21.30g

Weight of co-digestion mixture = (21.30-20.25)g

=1.05g

Weight of moisture = (3.5-1.05)g

=2.45g

Moisture content =2.45/3.5×100%

=70%

So total solid = 30%

Here 500g mixture is used for biogas production. In 500g mixture 150g is total solid and 350g is moisture.

For 8% total solid 92×150/8 ml or 1725 ml water is required. But in 500g mixture 350g moisture is present. So extra (1725-350) ml or 1375 ml water is added.

### So sample-5 contains

| | |
|---|---|
| Potato waste | 50g |
| Cow dung | 450g |
| Water | 1375 ml |
| Cow dung slurry | 60 ml |

## Result

**Table: Gas Production from sample-1**

| Date | Room Temperature( $^{0}$c) | Total production from first day(ml) |
|---|---|---|
| 19.06.12 | 30 | 0 |
| 24.06.12 | 30 | 200 |
| 01.07.12 | 31 | 300 |
| 03.07.12 | 30 | 350 |

| | | |
|---|---|---|
| 05.07.12 | 30 | 400 |
| 15.07.12 | 30 | 450 |
| 16.07.12 | 31 | 450 |
| 17.07.12 | 31 | 470 |
| 18.07.12 | 30 | 470 |
| 19.07.12 | 30 | 520 |

**Table: Gas production from sample-2**

| Date | Room Temperature($^0$ c) | Total gas production from first day(ml) |
|---|---|---|
| 03.07.12 | 30 | 0 |
| 05.07.12 | 30 | 250 |
| 15.07.12 | 30 | 1000 |
| 16.07.12 | 31 | 1100 |
| 17.07.12 | 31 | 1150 |
| 18.07.12 | 30 | 1200 |
| 19.07.12 | 30 | 1250 |

| | | |
|---|---|---|
| 22.07.12 | 29 | 1400 |
| 23.07.12 | 29 | 1450 |
| 24.07.12 | 30 | 1500 |
| 26.07.12 | 30 | 1600 |
| 29.07.12 | 30 | 1900 |
| 03.08.12 | 30 | 2200 |

**Table: Gas production from sample-3**

| Date | Room Temperature($^0$ c) | Total gas production from first day(ml) |
|---|---|---|
| 03.07.12 | 30 | 0 |
| 05.07.12 | 30 | 250 |
| 15.07.12 | 30 | 2100 |
| 16.07.12 | 31 | 2200 |
| 17.07.12 | 31 | 2400 |
| 18.07.12 | 30 | 2600 |
| 19.07.12 | 30 | 2800 |

| | | |
|---|---|---|
| 22.07.12 | 29 | 3600 |
| 23.07.12 | 29 | 3800 |
| 24.07.12 | 30 | 4200 |
| 26.07.12 | 30 | 4600 |
| 29.07.12 | 30 | 4900 |
| 03.08.12 | 30 | 5050 |

**Table: Gas production from sample-4**

| Date | Room Temperature($^0$ c) | Total gas production from first day(ml) |
|---|---|---|
| 04.07.12 | 30 | 0 |
| 05.07.12 | 30 | 200 |
| 15.07.12 | 30 | 1100 |
| 16.07.12 | 31 | 1200 |
| 17.07.12 | 31 | 1300 |
| 18.07.12 | 30 | 1350 |
| 19.07.12 | 30 | 1400 |
| 22.07.12 | 29 | 1700 |

| | | |
|---|---|---|
| 23.07.12 | 29 | 1800 |
| 24.07.12 | 30 | 1950 |
| 26.07.12 | 30 | 2300 |
| 29.07.12 | 30 | 2700 |
| 03.08.12 | 30 | 3300 |
| 04.08.12 | 31 | 3450 |

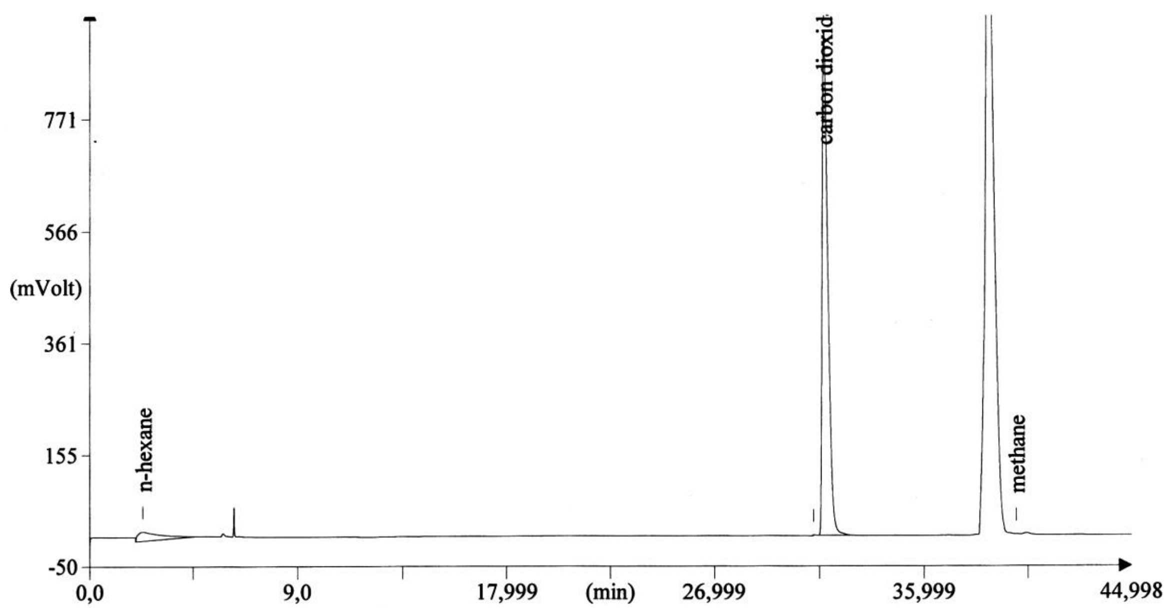
**Table: Gas production from sample-5**



| Date | Room Temperature($^0$c) | Total gas production from first day(ml) |
|---|---|---|
| 01.10.12 | 29 | 0 |
| 02.10.12 | 30 | 100 |
| 03.10.12 | 30 | 200 |
| 04.10.12 | 29 | 300 |
| 07.10.12 | 30 | 400 |
| 08.10.12 | 30 | 500 |
| 09.10.12 | 30 | 650 |

| | | |
|---|---|---|
| 10.10.12 | 30 | 750 |
| 11.10.12 | 29 | 900 |
| 12.10.12 | 30 | 1000 |
| 13.10.12 | 30 | 1100 |
| 14.10.12 | 30 | 1150 |
| 15.10.12 | 29 | |

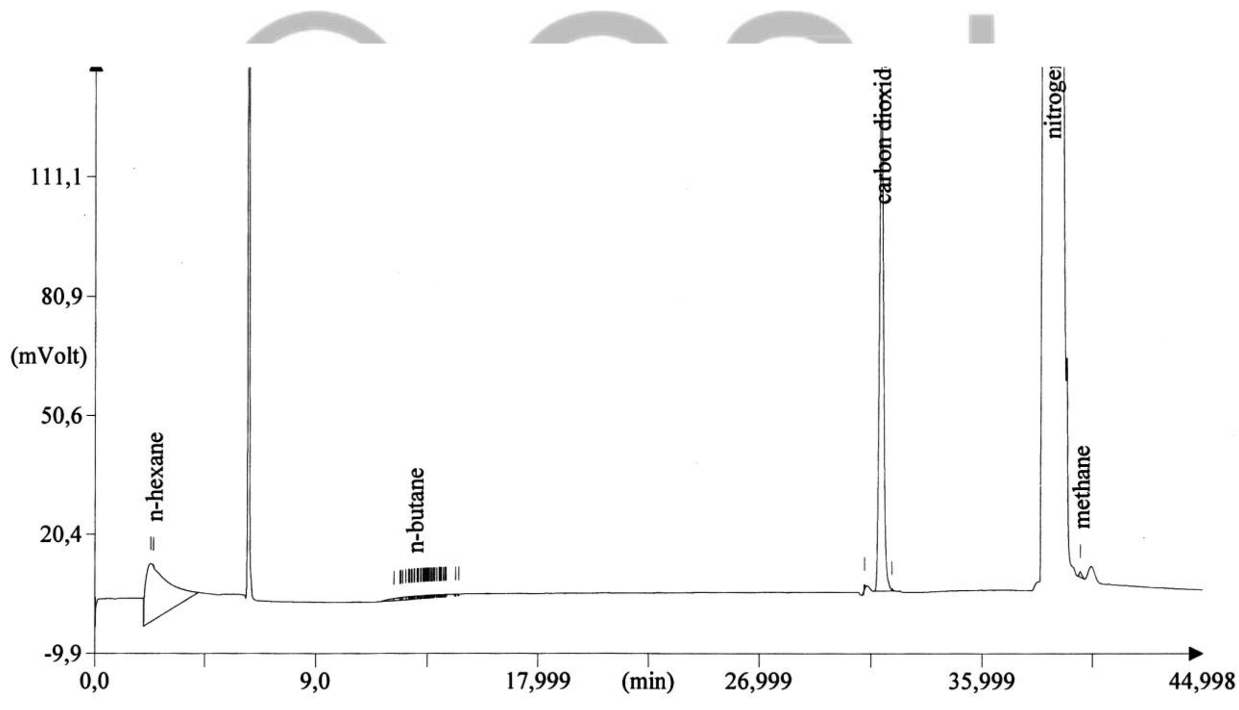
**Analysis of Gas of sample 2 is done by GC**




**Composition of Gas of sample 2 after 3 days**

| Gas | Percentage |
|---|---|
| n-hexane | 7.162 |
| carbon dioxide | 92.831 |
| methane | 0.007 |
| **Totals** | **100.00** |

**Analysis of Gas of sample 5 is done by GC**




**Composition of Gas of sample 5 after 3 days**

| Gas | Percentage |
|---|---|
| n-hexane | 0.072 |
| n-butane | 0.146 |
| carbon dioxide | 98.803 |

| | |
|---|---|
| nitrogen | 0.281 |
| methane | 0.696 |
| **Totals** | **100.00** |

Conclusion

Biogas is not produced from potato waste only.Because carbon dioxide percentage is higher than methane.If potato waste and Cow dung mixture is used where 90% is cow dung then biogas is produced.This mixture contains higher percentage of methane.

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