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RECOVERY OF BIOLOGICAL CONVERSION PRODUCTS: COMPOST AND BIOGAS

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Abstract

It mainly comprises of hydro-carbon which is combustible and can produce heat and energy when burnt. Bio-gas is produced through a bio-chemical process in which certain types of bacteria convert the biological wastes into useful bio-gas. Since the useful gas originates from biological process, it has been termed as bio-gas. Methane gas is the main constituent of biogas.The process of bio-gas production is anaerobic in nature and takes place in two stages. The two stages have been termed as acid formation stage and methane formation stage. In the acid formation stage, the bio-degradable complex organic compounds present in the waste materials are acted upon by a group of acid forming bacteria present in the dung. Since the organic acids are the main products in this stage, it is known as acid forming stage. In the second stage, groups of methanogenic bacteria act upon the organic acids to produce methane gas. Anaerobic digestion is a natural form of waste-to-energy that uses the process of fermentation to breakdown organic matter. Animal manure, food scraps, wastewater, and sewage are all examples of organic matter that can produce biogas by anaerobic digestion. Due to the high content of methane in biogas (typically 50-75%) biogas is flammable, and therefore produces a deep blue flame, and can be used as an energy source.

Keywords:-Biological, Methane gas,Digester, Mixing tank

Introduction

This anaerobic process of decomposition (or fermentation) of organic matter happens all around us in nature, and has been happening for a *very* long time. In fact, the bacteria that break down organic material into biogas are some of the oldest multi-celled organisms on the planet. Human use of biogas, of course doesn't go *that*far back, however, some anecdotal evidence traces the first uses of biogas to the Assyrians in the 10th century and the Persians in the 16th century. More recently, the 20th century has brought about a renaissance of both industrial and small-scale biogas systems.In the 18th century it became clear to Flemish chemist Jan Baptise van Helmont that decomposing organic matter produced a combustible gas. Soon after, John Dalton and Humphrey Davy clarified that this flammable gas was methane. The first major anaerobic digestion plant dates back to 1859 in Bombay. Not long after, in 1898, the UK used anaerobic digestion to convert sewage into biogas, which was then used to light street lamps. For the next century, anaerobic digestion was primarily used as a means to treat municipal wastewater. When the price of fossil fuels rose in the 1970's industrial anaerobic digestion plants increased in popularity and efficiency.

Small-Scale Biogas Systems

Small-scale, or family-size biogas digesters are most frequently found in India and China. However, the demand for such units is growing rapidly throughout the world thanks to more advanced and convenient technologies, such as Home Biogas. As the modern world is producing more and more waste, individuals are eager to find ecologic ways to treat their trash. Traditional systems typically found in India and China focus on animal waste. Due to a lack of energy in rural areas combined with a surplus of animal manure, biogas digesters are very popular, useful, and even life-changing. In many developing countries, biogas digesters are even subsidized and advocated by the government and local ministries, who see the variety of benefits produced from using biogas. In addition to having a clean renewable energy provide gas in the kitchen, many families make extensive use of the fertilizer by-product that biogas digesters provide. In African countries, some biogas users even turn a profit by selling the bio-slurry by-product produced by biogas systems. This bio-slurry is different from the liquid fertilizer that is produced daily. Bio-slurry refers to the most decomposed stage of the organic matter, after it has been broken down in the system. Bio-slurry sinks to the bottom of the biogas system, and with the help of modern units like HomeBiogas, is easily emptied out once accrued (usually an annual process). This bio-slurry is in fact a nutrient-dense sludge that provides lots of benefits to soil, and can increase productivity of vegetable gardens.Biogas is a technology that mimics nature's ability to give back. Both industrial-size and family-size biogas units are becoming incredibly popular and relevant in today's world. As the application and efficiency grows, biogas can make a significant impact on reducing greenhouse gases. As a clean source of energy and a renewable means of treating organic waste, biogas is applicable both in under-developed and industrialized countries.

Components of Biogas Plants

- **Mixing tank** - The feed material (dung) is collected in the mixing tank. Sufficient water is added and the material is thoroughly mixed till a homogeneous slurry is formed.
- **Inlet pipe** - The substrate is discharged into the digester through the inlet pipe/tank.
- **Digester** - The slurry is fermented inside the digester and biogas is produced through bacterial action.
- **Gas holder or gas storage dome** - The biogas gets collected in the gas holder, which holds the gas until the time of consumption.
- **Outlet pipe -** The digested slurry is discharged into the outlet tank either through the outlet pipe or the opening provided in the digester.
- **Gas pipeline -** The gas pipeline carries the gas to the point of utilization, such as a stove or lamp.

Availability of raw materials

The size of the biogas plant is to be decided based on availability of raw material. It is generally said that, average cattle yield is about 10 kg dung per day. For eg. the average gas production from dung may be taken as 40 lit/kg. of fresh dung. The total dung required for production of 3 m^3 biogas is 3/0.04= 75 kgs. Hence, a minimum of 4 cattle is required to generate the required quantity of cow dung.

Useful Resources

Average maximum biogas production from different feed stocks

Sl. No.	Feed Stock	Litre /kg of dry matter		% Methane content
1.	Dung	350*		60
2.	Night-soil	400		65
3.	Poultry manure	440		65
4.	Dry leaf	450		44
5.	Sugar cane Trash	750		45
6.	Maize straw	800		46
7.	Straw Powder	930		46

- Average gas production from dung may be taken as 40 lit/kg. of fresh dung when no temperature control is provided in the plant. One Cu. m gas is equivalent to 1000 litres.

Average dung yield

Sl. No.	Living Beings	Quantity of Dung / Night Soil produced (kg/day)
1.	Cow, Heifer	10.0
2.	Bullock	14.0
3.	Buffalo	15.0
4.	Young bovine	5.0
5.	Horse	14.0
6.	Horse, young	6.0
7.	Pigs, over 8 score	2.5
8.	Pigs, under 8 score	1.0
9.	Ewes, rams and goats	1.0
11.	Lambs	0.5
12.	Duck	0.1
13.	10 hens	0.4
14.	Human beings	0.4

Note : For free grazing animals the availability of dung may be taken as 50 per cent of the amount given in the table

Carbon to Nitrogen Ratio of various materials

Sl. No.	**Material**	**Nitrogen Content (%)**	**Ratio of Carbon to Nitrogen**
1.	Urine	15.18	8:1
2.	Cow dung	1.7	25:1
3.	Poultry manure	6.3	N.A.*
4.	Night soil	5.5-6.5	8:1
5.	Grass	4.0	12:1
6.	Sheep waste	3.75	N.A. *
7.	Mustard straw	1.5	20:1
8.	Potato tops	1.5	25:1
9.	Wheat straw	0.3	128:1

*** N.A.:-** Data Not Available

Calorific values of commonly used fuels

Commonly used fuels	**Calorific values in Kilo calories**	**Thermal efficiency**
Bio-gas	4713/M^3	60%
Dung cake	2093/Kg	11%
Firewood	4978/Kg	17.3%
Diesel (HSD)	10550/Kg	66%
Kerosene	10850/Kg	50%
Petrol	11100/Kg	---

Equivalent quantity of fuel for 1 m^3 of biogas

Name of the fuel	Kerosene	Fire-wood	Cowdung cakes	Charcoal		Soft coke	Butane	Furnace Oil	Coal gas	Electricity
Equivalent quantities to 1 m3 of Bio-gas	0.620	3.474 kg	12.296 kg	1.458 kg		1.605 kg	0.433 kg	0.4171	1.177 m3	4.698 kWh

Biogas Requirements

Sl. No.	**Use**	**Quantity requirement**
1.	Cooking	336 - 430 1/ day / person
2.	Gas Stove	330 1/ hr /5 cm burner
		470 1/hr/10 cm burner
		640 1/hr/15 cm burner
3.	Burner Gas Lamp	126 1/lamp of lighting equivalent to 100 watt filament lamp.
		70 1/hr/1 mantle lamp
		140 1/hr/2 mantle lamp
		1691/lir/3 mantle lamp
4.	Dual fuel engine	425 1/hp/hr

Technical guidelines for establishment of Biogas plants

i. Digester Design

- The recommendation of KVIC is to have a digester volume of 2.75 times the volume of gas produced per day.
- KVIC recommendation for the depth of the plant is between 4 to 6 m according to the size but for economical use of building materials, a depth to diameter ratio between 1.0 to 1.3 are considered ideal for all types of plants. In a floating drum plant, a continuous ledge is built into the digester at a depth 10 cm. shorter than the height of the gas drum to prevent the gas holder from going down when no gas is left in it. It

helps in preventing the gas inlet being choked. It also guides the gas bubbles rising from the side of the plants into the gas bolder.

- In some plants slurry is fed at the bottom and removed at the top. When the digester diameter exceeds 1.6 m, a partition wall is provided in the digester to prevent short circuiting of slurry flow and increasing its retention period. In case of fixed dome plants, the volume of digester comes to between 1.5 times to 2.75 times the gas produced per day. Here, the higher the plant capacity, the lesser becomes the ratio of digester volume to gas produced per day.

ii. Gas Holder Design

- The design of a gas holder is influenced by the digester diameter and distribution of gas use during the day. For domestic plants, the gas holder capacity is kept at 60 per cent of a day's gas production and in case of laboratories, it is kept at 70 per cent of the day's gas production.
- In a floating drum plant, the gas holder diameter is 15 cm. less than the diameter of the digester and accordingly the other dimensions are decided. The gas holder can be given a rotary movement around its guide to break the scum formation at the top.
- In a fixed dome plant the dome angle is kept between 17° and 21° and it gives a pressure upto 100 cm. of water. Due to higher pressure, the diameter of gas pipelines can be reduced and the gas can be taken to greater distance. In this plant, care should be taken to provide an earth pressure equivalent to 100 cm of water column from the top of the dome. Always use 'A' class bricks in the domes for better stability.

iii. Inlet Tank

- Before the dung is fed into the plant, it is mixed with water in a tank to give a solid content of 7.5 per cent to 10 per cent in the slurry. This tank also helps in removing grass and other floating materials from the raw materials to prevent excessive scum formation in the plant. This tank is connected to the digester by an asbestos cement pipe. The floor of the mixing tank is given a slope opposite to the direction of inlet pipe to help heavy inorganic solid particles to settle and get separated from the slurry.

Applications Biogas

Biogas can be used for electricity production on sewage works, in a CHPgas engine, where the waste heat from the engine is conveniently used for heating the digester; cooking; space heating; water heating; and process heating. If compressed, it can replace compressed natural gas for use in vehicles, where it can fuel an internal combustion engine or fuel cells and is a much more effective displacer of carbon dioxide than the normal use in on-site CHP plants.

Biogas upgrading

Raw biogas produced from digestion is roughly 60% methane and 39% CO_2 with trace elements of H_2S: inadequate for use in machinery. The corrosive nature of H_2S alone is enough to destroy the mechanisms.

Methane in biogas can be concentrated via a biogas upgrader to the same standards as fossil natural gas, which itself has to go through a cleaning process, and becomes *biomethane*. If the local gas network allows, the producer of the biogas may use their distribution networks. Gas must be very clean to reach pipeline quality and must be of the correct composition for the distribution network to accept. Carbon dioxide, water, hydrogen sulfide, and particulates must be removed if present.

There are four main methods of upgrading: water washing, pressure swing absorption, selexol absorption, and amine gas treating In addition to these, the use of membrane separation technology for biogas upgrading is increasing, and there are already several plants operating in Europe and USA.

The most prevalent method is water washing where high pressure gas flows into a column where the carbon dioxide and other trace elements are scrubbed by cascading water running counter-flow to the gas. This arrangement could deliver 98% methane with manufacturers guaranteeing maximum 2% methane loss in the system. It takes roughly between 3% and 6% of the total energy output in gas to run a biogas upgrading system.

Biogas Gas-Grid Injection

Gas-grid injection is the injection of biogas into the methane grid (natural gas grid). Until the breakthrough of micro combined heat and power two-thirds of all the energy produced by biogas power plants was lost (as heat). Using the grid to transport the gas to consumers, the energy can be used for on-site generation, resulting in a reduction of losses in the transportation of energy. Typical energy losses in natural gas transmission systems range from 1% to 2%; in electricity transmission they range from 5% to 8%.

Before being injected in the gas grid, biogas passes a cleaning process, during which it is upgraded to natural gas quality. During the cleaning process trace components harmful to the gas grid and the final users are removed.

Biogas in Transport

"Biogaståget Amanda" ("Amanda the Biogas Train") train near Linköping station, Sweden

If concentrated and compressed, it can be used in vehicle transportation. Compressed biogas is becoming widely used in Sweden, Switzerland, and Germany. A biogas-powered train, named Biogaståget Amanda (The Biogas Train Amanda), has been in service in Sweden since 2005. Biogas powers automobiles. In 1974, a British documentary film titled *Sweet as a Nut* detailed the biogas production process from pig manure and showed how it fueled a custom-adapted combustion engine.

Biogas is part of the wet gas and condensing gas (or air) category that includes mist or fog in the gas stream. The mist or fog is predominately water vapor that condenses on the sides of pipes or stacks throughout the gas flow. Biogas environments include wastewater digesters, landfills, and animal feeding operations (covered livestock lagoons).

Ultrasonic flow meters are one of the few devices capable of measuring in a biogas atmosphere. Most of thermal flow meters are unable to provide reliable data because the moisture causes steady high flow readings and continuous flow spiking, although there are single-point insertion thermal mass flow meters capable of accurately monitoring biogas flows with minimal pressure drop. They can handle moisture variations that occur in the flow stream because of daily and seasonal temperature fluctuations, and account for the moisture in the flow stream to produce a dry gas value.

Biogas Generated Heat/Electricity

Biogas can be used in different types of internal combustion engines, such as the Jenbacher or Caterpillar gas engines. Other internal combustion engines such as gas turbines are suitable for the conversion of biogas into both electricity and heat. The digestate is the remaining inorganic matter that was not transformed into biogas. It can be used as an agricultural fertiliser.

Biogas can be used as the fuel in the system of producing biogas from agricultural wastes and co-generating heat and electricity in a combined heat and power (CHP) plant. Unlike the other green energy such as wind and solar, the biogas can be quickly accessed on demand. The global warming potential can also be greatly reduced when using biogas as the fuel instead of fossil fuel. However, the acidification and eutrophication potentials produced by biogas are 25 and 12 times higher respectively than fossil fuel alternatives. This impact can be reduced by using correct combination of feedstocks, covered storage for digesters and improved techniques for retrieving escaped material. Overall, the results still suggest that using biogas can lead to significant reduction in most impacts compared to fossil fuel alternative. The balance between environmental damage and green house gas emission should still be considered while implicating the system.

Conclusion

HomeBiogas also surpasses composting in that it instantly produces fertilizer and continuously supplies gas from broken down matter (while it can take weeks to see results from composting) and it can do so with any type of kitchen waste! You cannot usually compost meats, dairy, or oils, amongst other things, because they do not easily break down and can attract vermin and flies. But with HomeBiogas, you can chuck in all of these plus animal manure without worrying about any types of odors or pests, thanks to HomeBiogas' filters and closed system design. Composting is easy for hobby gardeners. Biogas technology offers an excellent process for the recycling of digestable biomass into valuable fertilizer and renewable energy. The most common feedstocks for the Anaerobic Digestion (AD) process are agricultural by-products such as manure, followed by various kinds of bio-waste, including sewage sludge, source-separated municipal waste, and organic fractions of household and industrial waste. The main product of the AD process is methane which is most frequently converted into electricity and heat by a Combined Heat and Power unit (CHP). Biogas can also be upgraded to meets all the technical requirements set by the manufacturers of natural gas-powered vehicles (CNG) and natural gas transportation operators.

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