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Implementation of Small-Scale Biogas Plant in a Dairy Cattle Farm

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ABSTRACT

A biogas plant is an anaerobic digester that produces biogas from organic materials such as animal waste, sewage slurry, vegetable waste and others waste materials. Sahiwal Cattle Farm, College of veterinary Science, AAU, Khanapara has developed a small-scale biogas plant in farm complex. The objectives of this plant is to promote green technology and zero waste concepts on animal farming and to mitigate adverse effects on the environment due to unsystematic management of animal waste disposal. The biogas produced is used as fuel for biogas stove, biogas water heater. Furthermore, the residual solid waste produced at the end of the process has been used as organic fertilizer in the fodder plot of the sahiwal farm complex. Although the hydro-carbons which are derived from direct chemical processes, bio-gas is produced through a bio-chemical process in which some bacteria convert the biological wastes into useful bio-gas comprising methane through chemical interaction. Such methane gas is renewable through continuous feeding of biological wastes and which are available in plenty in rural areas in the country. Since the useful gas originates from biological process, it has been termed as bio-gas in which methane gas is the main constituent. The gas which is produced by the above process in a bio-gas plant does not contain pure methane and has several impurities containing methane, carbon dioxide, Nitrogen, Hydrogen, Carbon monoxide, Oxygen and Hydrogen sulphide.

Key words: *Biogas, Biogas plant, Green technology, Animal waste.*

Introduction

The innovative biogas plant is an anaerobic digester that produces biogas from organic materials such as animal waste like dung, urine, sewage slurry, vegetable waste and others. The livestock industry is a part of the agricultural sector which is a growth sustaining industry in India. However, the unsystematic management of animal waste disposal is one of the causes of the greenhouse effect and serious environmental pollution especially soil and water pollution. The initiative has been undertaken to mitigate its adverse effects to the environment by the application of biogas technology for livestock farms in India and abroad. The Biogas plant is a source of green technology, a renewable energy and has high potential to be expanded. An effective biogas programme can lead to efficient use of cow dung for gas recovery and to partial supplement of nutrient requirement in the fodder plot as fertilizer. This programme can lead to improvement in rural livelihood including rural sanitation. The Table 1 shows the commonly used fuels and its calorific values and Table 2 shows typical composition of biogas.

The cattle dung which is available in plenty can be used as basic feed material forbio-gas plants in

Table 1.

Commonly used fuels	Calorific values in Killo Calories	Thermal efficiency
Bio Gas	4713/M3	60%
Dung Cake	2093/Kg	11%
Fire wood	4978/Kg	17.03%
Diesel	10550/Kg	66%

Table 2. Typical composition of biogas

Compound	Chemical Formula	Percentage (%)
Methane	CH_4	60
Carbon Dioxide	CO_2	38.0
Nitrogen	N_2	0.8
Hydrogen Sulphide	H_2S	0.2
Hydrogen	H_2	0.7
Carbon Monooxide	CO	0.2
Oxygen	O_2	0.1

India. The estimated cattle population of 192.49 million in the country has the potential to produce about 1000 million tonnes of dung. According to an estimate (1977) of Khadi and Village Industries Commission (KVlC), bio-gas plants of average family size may provide energy equivalent to 5432 million liters of kerosene which in terms of current prices may cost well over Rs. 1000 crore per annum. Although, cattle dung has been recognized as the chief raw material for bio-gas plants, other materials like night-soil, poultry litter and agricultural wastes are also used where they are socially acceptable. In addition to gas, the bio-gas plants would also be a source for conserving organic manure, rich in NPK. The recoverable dung from 192.49 million cattle can add about 3.5 million tonnes of Nitrogen to the soil every year and for ensuring its conservation bio-gas plants can be very useful. The scope for bio-gas plants in India, therefore, is substantial if the benefits accruable from such plants are exploited by people living in rural areas.

Design and Construction

Biogas plants are often designed and constructed as big or small units **as** needed counting on the quantity of waste available and therefore the amount of gas needed. (Jatinder and Sarbjit, 2003). Figure 1 shows the basic diagram of a biogas plant that has been constructed in the farm complex of Sahiwal Cattle Farm, College of Veterinary Science, AAU, Khanapara. A 50 m^3 concrete biogas digester was constructed below ground with a diameter of 6 meters and height of two meters. There are numerous materials which will be used to construct the biogas digester, namely bricks and cement, chrome steel and fibre glass, whereby each of them have their advantages and disadvantages in terms of price and quality (Molla *et al.* 2021). Basically, a biogas plant consists from an equivalent principle component which are biogas digester, gasometer or dome, collection sump, inlet chamber, outlet chamber and storage balloon (Aichinger *et al*., 2015; Mao *et al.,* 2015). Technically, each part has its function within the operation of the plant. The participating commercial dairy has 50 heads of cattle including 25 young cattle. In initiating the operation of the biogas plant, the dairy was cleaned twice each day. The slurry was then channelled directly from the cow shed into the gathering sump through an underground drainage piping system. A bar screen was installed at the gathering sump to stop the unwanted impurities from entering the inlet chamber which will clog the pump. Then the slurry was channelled into the inlet chamber from the gathering sump and left to accept a selected time until the sediment slurry formed at the bottom of the inlet chamber. The slurry was pumped into the biogas digester once daily until the biogas digester reached its capacity. The slurry was pumped from the highest of the biogas digester so as to avoid the formation of a tough crust which will disturb the method of manufacturing biogas and possibly trap biogas within the slurry. This system is sort of significant because the upkeep cost of the biogas digester is often reduced if there's no formation of a tough crust. This minimises cost of capital and therefore the use of electricity as there's no need for a stirrer to work the plant (Ebner *et al.,* 2016; Kuo and Dow, 2015). The biogas digester with a volume of fifty m^3 was crammed with slurry and it had been left to ferment for a minimum of 3 weeks to supply optimal top quality biogas. The temperature of the biogas digester must be maintained between 35°C to 40°C in order that the anaerobic digestion process can reach completion. The biogas produced was accumulated at the gasometer or dome before browsing 3 stages of filtration processes to get rid of water vapor and sulfide which is corrosive and other impurities that exist as constituents in biogas by using water, iron oxide and activated carbon respectively (Andrew *et al.,* 2011). The remaining gas was subsequently stored in the storage balloon. Since the anaerobic

digestion process runs continuously inside the biogas digester, a pressure relief device was installed to stop gas explosion caused by over pressurisation of the storage balloon. The biogas produced was then available to be routed on to the biogas rice cooker, biogas lamp, biogas hot-water heater, biogas stove. All biogas appliances are slightly different from normal appliances. The amount of gas supplied to biogas appliances are often controlled by employing a control valve. The generator with the power capacity of 1 kW was connected to the distribution board that will supply electricity to a lighting system and switch sockets for farm use. Hence the farmers can save money on electric bills (Momoh *et al.*, 2008). Moreover, the utilization of methane gas for cooking produces little or no odour and smoke, consequently reducing smell and pollution. Finally, at the top of the anaerobic digestion process, the effluent produced was channelled into the outlet chamber and it are often dried and processed to be used as an organic fertiliser. The Semenyih biogas plant was implemented for the aim of manufacturing biogas for cooking and generating electricity. It is one of the ways which could help save the environment from serious pollution and climate change. Methane is a greenhouse gas that is more damaging than carbon dioxide. Thus, the implementation of biogas plants is one among the methods so as to save lots of the environment from serious pollution and preventing global climate change (Labatut, 2014; Maranon *et al.*, 2012). The size (capacity) of a biogas plant is that the quantity of biogas (m^3), which it can supply 24-hourly. From literature reviews, one adult cattle produces about 25-50 kg of manure depending on their body weight and each ton of fresh cattle manure can yield 32 m^3 of biogas (SP Multitech). A cubic meter of biogas can generate 100 W of electrical power and produce 2.4 kWh of electrical energy per day. Thus, the farmers can estimate the size and capacity required in order to build a biogas plant within their farms. Fig. 1 shows the bio gas plant constructed in the Sahiwal Farm Complex.

Types of Biogas Digesters and Plants

- Fixed Dome Biogas Plants.
- Floating Drum Plants.
- Low-Cost Polyethylene Tube Digester.
- Balloon Plants.
- Horizontal Plants.
- Earth-pit Plants.

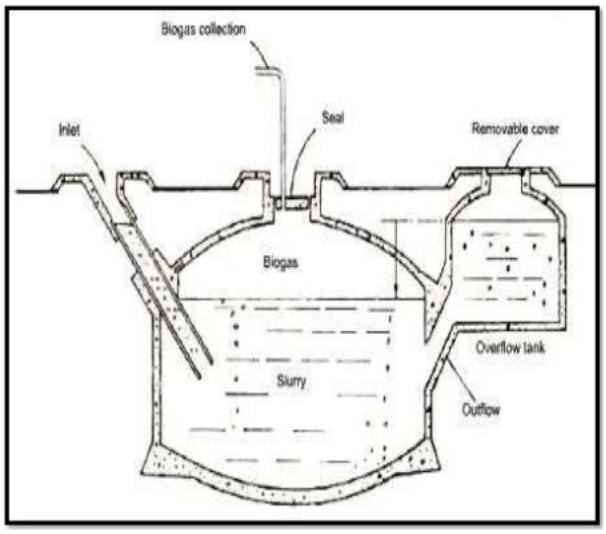

Fig. Bio Gas Plant

- Ferro-cement Plants.

Pre-requisites of Bio-Gas Plant

(1) Land and Site: While selecting a site for a bio-gas plant, following aspects should be considered:

- The land should be levelled and at a higher elevation than the surroundings to avoid runoff water.
- Soil should not be too loose and should have a bearing strength of 2 kg/cm^2
- It should be nearer to the intended place of gas use.
- It should also be nearer to the cattle shed/ stable for easy handling of raw materials.
- The water table should not be very high.
- Adequate supply of water should be there at the plant site.
- The plant should get clear sunshine during most part of the day.
- The plant site should be well ventilated as methane mixed with oxygen is very explosive.
- A minimum distance of 1.5m should be kept between the plant and any wall or foundation.
- It should be away from any tree to make it free from failure due to root interference.
- It should be at least 15m away from any well used for drinking water purpose.
- There should be adequate space for construction of slurry pits.

B) Feed for gas plants: The feed for gas plants in India mainly comprises of dung from cattle. Although, quantity of dung per cattle depends upon health,

age, type and many other factors, it is generally believed that, average cattle yield is about 10 kg dung per day.

Even though there are a lot of biogas plants built in a few countries recently, the manure digester technology especially in livestock industry is still in its infancy in Assam. Moreover, it's very expensive and therefore the payback period takes around two to 10 years supported the dimensions and capacity of the biogas digester (Emma *et al.,* 2019). The construction cost of implementing biogas plant depends on the farm size, amount of animal waste available, location, management and energy needs (Nurul *et al* 2012; Mirzaman *et al.,* 2017). However, there are a lot of advantages in the implementation of the biogas plant because it is not only producing gas as cooking fuel and to generate electricity, but also can minimise manure odour and greenhouse emissions, improve air and water quality, save the value of removing the waste and save fuel purchase like Liquefied Petroleum Gas (LPG). In addition, at the top of the method of manufacturing biogas, the residual slurry are often processed to be used as organic fertilizer.

Conclusion

Biogas is an excellent source of energy and the implementation of biogas plant is an alternative method in order to mitigate environmental pollution and global warming due to unsystematic management of animal waste disposal. Furthermore, there are tons of benefits of implementing biogas plant at animal farms. The simplicity of implementing a biogas plant in an animal farm, makes it one among the foremost environmentally sound energy sources especially for rural needs.

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