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Biogas Technology for a Sustainable Energy: The Case of Poultry Farm in Bangladesh

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Dhaka is the third dense city in the world. Dhaka, capital of Bangladesh is one of the most electricity deprived cities in the world. Energy conservation is the practice of decreasing the quantity of energy used. Energy conservation may result in increase of financial capital and also to increase environmental value. Use of fossil fuels contributes to air and water pollution and also global warming of the earth. This is why the human settlement pattern that supports contemporary civilization must become the focus of every energy consumption and energy conservation discussion. Because of the limited amount of non renewable energy sources, it is important to conserve our current supply or to use renewable sources so that our natural resources will be available for future generations. Despite large potential for renewable energy sources in Bangladesh, currently their contribution to the electricity supply remains insignificant for local poultry farm. The aim of the research is searching for alternate technology such as use of biogas plant in poultry farm to produce electricity. The research selects some number of poultry farm as a case study. Field study was done in suburban areas at Dhaka in Bangladesh. The result shows that 2 kWh is enough energy to power 10nos 10 W light bulb for 12 hours in a poultry farm. It is important to raise public awareness about the programmed in order for communities to join for sustainable future.

Keywords: Poultry Farm, Waste Materials, Biogas Technology, Bangladesh, Sustainability

1. Introduction

Dhaka, capital of Bangladesh is third dense city in the world. Dhaka is one of the most electricity deprived cities in the world. Despite large potential for renewable energy sources in Bangladesh, currently their contribution to the electricity supply remains insignificant.

Energy conservation is the practice of decreasing the quantity of energy used. Energy conservation may result in increase of financial capital, national security, personal security, and human comfort and also to increase environmental value. Use of fossil fuels contributes to air and water pollution and also global warming of the earth. This is why the human settlement pattern that supports contemporary civilization must become the focus of every energy consumption and energy conservation discussion. Because of the limited amount of non-

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renewable energy sources on Earth, it is important to conserve our current supply or to use renewable sources so that our natural resources will be available for future generations. The aim of the research is searching for alternate technology such as use of renewable energy to preserve the limited resources of Bangladesh. Objective of this research is to find out the scope of biological treatment of organic waste of poultry farm in Bangladesh to produce biogas as an effective alternative energy technology to ward sustainable energy development in poultry farm. Biogas is a byproduct of the decomposition of organic waste by anaerobic bacteria. Organic waste is put into a sealed tank called a digester (or bioreactor) where it is heated and agitated. In the absence of oxygen anaerobic bacteria consume the organic matter to multiply and produce biogas. Biogas is typically composed of 60% methane and 40% CO2. It is similar to natural gas which is composed of 99% methane (Electrigaz 2006). Natural gas rates are generally structured the way electricity rates are (Alexander, 1989). Biogas is a clean and renewable energy that may be substituted to natural gas for generating electricity at poultry farm in Bangladesh. The uses of biogas plant at poultry farm in Bangladesh will also improving our socio-economical development. The climate of Bangladesh and the climatic condition which is suitable for biogas production is discussed in following section 2 and 4. The literature review is also briefly explained in section 3. The conversion method of biomass to biogas is also discussed in section 5. Methodology and result of the study also explained in section 6 and 7.

2. Climate of Bangladesh

In terms of ecological region or biomes described by UNESCO (United Nations Educational, Scientific and cultural organization) (Lean 1990). Bangladesh, lying between 20º34′ N to 26º33′ N and 88º 01′E to 92º 41′E, is in the Indo-Malayan Realm. The climate of Bangladesh based on the widely used classification by Atkinson (Koenigsberger, 1973). Climatic variables are shown in table 1.

Table 1: **Classification of the seasons and climatic variable in Bangladesh.**

Gregorian Calendar Months	Ave. air Temp For 91-06(K)	Mean RH For 91-0006(%)	Mean Rainfall For 91-06 (mm)	M.Wind Speed & Direction for 91-06 (m/s)
January	18.8	72.4	11	1.4(NW)
February	21.9	67.0	27	1.9(N)
March	26.6	63.6	69	2.4 (SW)
April	28.9	70.9	120	2.9(SW)
May	29.0	78.4	342	2.4 (S)
June	29.5	82.3	267	2.3 (SE)
July	29.1	84.0	371	2.2(SE)
August	29.2	83.6	335	2.2(SE)
September	29.0	83.5	293	2.1(SE)
October	28.0	80.7	197	2.1(N)
November	24.5	75.7	26	1.3(NW)
December	20.3	74.4	13	1.6(NW)

The climate of Bangladesh, based on the widely used classification by Atkinson (Koenigsberger, 1973), is categorized as warm-humid. Generally the climate has short and dry winters while the summer is long and wet. Although a large part of the country's land mass lie above the Tropic of Cancer, the nature of the climate being tropical is attributed to the regional geographical character. The Himalayan mountain range and Tibet Plateau being in the north causes a significant amount of rainfall (Hossain and Nooruddin, 1993; Rashid, 1991).

3. Literature Review

Meteorologically the climate of Bangladesh is categorized into four distinct season-winter, pre-monsoon, monsoon and post-monsoon (Hossain & Nooruddin, 1993), where the winter is cool and dry, the pre-monsoon is hot and dry, monsoon and the post-monsoon periods are hot and wet. The winter months, December to February, are characterized by infrequent rains, cold northerly winds, mean temperature 21°C and maximum below 26°C. In the northern part of the country, the minimum temperature in winter often drops below 10°C for few days. The pre-monsoon period covers the months March, April and May and is characterized by occasional thunderstorms, and a maximum temperature of 34°C. The monsoon is the longest season covering the months June to September, a period with torrential rains 781mm to 1499 mm recorded in Dhaka, with the average relative humidity above 80% and an average temperature of 31 °C (Khandokar, 1995). The post-monsoon season ranges between the months October and November. It is also regarded as a transitional period (winter) with infrequent rains and temperatures below 30°C. The humidity is fairly high throughout the year and especially during the months June to September when it is often over 80%. Biogas is a sustainable renewable energy plant for poultry farms. In terms of process, sustainability is perceived less as an ultimate outcome and more as a pathway to change (Norman, 2009). Biogas plants produce excellent safe fertilizers for use on the farm to produces plants and vegetables. Biologically digested biomass becomes ecologically clear fertilizer that increases crops up to 40-50% (Md. Abdul Gufran, 2009).Farm waste including slurry and sewage sludge to a gas that can fuel a gas generator. It has a number of advantages such as relatively high efficiency for electricity production at a considerable range of scale (Peter, 2003). Biogas plants can help in the fight against global warming by allowing to burn methane from organic waste of the poultry farm, instead of letting it escape into the atmosphere where it adds to the greenhouse effect. Previous study results showed that the range of methane potential for single substrates was between 114 - 215 L/Kg VS, except for leaves & straw, which showed much lower potential than the above range (Ashekuzzaman, 2010). But volumetric methane potential of leaves & straw was the highest followed by food waste among any other single substrates. These results indicated the most biodegradable nature of food waste, and the suitability of using leaves & straw as a bedding material to increase the volumetric methane productivity. However, process instability with both of these substrates and high ammonia concentrations with chicken litter were also observed (Ashekuzzaman, 2010).

The outcome of the study indicated that the whole quantity of dung produced in the stable was not fed into the plant (Prakash, 2005). It showed that out of the

theoretical available dung (calculated based upon the number of cattle and poultry) of 5370.9 kilograms (81.37 kg/household on an average), 4327.7 kilograms (81%) was fed into the biogas digesters. However, the prescribed quantity of dung based upon the hydraulic retention time of 40-45 days for the Bangladesh context is 6362.5 kg, which is 19% more than the available feeding and 47% more than the actual feeding presently practiced (Prakash, 2005).

4. Climate Consideration for Biogas Plant in Bangladesh

The temperature of the process is quite important because methane-producing bacteria to do their work best at temperatures between 30°C – 40°C or 50°C – 60°C. It takes from 2 to 8 weeks to digest a load of waste, depending on the temperature (PACE). The rate of bacteriological methane production increases with temperature. Since, however, the amount of free ammonia also increases with temperature; the bio-digestive performance could be inhibited or even reduced as a result. In general, unheated biogas plants perform satisfactory only where mean annual temperatures are around 20°C or above or where the average daily temperature is at least 18°C. Within the range of 20-28°C mean temperature, gas production increases over-proportionally. If the temperature of the bio-mass is below 15°C, gas production will be so low that the biogas plant is no longer economically feasible (ISAT). For Bangladesh during winter season the temperature becomes low for one or two weeks only. It is considerable for little time if the production becomes low. The temperature of the process is quite important because to do their work best at temperatures between 30°C – 40°C (ISAT). So according to the climatic analysis of Bangladesh, the biogas plant is suitable for local climate. The plants should be made on a high place for protection from flood effect. Direct sun light is important to maintain the temperature range. Don't place the plants under the tree shade. The full plant is placed under the earth so it is generally safe from other disaster. The only danger is from explosion if it is mixed with air and lit by fire.

5. Climate Consideration for Biogas Plant in Bangladesh

Raw slurry is fed into the holding tank acting as a buffer for feeding the reactor with biomass. From there, the biomass is pumped into the reactor and further to storage tanks. To keep the waste mass homogenous and to avoid the formation of a scum layer, the mass is continuously mixed and stirred throughout the process. This mixing also prevents floating layers or sedimentation inside the system. If bacteria and waste require it, nutrients or additives can be added to the process at some points. Several times a day, waste is fed into the system in small quantities on a continuous basis, as old material is removed. The normal bio digestion period is between 20 to 50 days. The reactor is a completely gas-tight system, from which the gas is formed and collected for further use. All tanks are insulated for proper operation during cold periods. Heating is provided by a gas generator that produces heat and electricity from the biogas recovered (PRESECO OY).

6. Methodology

Maximum data of this research is collected from field measurement and questionnaire survey in suburban area of Bangladesh. Data are collect from

several number of poultry farm in Bangladesh. Maximum farm used biogas plant for only cooking and road side lighting. Through literature review this research find out mathematical calculation of biogas plant to run a gas generator for producing electricity. Through field survey the perfect biogas plant design is selected and adds the biogas plant with generator to produce electricity.

7. Result of this Research

7.1 Biogas Model Design for Poultry Farm in Bangladesh

The amount of biogas can extract from waste depends on the waste itself and the design of the digester system. It all depends on waste quality, digester design and proper operation of the system. The result shows that each cubic meter (m^3) of biogas convert biogas to electricity, in a biogas powered electric generator, which produces 2 KW/h of useable electricity, the rest turns into heat which can also be used for heating applications. Biogas plants produce heat after cooling generator without any additional gas combustion. 2 KW/h is enough energy to power 180nos of 10 W energy bulbs for 12 hours in a poultry farm. We design the model for 12 hours lighting system because the field questioners survey result shows that effective production of eggs the birds need 12 hours light within 24 hours according to birds healthy lifecycle.

Figure 1: Plan of Biogas plant of a poultry farm

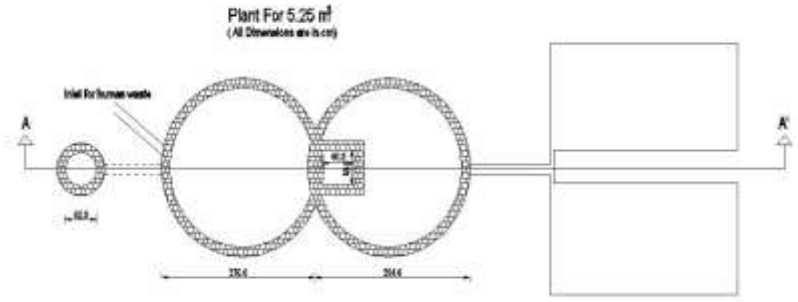
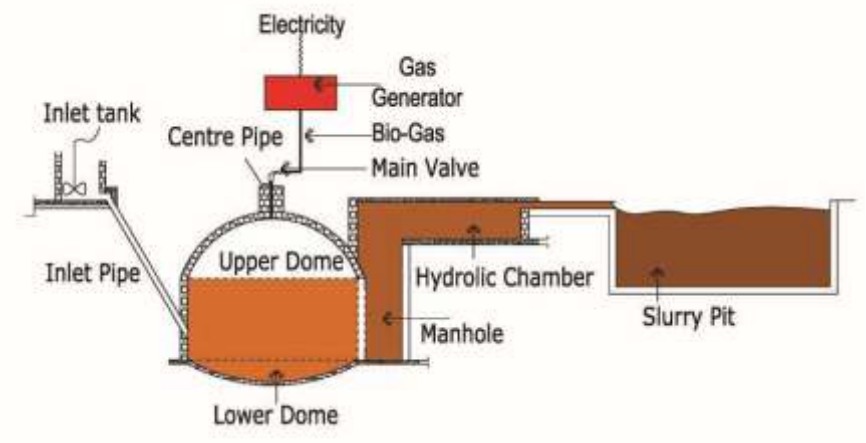


Figure 2: Section of Biogas plant model of a poultry farm



Every biogas system is unique, because everyone's waste quantity and quality is different. To ensure the economic viability of the biogas plant great care must go in the design, construction and operation of the biogas plant for poultry farm. The plant size is depends on number of chickens in poultry farm. The table 2 shows the ratio between row materials for plants as a unit. The incubators are supported to imitate and maintained optimal temperature for eggs. They are used to increase brooding efficiency.

Table 2: Relationship between volume of biogas plant and generator running hours

Volume of biogas plant (Daily Production of in m3)	No. of Poultry Birds waste	Amount of Poultry Birds waste daily (Kg)	Amount of water Daily (Kg)	KW Generator	Hrs
4.8	700	67	134	2	3.5
8	1200	115	230	2	6
17	2500	240	480	2	12.5
20	3000	288	576	2	15

Calculation of Biogas plant for 2500 chicken waste (as an unit) in poultry Farm

1 poultry (bird) waste =0.094 kg litre/day
2500 poultry (bird) waste= 235 kg litre/day
1 kg poultry liter can produce 2.6 cft gas
235 kg poultry liter can produce 611cft gas = 17.30388 m3
[1m3 (gas) = 35.31cft]
0.68 m3 gases produce 1 KW/h
17.30388 m3 gases produce 25 KW/h
So, 2 KW generators can run 12.5 hrs

7.2 Sustainability Study of Biogas Plant at Poultry Farm in Bangladesh

In poultry farm to get rid of organic waste it always costs money. Otherwise, this wastes probably creating an environmental hazard. By putting a digester in waste treatment chain can introduce a potential renewable energy sources. In a poultry farm the manure is not considered to be a waste but a fertilizer also. By installing a digester the farmer can profit from the biogas by reducing smell and enhancing the fertilizing value of the manure. The biogas is used to reduce some energy cost in the poultry farm. Introduction of biogas technology in the poultry farm is the fact that rural populations often cannot afford the investment cost for a biogas plant. Biogas plants have already proven economically viable investment in many cases in Bangladesh. There is several company starts to supply biogas plant in several region of the country on credit also as a small energy supply like low energy light and for cooking only. This study also finds out the cost effectiveness of biogas plant in poultry farm to run a generator for supplying electricity. After an initial investment in the plants for poultry farm,

there is no need to spend money on fuel for running a generator to generate electricity for poultry farm lighting. Efforts have to be made to reduce construction cost but also to develop credit and other financing systems. The society as a whole can benefit from biogas. Financial support from the government can be possible as an investment of biogas plants in poultry farm to reduce future costs of energy use and inorganic fertilizers, through increasing costs for health and hygiene and through natural resource degradation to achieve human wellbeing. If people feel exposed to energy price fluctuation and people have an environmental conscience about waste management of poultry farm then biogas plant might be a sustainable solution for people of Bangladesh. Biogas plants produce excellent safe fertilizers for use on the farm to produces plants and vegetables. Biologically digested biomass becomes ecologically clear fertilizer that increases crops up to 40-50% (Md. Abdul Gufran, 2009). It will save lots of money for using fertilizer at crops fields in Bangladesh. Biogas plants can help in the fight against global warming by allowing to burn methane from organic waste of the poultry farm, instead of letting it escape into the atmosphere where it adds to the greenhouse effect. So bio gas plant includes economic and social concerns as well as environmental aspects of sustainability.

7.3 Conservation

The conversion of poultry farm's organic waste material into biogas and fertilizer helps protect the environment in different way those are state below,

a) The generated biogas in poultry farm can replace traditional energy sources like firewood and animal dung, thus contributing to combat deforestation and soil depletion.

b) Biogas can contribute to replace fossil fuels, thus reducing the emission of greenhouse gases and other harmful emissions from poultry farm.

c) By tapping biogas in a biogas plant and using it as a source of energy, harmful effects of methane on the biosphere are reduced.

d) By keeping waste material at a confined space in poultry farm, surface and groundwater contamination as well as toxic effects on human populations can be minimized.

e) By conversion of poultry farm's organic waste into a more convenient and high-value fertilizer ('Biogas slurry'), organic matter is more readily available for agricultural purposes, thus protecting soils from depletion and erosion

8. Conclusion

Biogas plants are significant capital investments that require careful planning to maximize the chances of success. If poultry farm exposed to energy price fluctuation and an environmental conscience about its organic waste then biogas plants might be a sustainable solution for poultry farm. An alternative Biogas technology can substantially contribute to conservation and development, if the climatic conditions are favorable. However, the required high investment capital and other limitations of biogas technology should be thoroughly considered for sustainable poultry farm in warm humid tropical climate in Bangladesh. Now a

day, all biogas plants are customized to fit all the needs. Recycling biomass for energy and other uses cuts down on the need for landfill to hold garbage in poultry farm. In addition the recognition of the poultry farm is that the social dimension is to be addressed by public participation and consultation in the use of biogas plant for sustainable poultry farm in Bangladesh. The importance of converting biomass to biogas is also discussed here which can contribute in production energy. The main limitation which is found in this study was the maintenance and quantity of production of energy.

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