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Generation of Biogas from Bio-waste in Rural Area of Palestine

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Abstract. This study represents a 6 months period of research and investigative carried out to examine the generation of methane gas and soil fertilizer from biosolids (cow manure). Within the framework of this study, one biogas plant of Indian type has been built in Al-Aroub Farm Complex (AFC). The operation of the system was monitored during the research work and the gas fraction and other parameters that affect gas generation were measured.

The study includes the measurements of feedstock's quantity and quality, initial Total Solids percentage (TS%), initial Volatile Solids percentage (VS%), pH changes/fluctuations versus time, and many other essential analyses like Ash Ratios, Moisture Content (MC%), the initial Total Dissolved Oxygen (TDO) in mg/l, Electric Conductivity (EC) in micro siemens per cm and the Salinity in gm/l. All these experiments and measurements were run under ambient temperature conditions.

The results of the study show that biogas can be generated in a big quantity in rural areas of Palestine. Using the Indian biogas model in AFC is considered a good real start to generate methane from cow manure. Produced biogas did not burn during the first two weeks because the percentage of methane (CH_4) was still under 60% which is the lowest percentage in the whole gas produced needed for biogas to burn. Finally, it was found that the annual net profit (revenue) from AFC plant (as biogas + slurry) reaches approximately 858$ in the first year of operating the system and 1458$ every year for the following 14 years of operation, assuming that the service life period of the plant is 15 years.

Keywords: Bio-solids, cow manure, digester, feedstock, slurry.

1. Introduction

Nowadays the demand for energy around the world is increasing, and the controlling of energy sources, should be the first aim for the decision makers. Extracting energy from biosolids is nowadays considered one of the most significant approaches in energy technologies around the world because of its benefit as clean energy, friend to atmosphere, cheap, helps to treat biosolids and for its economical benefits. Energy can be directly generated from dry biosolids by burning them using thermo turbines while from wet biosolids by fermenting them anaerobically in what is technically called a biodigester to generate methane (CH_4) rich biogas [1], [2].

In Palestine, energy price are considered the highest in the world. The energy sector is fully controlled by Israel, and the Palestinian people are suffering the daily violence committed by the Israeli occupation forces. As Palestine is a fertile land where biological residues (especially the agricultural) exist in large quantities, biogas generation opportunities must be grasped and applied to sustain the stand stiffness of the Palestinian people on their own homeland soil [3].

The present work aims to study and investigate the processes of converting cow manure in rural areas into gas fuel and other beneficial products like soil fertilizer, and identify the type, quantity and concentration of feedstock material needed to reach the optimum biogas output, taking in consideration the

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climatic conditions prevailing at our country, as well as the socio-economic status and the environmental impacts of implying such projects.

2. Biogas Technology in Palestine

The biogas energy is considered one of the best alternative energy resources in the Palestinian territories especially in rural areas. The rural areas are considered an excellent environment to construct biogas systems. Hence, previous studies indicated that 60% of Palestinian villagers have their own animals, which their wastes can be used for the generation of the biogas [4], [5]**.**

Compared to other countries in the world, the use of biogas technology in Palestine began lately where there are only three projects nowadays using this method as follow [6]:

1. Jericho digester: It was constructed in spring 1998 with 5 m^3 effective volume; it produces about 1 m^3 of biogas and 200 liters of natural fertilizer, this plant is used as demonstration model for the garden visitors to give an idea about the biogas production.

2. Agricultural college digester/An Najah University**:** It was constructed in 2000, in Khadori College for Agriculture at Tulkarm, to serve the farm that contains 15 cows. The plant can produce 4 m^3 biogas and about 700 liter of natural fertilizer daily. It is volume is 14 m^3 for the digester and 3 m^3 for the fixed-dome which can store 60% of the daily production of the biogas.

3. Farajlla Farm in Idna: A biogas plant, following the Indian style was constructed in Farajlla farm in Idna near Hebron as a joint-project with the ministry of agriculture in Palestine. This plant was constructed in 2002 with effective volume approx. 9 m^3. Now this plant is abandoned due to financial difficulties.

3. Material and Methods

3.1. Introduction

Al-Aroub Farm Complex biogas plant was chosen to be constructed of Indian style. This style is considered the simplest and cheapest among other types (e.g. the Chinese dome, the UASB, the inflating bag…etc). It is also considered an explosion-proof kind in a country suffering a sustainable conflict conditions as the movable dome (gasholder) rises automatically and proportionally with the amount of gas generated. Easy to feed and empty. Building AFC plant of cylindrical galvanized iron containers gives it extra advantage that is providing the plant with powerful and reinforced walls which can bear immense stresses without showing any fracture or joint. Other reasons for choosing the galvanized iron are it is antirust and in case of jointing it is easy to pull the dome out, empty the digester and wild the joints. As well as it fits with the prevailing climatic conditions in Al-Arroub village [7], [8].

3.2. Description of the plant

The plant was designed to consist of the following components:

1. The main digester chamber: it is a pit dug in the ground very near to the cow barn. The pit is cylindrical in shape 6 m deep by 3 m diameter. Instead of building the pit walls out of reinforced concrete, 3" thick galvanized iron cylindrical container with dimensions of 2.7 m diameter by 5 m height ($V=28.6\ m^3$) was selected to be installed in the pit (see Figure 1). The preference of the iron container was made because galvanized iron is rustproof, very well sealed and does not crack or fail neither partially or completely when subjected to pressure shocks, due to its high ductility.

The ground of the pit was cleaned up and 25 cm thick reinforced concrete ground slap was laid down then the container was installed in vertically by using a JCB lift. The spacing left between the pit walls and the iron container were filled with concrete.

The container upper edges rise about 0.5 m above the ground surface in site to protect the hole from any fallings or undesired trash [9], [10].

2. The dome or the cover: it is made up of the same material as the main container. It is provided with a gas pressure meter and a gas outlet valve on the upper side. It is dimensions are 2.5 m diameter by 4 m height to allow it move freely up and down according to the gas quantity trapped in.

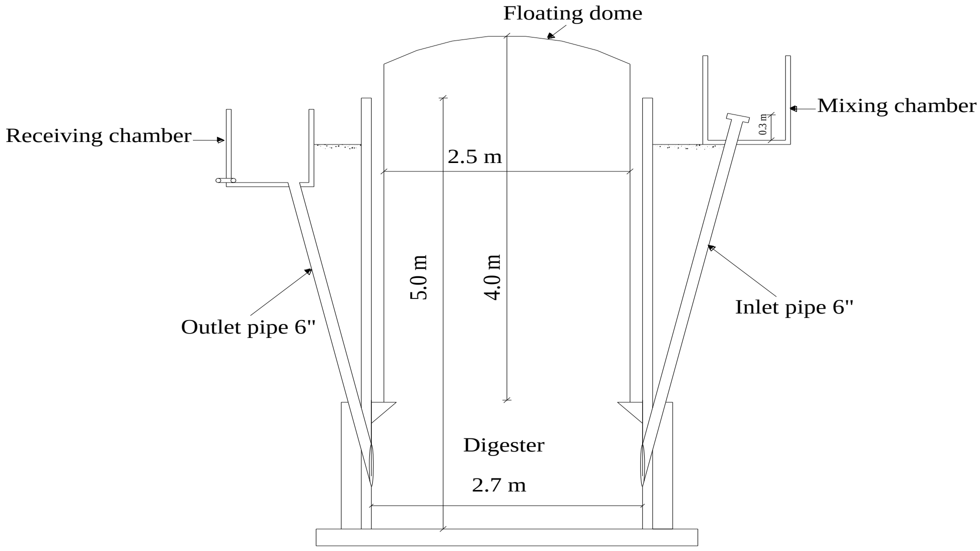

Fig. 1: Al-Aroub Farm Complex Biogas Plant Components

3. Mixing chamber: It is approx. 1 m^3 in volume, made up of reinforcement concrete, cubic sealed and with an inlet pipe of 6″ diameters that 30 cm raised above the ground of the pit. This effected prolongation (the 30 cm) is covered with an orifice of 0.5 cm mish size sieve.

The feedstock should be mixed with water before it is introduced to the main mixing chamber[11].

4. The effluent receiving chamber: It is similar in size and shape to the mixing chamber but 0.5 m lower from it. The out coming digested slurry that rises to this chamber by gravity is directed to the adjacent composting facility nearby.

5. The connections**:** The mixing chamber pushes its influent to the bottom of the main chamber through a galvanized iron pipe of 6″ diameter via an orifice with 0.7 cm mesh cover. This pipe is 25 cm above the mixing chamber base to allow segregation of grit and stones and to prevent straw and trimmings from reaching the digester.

The effluent receiving chamber is connected to the main chamber by galvanized iron pipe of 6″ diameter. The moving drum has valve opening of 1/2″ diameter for gas release.

6. The feedstock: in the first phase it is suggested to use only the fresh cow manure mixed with fresh tap water of ratio 1: 9 respectively.

4. Field and Laboratory Work

In study area, many sorts of feedstock material are available for feeding the digesters like cow, chicken, sheep manure, soft grasses, municipal bio-residues, barn remains and many agricultural (fruits +vegetables) leftover stocks.

In this study, the experiments focused on the cow manure, as it is the most accessible and light to work with feedstock, as well as many cow barns spread all over the country.

The analysis carried out had involved the following parameters: total solids by percentage in the sample (TS %), volatile solids by percentage in the sample (VS %), ash percentage in the sample (Ash %), monitoring the pH of the sample, monitoring the electric conductivity of the sample in micro siemens per cm (µs/cm), measuring the total dissolved solvents in the sample in mg/L (TDS), measuring the moisture content (mc) of the sample, measuring the temperature of the sample in centigrade degree (^oC), measuring the salinity of the sample (Sal.) in gm/L, measuring the ambient temperature, at the time of sampling, that is the atmospheric temperature in the field and the temperature in the lab, as well as the temperature of the slurry in the digester is recorded at the time of sampling, measuring the quantity of the biogas produce versus time (Q in liters and time in hrs), recording any extra phenomenon (observation) during the experiment, e.g. seepage, leakage, lime addition, failure of the system… etc, and recording the initial content of the dissolved oxygen in the feedstock.

5. Discussion of Results

The basic data and the results of the analysis for Al-Aroub Farm Complex Biogas Plant are given below:

- Type: Indian type.
- Date of construction: March 2004, while the Date of fed: 10th –17th of May 2004.
- Digester effective volume (V_D) = 19500 L.
- Feedstock: Concentrated Screened Cow Manure from AFC.
- Total initial solids (Ts) percentage: 1.4 %.
- Total solid Quantity of feedstock (Q_{total}) = 275 kg, Total initial Volatile solids (Vs) percentage: 0.4 % and Total Quantity of Vs = 78 kg
- Initial Total Dissolved Solvents = 4350 gm/l, Initial Electric Conductivity = 4900 µs/cm and Initial dissolved oxygen = 1.02 g\L.
- Retention time proposed = 35 days: 1 cycle while the Quantity of slurry required per cycle = 19500L and the Daily supply = 19500/35 = 557 L/day.

The quantity of gas generated during the time of experiment is presented in Figure (2).

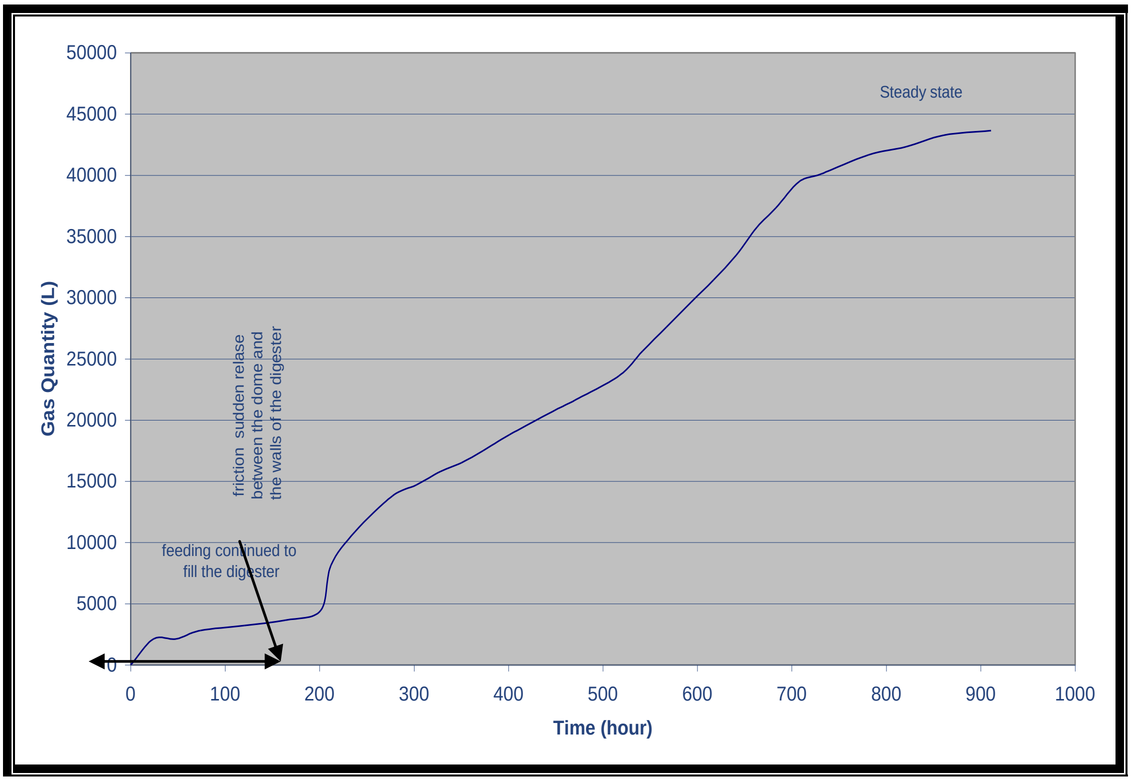

Fig. 2: Cumulative Yielded Gas Quantities versus Time in AFC Plant.

In the first stage of operating the biogas-meant after putting down the gas holder (Dome)- feeding continued to fill the digester up to the desired size (19.6 m^3) for some few days (approx. 10days).

Most biogas released was found to be rich in CO_2, H_2O and H_2S trying to burn the biogas released failed which means that the methane percentage in the released biogas was still below at least the 60 % of the total volume of the biogas. This percentage (60% methane) is considered the minimum percentage needed for the biogas to be burnable.

In the 12th of June the trying to burn the biogas was successfully, the characteristics of the flame were odorless and colorless.

6. Conclusions

The amount of biogas that can be generated in the Palestinians territories could be huge enough to cover considerable demands especially in the rural fertile areas. This fact can be enhanced through disseminating the culture of biogas generation processes among various sectors in the Palestinian society.

Using the Indian biogas model in AFC is considered a good real start to generate methane from cow manure. Anyhow, some modifications to AFC design should be added if new plants are going to be constructed.

It is found that generation of biogas in AFC is economically feasible and environmentally beneficial and it helps improving the cleaning level in the farm.

Produced biogas did not burn during the first approx. 2 weeks of dome installation, because the percentage of CH_4 (methane) was still under 60% which is the lowest percentage in the whole gas produced needed for biogas to burn. This was detected by smelling the biogas. It was observed that the percentage of bad odors (mainly due to the higher content of H_2S in the biogas) decreases as the percentage of methane increases. This increase in methane percentage is axiomatically on the cost of CO_2 gas. On Thursday 10th of June 2004 and during the daily examination to try to burn the biogas produced, it was observed that the biogas started to burn which means that the percentage of the methane (CH_4) in the generated biogas should have crossed the 60% of the total.

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