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Production of Purified Methane and Bio-Fertilizers by Anaerobic Digestion of Food Waste

S. P. Sangeetha, Happy Sarkar, N. Pradhyumna Reddy, Aasim Dahal Chettri

Abstract: ***Anaerobic digestion is a biochemical process in which the organic substances are digested by microorganisms to methane (biogas) and carbon dioxide in the absence of oxygen. This process is spontaneous but the control on large scale requires good knowledge. The search for appropriate models of this entire system of bio gas production with filtration process by benefitting the society, improving world's economy, and protecting the environment at the same time making biogas as a sustainable energy resource is covered. The aim of this paper is filtration of raw bio gas and methane production in all economic aspects. For this, a low costbio gas system by separating the other gases from methane, called chemical scrubbing was developed. Purified methane obtained can be used in various fields as domestic and industrial (cooking, electricity, transport and other power application).***

Keywords: Anaerobic digestion, Microbial activity, Filtration, Methane production

I. INTRODUCTION

Severe crisis for fuel and waste management are the major concerns on earth in the present scenerio. To overcome this problem, an economic and efficient technology has to be identified. Organic digestion of solid waste is required to manage in such a way as to minimize the bad impact on the environment, fewer hazards for human being and to keep ecological balance. Anaerobic digestion of solid waste is an effective technology that reform and deform different types of organic waste. Anaerobic digestion of solid waste helps the society in terms of energy, ecological balance and economy. Anaerobic digestion is considered to be one of the most innovative and efficient technology which can be adopted for waste treatment or management. The main aim of these researches is to analyze the parameters that will affect the production of a biogas plant to get a higher amount of methane in the form of biogas. The various factors which affect the production of methane are pH, Volatile Fatty Acid, the quantity of substrate being used, and alkalinity and temperature. The level of these factors must be in correct proportion in order to keep the production of biogas in a particular level. The purpose of this study is to optimize the filtration process for increasing the percentage of methane production in a short duration. By increasing its methane content the quality of gas can be taken nearer to that of CNG. It can be used as a fuel for vehicle engines like CNG after increasing the methane content of biogas and its compression up to 150 bar. The demerits of raw biogas are (i) it has a low heating value (ii) Difficult to liquefy and more expensive, purification has to be followed by compression. HilkiahIgoni(2008) and Shalini Singh et al. (2000) has experimented and analysed the concentration effect of solid mass present in the biogas which is produced in the municipal solid waste treated in an anaerobic digester. They concluded from their experimental results that the total solid concentration present in the solid waste will affect the pH value, temperature and microorganisms role in the decomposition process. Kumar et al., (2004) summarized in their paper that about 4 to 18% of methane originates from landfills.

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* Correspondence Author
Dr.S.P.Sangeetha*, Civil Engineering*, Aarupadai Veedu Institute of technology,VMRF,Paiyanoor,Kancheepuram District,Tamilnadu,India,Email:sangeetha@avit.ac.in
Happy Sarkar, Aarupadai Veedu Institute of technology,VMRF,Paiyanoor,Kancheepuram
N. Pradhyumna Reddy, Aarupadai Veedu Institute of technology,VMRF,Paiyanoor,Kancheepuram
Aasim Dahal Chettri , Aarupadai Veedu Institute of technology,VMRF,Paiyanoor,Kancheepuram

II. COMPOSITION AND PROPERTIES OF BIO GAS

Biogas has a composition of 50-70% methane, 30-45% carbon dioxide (CO_2), traces of moisture (H_2O) as well as of hydrogen sulfide (H_2S). Based on the feedstock used, its percentage of composition may vary. The temperature in digester is more important for methane content in raw biogas. If the digestion takes place in lower temperature, methane content in raw biogas will be higher but gas production will be less. Properties of raw gas are mentioned below:

i. Its calorific value is between 21- 24 MJ/m^3.
ii. It is 20% lighter than air and has a density of 0.95 kg/m^3.
iii. It requires about 5.7 m^3 of air for its combustion with a required speed of 40 cm/s.
iv. Its ignition temperature is around 700°C. The flammable temperature will be around 860°C.

III. METHODOLOGY

The food waste for the production of methane was collected from the canteen of the study area which consisted of cooked rice, vegetables and peels of vegetables. The waste collected was then ground in a mixer grinder and mixed with water to form a slurry. The experiment was done in a 150 litre digester. Different concentration & combinations of food wastes were used for the study.

Fresh cow dung was then mixed with water and poured into a 150 litre capacity digester. The required microorganism for anaerobic digestion was collected from the inoculum of previous experiment. After the inoculation, digester was kept stable without any disturbance for few days and gas production was checked at regular intevals. Later food waste from kitchen was added to check the production of gas.

Figure 1 is schematic representation of anaerobic digestion of food waste.

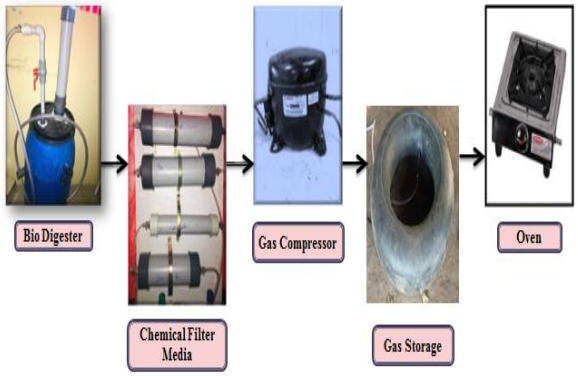

Fig 1 Anaerobic process with filtration

Different parameters like volatile fatty acid, total solid, pH value, volatile solid Temperature, along with composition of Nitrogen, Carbon, Phosphorous contents were measured. 30 litres of methane was generated in a 150 litre digester.

IV. FILTRATION PROCESS OF BIO GAS (ANAEROBIC DIGESTION)

Anaerobic digestion can be used as an effective treatment method to convert food waste into fuel because organic matter in food waste helps for anaerobic microbial growth.Impurities/contaminants like hydrogen sulphide (H_2S), carbon dioxide and moisture present in it should be reduced as maximum as possible to use biogas produced by this method as fuel for vehicles.

A. *Process of Removal of H_2S from Biogas*

Hydrogen Sulfide (H_2S) present in dissolved form is corrosive in nature due to the metallic components present in it. SO_2 is produced by the combustion of raw bio gas, which then combines with water vapor to produce sulphuric acid (H_2SO_4). If its concentration is found to be more than 1%, it may corrode the exhaust pipes and engine. The heating efficiency of the fuel may be reduced due to corrosion caused by moisture content in raw biogas. The allowable limits of H_2S for electricity by internal combustion engine is 100 ppm.

B. *Removal of CO_2 from Biogas*

The energy efficiency will be reduced due to the Co_2 present in raw biogas from digester. The power output from the engine will be lowered due to the presence of CO_2 and will affect the ignition value. Since CO_2 will occupy additional space in the storage tanks refilling of fuel tank will become essential and it is done by compressing the bio gas. Removal of carbon dioxide from biogas is very essential to increase the methane content Removal of CO_2 from biogas can result in improved heating value of the gas by about 80% on a volume basis and approximately 229% by weight.

C. *Removal of moisture from Biogas*

Metallic parts of engine and fuel supply system may corrode due to the presence of moisture and also reduces the ignition value. Sulphur dioxide reacts with water producing sulphuric acid which can corrode the combustion system. The carbon dioxide also may react with the water present in the moisture to form carbonic acid which may attack metals easily.

D. *Techniques used for removal of impurities from biogas*

During the purification/filtration process of biogas, methane content has to be increased. This can be achieved by using a pressurized water scrubber or chemical scrubber. Installation cost is very high for other processes like pressure driven adsorption, cryogenic separation and membrane separation. In our study carbon dioxide is removed using chemicals (mainly alkaline).

V. PURIFICATION PROCESS

A. *Removal of H_2S*

H_2S can be removed by ferrous materials available in the form of natural soil which is placed in a closed air tight chamber. The raw gas to be filtered is passed though the iron wool. The major drawback of this process is greater part of iron remaining as sulphide. Iron oxide either in the form of steel wool or scrap iron cut from lathe operation can be used to remove H_2S .Iron oxide will be converted to sulfur if raw biogas comes into contact with steel wool or chips.

Wet Technique

In wet technique, Sodium hydroxide (NaOH) solution with water in a ratio of 40:60 by weight is used to remove H_2S. Here Sodium hydrosulfide will be formed when H_2S reacts with sodium carbonate in the presence of raw bio gas in solution.

B. *Removal of Carbon di Oxide(CO_2)*

Water scrubbing process was found to be more economical to eliminate CO_2.The quantity of water required is more to absorb CO_2 from raw biogas. This chemical scrubbing process is carried out in the raw biogas. It reacts with caustic soda solution forming an irreversible carbonate followed by formation of bicarbonate which is reversible. For this, NaOH solution and water in the ratio of 40: 60 by weight was prepared in a container. When sodium hydroxide and water were mixed together, large amount of heat was generated since it is an exothermic reaction. The raw gas was allowed to pass through it when temperature gets cooled down. Alternatively solution of calcium hydroxide and water in the ratio of 40: 60 ratios was prepared in a container. When the temperature gets cooled, it was passed through the solution. Carbon di Oxide was filtered by this process.

D.Removal of Moisture from Bio Gas

Silica gel was used in our project to remove vapors in terms of moisture from the bio gas, since it has a very good moisture absorbing capacity. Similarly sawdust can also be used to remove moisture from biogas .

C. *Removal of Odors from Bio Gas*

By using Activated Carbon- Siloxanes ,Hydrogen sulphide was removed from bio gas.

After all these processes, the purified biogas obtained is tested as a fuel for cooking. The composition of purified biogas is compared with raw biogas, IS standards and tabulated as shown in table I.

Table-I Comparison of composition of raw biogas, Bio methane & purified biogas

Composition	Raw Biogas	Bio methane (as a fuel for Automobile Application as per IS standards)	Purified biogas
Methane (CH_4) %	62.2	90 (minimum)	93.1
Carbon Dioxide (CO_2) %	3.2	4 (maximum) w/v	3.44
Hydrogen Sulphide(H_2S) ppm	990	87	82
Oxygen (O_2) %	2.69	1.1	1.23
Moisture %	3.2	16 mg/m^3 (max)	0.9

VI. SCOPE FOR FURTHER RESEARCH

Our traditional fuel combustion makes our environment and atmosphere worst day by day. Bio methane produced in this project when used as a fuel will be a good alternative for household cooking, lighting and as vehicle fuel. The slurry obtained by this process can also be used as a clean organic biofertilizer that will help to improve the agricultural productivity, balancing nutrients and energy. It will be well suited for developing countries India which is rich in livestock. Bio gas can be generated in a very low cost even in household without affecting the environment. As a business purpose any one can develop this project in home and in any municipality area. Variety of feeds, such as crops, leaves, crops fruits, vegetable wastes, etc., can also be used and the process can be applied on a large scale. This allows the production of biogas at any place in the world in an ecofriendly way.

VII. CONCLUSIONS

Biogas is an alternative form of fossil fuel and green energy resource which also indirectly helps in disposing a number of organic wastes as a feedstock. The process of biogas production is simple and cost effective.

The production of biogas utilizing the available food waste from college canteen, households or any other place is an opportunity to reduce the greenhouse gas emission due to proper disposal of solid food waste. It also gives a strong support to the energy security in terms of methane and reduces the conventional fuel consumption. This is a sustainable alternative energy resource, which provides benefits to society, economy, and environment. Biogas from food waste can help weaker sections of the society due to rise in LPG prices. The process needs a lot of care with respect to the physical and biochemical changes like pH, temperature, and proper anaerobic conditions

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AUTHORS PROFILE

Dr.S.P.Sangeetha, Vice Principal Academics, Professor, Department of Civil Engineering is a Civil Engineer completed her Masters and Doctoral degree in Structural Engineering. Has wide experience in Teaching and Designing. She is a active member in Professional societies like American Concrete Institute, ISTE,IAENG,Chennai Civil Engineers ATCECEA,ACCE,ISTE,ACE,etc..She has delivered Technical lectures in various Institutions. She is the Programme Director for Institutional Social Responsibility cell to Inculcate Social awareness, values and environmentally responsible behaviour amongst students.She has received “Best faculty award “from DKRF and “Best recognition award “from Rotaract club of Chennai.

Mr.Happy Sarkar completed his undergraduate in Civil Engineering in Aarupadai Veedu Institute of technology.He has lot of expertise in design and waste management techniques.

Mr.Pradhyumna Reddy completed his undergraduate in Civil Engineering in Aarupadai Veedu Institute of Technology. He has lot of expertise in valuation and waste management techniques.