

Case Study of the Nisarguna Based Biogas Plant Installed at Delhi Technological University

Mohit Gupta^{*1}, Aadish Jain^{*2}, P.K Jain^{*3}

^{*}Department of Mechanical Engineering, Delhi Technological University, Bawana Road, Delhi-110042

¹mohitgupta2809@gmail.com(corresponding author)

²aadish.friend@gmail.com

³pdcej@yahoo.co.in

Abstract

The present study talks about the conversion of organic solid waste into useful biogas through the processes namely hydrolysis, acidogenesis, acetogenesis, methanogenesis and aerobic enrichment. Nisarguna technology enjoys an advantage of converting almost any type of organic solid waste over the conventional cowdung/ animal faeces based biogas plants. The reduction in the size of the plant has attracted many institutions to erect it in a rather confined space with less setup time and enhanced output. A similar plant has been installed at Delhi Technological University which handles 500 kg of organic solid waste per day aimed to supply the biogas to the university's canteen and research purposes. The output of the plant is nearly 60-65% biogas along with a high quality manure which is completely organic in nature. This paper talks about the technological aspects of such a plant and also stated the future scope through which the quality of biogas can be further

improved and make the plant a multi-utility plant.

Keywords: Renewable Technology; Biomass; Organic solid waste; Green House gas; Compressed natural gas; Nisarguna Technology

Introduction

A Sensible renewable technology must be simple to understand, reliable in functioning and economical in production. Along with these properties if it helps in addressing some major problems of the urban areas of developing world then the technology becomes lucrative and can be more easily accepted.[1] The search for promising and renewable sources of carbohydrates for the production of biofuels and other bio-renewables has been stimulated by an increase in global energy demand in the face of growing concern

over greenhouse gas emissions, solid waste management and fuel security. In particular, interest has focused on lingo-cellulosic biomass as a potential source of abundant and sustainable feedstock for bio-refineries. Further, Solid waste management for the same biomass is a serious problem in the urban areas of a fast developing nation like India. With the rapid increase in urban population the problem is becoming more severe with every passing day. However the solution to the problem on the same scale is still at large.

It is believed that substituting various biofuels for fossil based fuels will reduce production of greenhouse gases as biofuels sequester carbon through the growth of the feedstock. The studies supporting this belief may have omitted the amount of carbon emissions that occur as farmers worldwide change cropland to replace the grain and divert to biofuels (estimate emissions from land-use change pattern) various studies found that corn-based ethanol, instead of producing a 20% savings, nearly doubles greenhouse emissions over 30 years and increases greenhouse gases for 167 years. Biofuels from switch-grass, if grown on U.S. corn lands, increase emissions by 50%. This

result raises concerns about large biofuel mandates and highlights the value of using waste products.[5]

Converting forests, peatlands or grasslands to produce food crop-based biofuels creates a “biofuel carbon debt” by releasing 17 to 420 times more CO₂ than the annual greenhouse gas (GHG) reductions that these biofuels would provide by displacing fossil fuels. Whereas, biofuels derived from waste biomass incur little or no carbon debt and can offer immediate and sustained GHG advantages.[4]

Biomass such as cattle dung, agriculture wastes and other organic wastes provide a vast scope to convert these sources into biogas. Biogas production is a clean low carbon chain technology which converts fermentable organic wastes into cheap, versatile as well as clean fuel and organic soil conditioner. Biogas produced by anaerobic digestion of mentioned organic matters and biomass wastes can be used as an energy source for various applications such as cooking, heating, space cooling/refrigeration, electricity generation and gaseous fuel for vehicular application[6].

India is implementing one of the World's largest programme in renewable energy.

The country ranks second in biogas utilization. Unlike Solar energy Biogas can be generated and supplied round the clock and is immune to the problem of intermittent availability if planned adequately. Biogas plants provide one solution for concerns such as fuel, organic soil conditioner and waste management.

Bio-methanation process of converting waste biomass into gaseous fuel is superior and a sustainable process in comparison to general practice of burning waste which produces pollutant, ash and hence needs to be preferred for such biomass materials that can be processed in biogas plants.

Vipul and Shivangi of Delhi Technological University[7] have already conducted a study for feasibility of a Biogas plant in Campus and proposed 3 digesters of 1000 liters each to cater to the food waste at the campus. They suggested digesters to be placed near kitchen as food waste can be directly used as feedstock and calculated a potential of 650 lit of biogas daily in 1000 lit reactor, under ideal conditions [7](like maintaining pH, VFA, Alkalinity, etc.) and also concluded that biogas from food waste can save at least 50 % of the LPG(9-10 cylinders/day) gas consumption of the campus and also provide substantial

amount of manure for gardening purposes in the campus.

Functional principal:

A Biogas plant based on this Nisargruna technology digest all kinds of organic solid wastes comprises mainly of long organic polymer chains such as carbohydrates, fats and proteins in presence of Biocatalysts. First of all the waste is separated to make sure that no non-biodegradable material is left and processed to make slurry. The waste is then passed through the aerobic and anaerobic processes. The end products consist of biogas, carbon dioxide, water vapour and very good quality weed free manure. Recovery of nearly 70% of water can be made by recycling at the end of the process[8].

Description

The whole process of converting biomass to biogas is through 5 steps namely

- 1. Hydrolysis**
- 2. Acidogenesis**
- 3. Acetogenesis**
- 4. Methanogenesis and**
- 5. Aerobic Enrichment.**

- 1. Hydrolysis:** As we feed the digester at first the mass has to go through hydrolysis. During this

process long organic polymer chains breaks down to smaller parts such as simple Sugars, Amino and fatty acids. Molecules such as volatile fatty acid are first catabolized to smaller compounds.

2. **Acidogenesis** : Fermentation of the remaining components by Fermentative Acidogenic Bacteria occurs and fatty acids, ammonia and carbon di oxide are produced along with some other by-products. This biological breakdown towards smaller chains is also known as Acidogenesis.
3. **Acetogenesis**: The third stage anaerobic digestion. Here simple molecules created through the Acidogenesis phase are further digested by acetogens to produce largely acetic acid as well as carbon dioxide and hydrogen.
4. **Methanogenesis** : The final stage is Methanogenesis, during this stage Methanogenic bacteria (methanogens) utilizes the products formed in the earlier stages to give Methane, Carbon di oxide and some water-vapour which is mainly the Bio Gas. These methanogens act between a certain range of pH only i.e. pH level

should be maintained from 6.5 to 8 for the process to occur.

5. **Aerobic Enrichment** : The treated non-digestible overflow from this digester tank which is not digested by the bacteria is aerobically enriched and is converted to high quality manure.

The earlier Biogas plants conventionally used cow dung/ animal focus as primary or only fuel and required regular supply of feed stock and water for longer durations which made biogas plants unattractive for investment. But recent developments and introduction of Nisarguna, the plants can run on nearly all type of solid bio waste such as Kitchen waste, spoiled or left over food, all kinds of bio oils, used cooking oil, extracted tea powder, used flowers or leaves, gardening waste etc. and the whole process can be completed in time period of as low as 1 day for small scale plants. With introduction of this technology minimum required size of the plant is greatly reduced. This has given freedom of selection of size of the plant required and has also attracted many institutions to invest in biogas as size is the main economic factor for such kinds of plants.

Some important components of the system:

1. **Receiving / Sorting /Mixing platform:** Steel platform prefabricated & installed at some height. It holds mixer.
2. **Mixer:** Motor driven mixer is specially fabricated in M.S. and S.S. top for loading of waste and is connected to control panel with necessary electrical wiring and fixers
3. **Thermophilic Aerobic Bioreactor:** Digester with manholes , inlet and outlet holes working with compressor and solar water heater, constructed in mild steel with acid proof & rust proof two coats of red oxide and two coats of oil paint, connected to main digester with coated pipe (Total effective Capacity). Major amount of carbon-di-oxide is released in this tank. And the contents are tranfrered to Anaerobic Digestor.
4. **Anaerobic Bioreactor:** Has a dome on top for coaction of released methane gas, constructed in mild steel with acid proof & rust proof two coats of red oxide and two coats of oil paint coating, connected to slurry handling

system with coated pipes. Accessories such as pressure control valves, partition walls along with methane recycling grids and various other smaller components with equal importance are also connected to this tank.

5. **Gas Holder :** Thick Mild Steel dome with necessary supports of angles and brackets surface finished with rust proof Coating & two coats of red oxide and two coats of oil paint and Gas outlet.
6. Water pump, Compressor, Air and Water Injection, non-return valves and fittings, Control panel, Gas meter, Gas measuring equipment, Dome Balance system for balancing dome are also part of the standard equipment.

Output of the plant:

Description	Quantity
Capacity of Digester	500 kg / Day
Biogas Produced	40-60 m ³ / Day
CO ₂ Produced	50-60 m ³ / Day
Manure Produced	40 – 80 kg / Day

1. Primary output is Bio gas (i.e. around 60-65% biogas 35-30% carbon di oxide along with some water vapors and H₂S gas), can be directly used as cooking gas which burns with clear blue flame and gives out high energy.
2. Although secondary but the digester waste or spent slurry is very good quality manure which is 100% organic in nature. This 100% organic manure has good concentration of stable carbon which will help soil in improving microbial activity, nitrogen fixation, water retention and soil fertility and can be used in gardens or potted plants.

Benefits from the plant:

1. 100% recycling of organic / bio waste: with the freedom of putting any organic matter to the digester and get organic manure and high grade biogas and no other by product.
2. Treatment of waste locally at source reduces the load on Municipal corporations.
3. This type of system can be installed on individual or cooperative basis by hotels, chains or restaurants, malls, group of small eateries in a

region and can get cooking gas without having to worry about the waste disposal.

4. Reduced dependence on petroleum based resources.
5. Highly environment friendly as the waste will eventually degrade on landfill site and release the products to the environment and water may seep and pollute underground water is now being channelized to produce energy and other resources.
6. Reduction in Green House Gas emissions can help government to earn carbon credits.

Conclusion:

The process of composting, biogas generation has been know from very early times. NISARGRUNA biogas technology has accelerated the Biomethanation process which has reduced the time taken for the biodegradation of the bio mass and could be a potentially a good solution for the problem of solid waste management. Methane on one hand has high calorific value is also very lethal as Green House Gas (i.e. nearly 21 times more than CO₂) which is generally released in the environment if waste goes to land filling sites along with carbon dioxide

Future Scope:

Biogas may serve as fuel for India as India is an agricultural economy and large amount of biomass as waste is available. This certainly gives biogas an edge to become the fuel for the cause of economic growth and Energy Security. Technologies must be established for production, Bottling / storage, transporting of biogas in a decentralized manner.

Further, Biogas has nearly 65% of methane and enrichment processes can be applied to make it equivalent to Compressed Natural Gas (CNG) and the infrastructure for CNG is already well established and thus will not incur any new cost in this regard and Bio-methane could replace CNG as fuel for transportation etc.

References:

- [1.]M. Samer, Biogas Plant Constructions, Cairo University, Faculty of Agriculture, Department of Agricultural Engineering, Egypt
- [2.]Interim Technical Report, AFBI Hillsborough, 27 Months Performance Summary For Anaerobic Digestion Of Dairy Cow Slurry, Peter Frost And Stephen Gilkinson June, 2011
- [3.]Christian Müller, Anaerobic Digestion of Biodegradable Solid Waste in Low- and Middle-Income Countries Overview over existing technologies and relevant case studies Dübendorf, 2007
- [4.]Joseph Fargione, Jason Hill, David Tilman, Stephen Polasky, Peter Hawthorne, Land Clearing and the Biofuel Carbon Debt, 2008
- [5.]Timothy Searchinger, Ralph Heimlich, R. A. Houghton, Fengxia Dong, Amani Elobeid, Jacinto Fabiosa, Simla Tokgoz, Dermot Hayes, Tun-Hsiang Yu, Use of U.S. Croplands for Biofuels, Increases Greenhouse Gases Through Emissions from Land-Use Change, 2008
- [6.]Biogas Generation, Purification And Bottling Development In India – A case study
- [7.]Vipul Vaid and Shivangi Garg, Food as Fuel : Prospects of Biogas Generation from Food Waste, IJAFST, ISSN No. 2249-3050, Volume 4 No. 2 (2013) 68.
- [8.]http://www.barc.gov.in/technologies/kitchen/kitchen_br.html