THE INTERNATIONAL JOURNAL OF SCIENCE & TECHNOLEDGE

Biogas Production from Different Waste Matireals in India

Dhameliya Prathmika
CG Bhakta Institute of Biotechnology, UKA Tarsadia University
Gopal Vidhyanagar, Bardoli Mahuva Road, Tarsadi
Nimisha Patel
CG Bhakta Institute of Biotechnology, UKA Tarsadia University
Gopal Vidhyanagar, Bardoli Mahuva Road, Tarsadi

Abstract:
The requirement of liveliness has been better than before over the years as the sequence by rising of the world population and development of global industries especially for food and feed. In this article we discuss about biogas production from different raw materials and its application in agriculture. Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage, municipal, animal waste, plant material and crops. Biogas composition includes 50%-60% methane and 25%-45% CO_2. Anaerobic process basically involve the decomposition of organic and inorganic matter in the absence of oxygen and at the end of this process nutrient rich digested slurry is produce which is use as a biofertilizer. The extent of adaptation of biogas technology across the worlds is also briefly reviewed in this article. The need of a national policy is imperative to bring this technology at farmer's doorstep

Keywords*: Bio-gas generation, municipal solid wastes, biogas from different waste*

Introduction

The demand of energy has been greater than before over the years as the sequence by rising of the world population and expansion of global industries especially for food and feed [Department of Alternative energy Development and Efficiency (2009)]. Energy is an essential input for economic growth, social development, human welfare and improving the quality of life. [Nuttall , W.J. & manz, D.L. (2008).] Most of the energy expenditure is from power generation, transportation, industry, and community sectors. Moreover, the most utility energy, are taken from fossil oil, gas and coal. Many developing countries have their own policy to find the alternative energy, and many researchers have attempted to find the suitable resources to produce an alternative energy such as biomass, solar energy, geothermal, hydro power, wind energy and ocean energy. The concept of the alternative energy is to get the other resources to replace or substituted of the need of petroleum and also to reduce the main issued of global warming[Department of Alternative energy Development and Efficiency(2009)].

Every sector of Indian economy, agriculture, industry, transport, commercial and domestic needs inputs of energy. As a result, using up of energy in all forms has been steadily rising all over the country. This growing using up of energy has also resulted in the country becoming increasingly dependent on fossil fuels such as coal, oil and gas. Increased use of fossil fuels also causes environmental problems both locally and globally. It is common knowledge that the world's main energy income will be depleted within next several decades. The world is unavoidably faced with crises of fossil fuel shortage and environmental degradation as a direct result of growth in population, urbanization and industrialization. [Nuttall, W.J. and manz, D.L. (2008).]

Most countries find themselves under considerable energy constraints, while the growing demand for domestic energy use decreases fuel wood reserves and increases deforestation rates. Foreign exchange earnings have to be spent on imported fuels. In India, energy demand for gasoline and diesel fuels is as high as ever and imported petroleum product for a large proportion of the country's energy imports [Jiang C, Liu T, Zhong J. (1989)].

1. BIO-GAS

The discovery of biogas can be first traced back on the 17th century when Van Helmot noticed flickering lights beneath the surface of swamps and connected it to a flammable gas produced by decaying organic matter. In the scientific world, Volta noted as early as 1776 that biogas production is function of the amount of decomposing plant material and that the biogas is flammable under certain conditions. [Brian Herringshaw, Ohio state University].

Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen. Organic waste such as dead plant and animal material, animal dung, and kitchen waste can be converted into a gaseous fuel called biogas.

Biogas is produced by the anaerobic digestion or fermentation of biodegradable materials such as biomass, manure, sewage, municipal, green west, plant material and crops.

Biogas comprises primarily methane (CH4) and carbon dioxide (CO2) and may have small amounts of hydrogen sulphide (H2S) and moisture. The gases methane, hydrogen and carbon monoxide (CO) can be combusted or oxidized with oxygen this energy

release allows biogas to be used as a fuel. Biogas can be used as a fuel in any country for any heating purpose, such as cooking. It can also be used in anaerobic digesters where it is typically used in a gas engine to convert the energy in the gas into electricity and heat [Brian Herringshaw, Ohio state University].

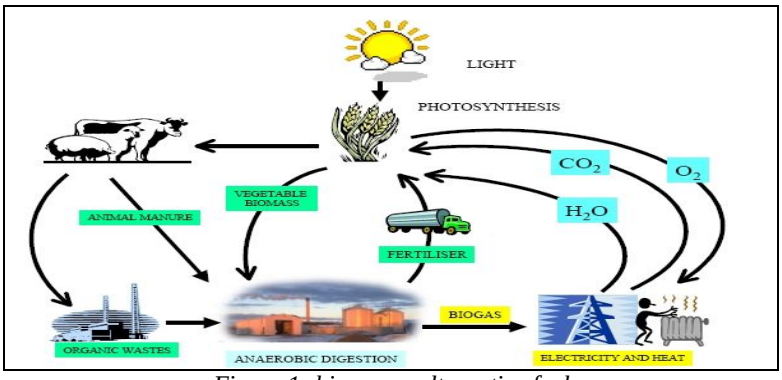

Figure 1: biogas as alternative fuel
Reference: http://teenbiotechchallenge.ucdavis.edu/2012

1.1. Biogas generation

It has been used in India for almost a hundred years. India has more cattle than any other country (450 million head, 19% of the world population) and the cow held in religious veneration and its products are considered purifying agents. Hence, there is a universal acceptance of even its dung, which otherwise would instinctively be thought of as repulsive. Cow dung is widely used in India as composted fertilizer and as a cooking fuel (dung cakes). Dung account for over 21 percent of total rural energy use in India, and as much as 40 percent in certain states of the country [Kanwardeep singh, (2010)].

1.2. Biogas Production Stages

1.2.1. Stage-I (Hydrolysis)

Firstly the biomass having complex compound such as fats, proteins, carbohydrates etc. are broken down into simple water soluble organic compounds through the influence of water called hydrolysis. Bacteria decompose the long chains of the complex carbohydrates, proteins and lipids into shorter parts. For example, polysaccharides are converted into monosaccharide. Proteins are split into peptides and amino acids.

1.2.2. Stage-II (Acid formation)

The micro-organism of anaerobic and facultative group (which grows in absence of O2) called acid forming bacteria produce mainly the acetic acid and propionic acid at low temperature of about 25° with release of CO2. In certain cases, the acid may be produced in such large quantities that all the biological activity is arrested. Thus, it becomes necessary to control the pH value of mixture. Acid-producing bacteria, involved in the second step, convert the intermediates of fermenting bacteria into acetic acid (CH3COOH), hydrogen (H2) and carbon dioxide (CO2). These bacteria are facultative anaerobic and can grow under acid conditions. To produce acetic acid, they need oxygen and carbon. For this, they use the oxygen dissolved in the solution or bounded-oxygen. Hereby, the acid-producing bacteria create an anaerobic condition which is essential for the methane producing microorganisms. Moreover, they reduce the compounds with a low molecular weight into alcohols, organic acids, amino acids, carbon dioxide, hydrogen sulphide and traces of methane.

1.2.3. Stage-III (Methane formation)

In this stage the anaerobic bacteria called as methane formers converts the organic acids formed in stage II into biogas having its main constituents as methane and carbon dioxide with other small trace of H2S, H2 and N2 etc. These methane formers are sensitive to pH changes (K.J. Chae, S.K. Yim, K.H. Choi, W.K. Park, and D.K. Lim).

1.3. Application of biogas

- Biogas stoves
- Fertilizer
- Lighting and power generation
- Cooking and heating.*(*Karthik Rajendra and mohammad J.Taherzadeh,2012)

1.4. Production Plant of Bio-Gas World capacity 2008

According to the United Nations' Food and Agricultural Organization (FAO), the world population of animals is 1.3 billion cattle, 1 billion sheep, 1 billion pigs, 800 million goats and 17 billion chickens. The waste the animals produce has 55 percent to 65 percent methane, which if released into the atmosphere is bad news for us (it traps heat at 21 times the rate that carbon dioxide does) but when burned is another matter entirely. It gives us energy. 62.5 liters of bio gas can be produced from one kilogram of cow manure (heated at around 28 degrees Celsius or 82.4 degrees Fahrenheit) (Chandra Kumar Sharma).

2. Anaerobic Digestion of Municipal Solid Wastes

Municipal solid waste (MSW) is the waste generated in a community with the exclusion of industrial and agricultural wastes (Tchobanoglous,1993). Hence MSW includes residential waste (e.g., households), commercial (e.g., from stores, markets, shops, hotels etc), and institutional waste (e.g., school, hospitals etc). Paper, paperboard, garden and food waste can be classified in a broad category known as organic or biodegradable waste.

The industrialization of anaerobic digestion began in 1859 with the first digestion plant in Bombay, India. By 1895, AD had made inroads into England where biogas was recovered from a well-designed sewage management facility and fueled street lamps in Exeter. Further AD advances were due to the development of microbiology. Research led by Buswell and other in the 1930s recognized anaerobic bacteria and the conditions that promote methane production. (lusk, 1997).

China and India have now adopted a trend towards larger, more sophisticated farm based systems with better process control to generate electricity. With time, AD systems are becoming more complex and not limited to agriculture or animal waste treatment. The technology is now being applied for municipal waste treatment as well as industrial waste. (lusk, 1996).

3. Feed Stock for Biogas Production

India has a very enormous prospective of tree-born non-edible oil seeds. The non-traditional seed oils available in the country, which can be exploited for this purpose, are *Madhuca indica*, *Shorea robusta*, *Pongamia glabra*, *Mesuaferra* (Linn), *Mallotus philippines*, *Garcinia indica*, *Jatropha curcas* and Salvadora (Chandra. R.,.K. Vijay, P.M.V. Subbarao and T.K. Khura, 2011). Out of these seeds, at the most 35 per cent is converted into vegetable oil and the remaining 65 per cent is rejected as toxic-oiled seed cake. However, this could be big source of bio-energy production from the generated waste (Chandra. R.,V. K. Vijay and P.M.V. Subbarao, 2009). the future scenario of non-edible oil seeds utilization for biodiesel manufacture in the country from Jatropha curcas (jatropha) and Pongamia pinnata (karanja) there is need for efficient consumption of their cakes.

Several attempts are being made to utilize non-edible seed cake for biogas production (Radhakrishna. P,2003). Though several Indian Institutes are attempting production of biogas from non-edible oil cake, at present, very little experimental work has been reported to assess the potential of oil cakes as the feed material for biogas production.

4. Fruits and Vegetables Waste for Biogas Production

India is a heavily populated country and this is the only reason for enormous wastes being produced regularly out of household & industrial activities like peeling and cutting of raw FVW prior to processing, eating, and cooking. Serious environmental and health problems are related to inadequate solid waste disposal. Garbage dumped in open places cause heavy pollution due to soil, groundwater and surface waters (Christian Muller, May 2007). FVW is generally stale or spoilt, not fit for human consumption. These materials are usually high in fiber content and are of different sizes and forms. Vegetable wastes have a high moisture content of 80-89%. Three fourth of the total solids present are volatile solids. Their biodegradability varies accordingly with the state of hardening and kind of waste material. Carbon to nitrogen ratio varies in each vegetable, however for mixed variety it may be around 1:20 to 1:30. The origin of biogas is traced back to the Persians. They discovered that organic matter such as rotting vegetables gave a flammable gas that could be used for other purposes (Veeken AHM, Hamminga P, Mingshu Z.) Vegetable wastes generated largely in markets were disposed in municipal landfill or dumping sites [Srilatha H R, Krishna N, Sundhakar Bada K & Madhukara K(1995)].vegetable wastes, due to high biodegradability nature and high moisture content (75 – 90%) seemed to be a good substrate for bio-energy recovery though anaerobic digestion process. [Viturtia A, Ata-alvarez J,(1996), Misi S N & Forester C F,(2002)]. A major limitation of anaerobic digestion of vegetable wastes is rapid acidification due to the lower pH of wastes and the larger production of volatile fatty acids(VFA), which reduce the methanogenic activity of the reactor [Bouallagui H, Touhami Y, Ben cheikh R & Hamdi M(2004)]. Preliminary treatment is required to minimize organic loading rate, hence aerobic processes are not preferred for vegetable wastes [Landine R C, Brown G J, Cocci A A and Virara H(1983)]. Preliminary treatment is required to minimize organic loding rate limiting step in vegetable waste is by methanogenesis rather than by hydrolysis because methanogenic bacteria take log mass doubling time of 3-4 days in anaerobic reactors. [Landine R C, Brown G J, Cocci A A and Virara H(1983)]. Carbohydrate rich substrates like FVW are quicker producers of volatile fatty acids (VFAs) (Mata A.J., Mace S., Llabres P., 2000). Anaand leads to excess acid accumulation leading to acidity, low pH and process inhibition. So, higher concentration of substrates for FVW leads to lowering of pH and thereby produces less biogas. Nevertheless, an important factor affecting AD process is temperature (Ahring B K., 1994.). Generally AD process is operated under mesophillic or thermophillic condition in which thermophillic digestion is reported as more efficient method (Griffin M.E., McMahon K.D., Mackie R.I., 1998.). Compared with wet AD process, dry AD process is much beneficial to compact digester with high organic loading rate and its energetically effective performance (Pavan P., Battistoni P., Mata A.J., 2000. Perfor). Literature review shows that India stands second in the production of fruits and vegetables in the world. It contributes about 10 and 14 % of fruit and vegetable in the world production (Harender Raj Gautam and Guleria SPS Jan 2007). Vegetable wastes are created by marketing, processing, harvesting, transportation etc. that deteriorate easily and cause foul smelling. Many researchers studied anaerobic digestion of vegetable wastes in one stage systems in laboratory scale reactors.

5. Biomass Waste for Biogas Production

Biomass exists in the thin surface layer of the earth called biosphere. It represents only a tiny fraction of the total mass of the earth but it is an enormous store of energy. This store is being replenished continuously. Sun is the main source for supplying energy. In fact, very small fraction, about 0.5 % of the solar energy striking the earth is believed to be captured by plants through photosynthesis on world basis.

6. Plant Waste for Biogas Production

Any biodegradable material whether plant or animal origin can be used for the production of renewable energy through anaerobic digestion process. Plant materials such as crop residues, weeds, aquatic plants, etc are also source for methane production. Various agricultural residues such as rice straw, wheat straw, maize stalk, leguminous plants, etc. have been used to produce methane in conjunction with animal waste. Cellulolytic plants materials can be easily degraded by the bacteria for methane generation while the ligneous materials are hard to digest by bacteria and hence, it should be avoided.

6.1. Coconut HUSK LEACHATE using UASB-Reactor for Biogas

In recent years numerous designs have been developed to enlarge of anaerobic (Bull, 1984) treatment of wastewater. UASB (Lettinga and Hulshoff, 1986), process is currently the most widely used treatment system among the presently available treatment processes. Good performance of the UASB-reactors depends upon the formation of a bed of well settling and highly active granular sludge, with a low sludge volume index and a high methanogenic activity. The main objective of the present work is to study the anaerobic treatment of coconut husk leachate in a laboratory scale UASB-reactor. Coconut husk is taken in the feeding tank and it is subjected to leaching. The leachate is fed to the reactor through the influent pipe, which leads into the conical shaped bottom of the reactor. The effluent of the reactor is coming out through the effluent tube. The influent is fed to the reactor with a pump of FMI Lab pump model QG 400. The gas produced in the reactor is measured with an INSREF Wet Gas Flow Meter.(Bouallagui H, Touhami Y, Ben Cheikh R and Hamdi M, 2004.)

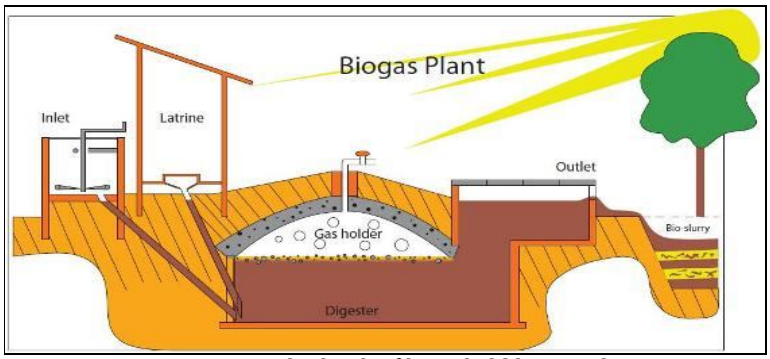

Figure 2: Simple sketch of household biogas plant
Reference: http://en.wikipedia.org

7. Animal Waste for Biogas Production

Animal wastes are tremendous raw materials for methane generation. In the developing countries, where biogas technology is much advanced, it is customary to use cattle and buffalo dung to feed the digester. A homogenous mixture can be made while mixing the dung with water facilitating the digestion process. Chicken or poultry manure is also a good source for biogas production. It should be noted that while mixing with water, goat and sheep manure has the tendency of floating whereas horses and elephant dung contain fibrous materials.

7.1. Biogas Production from Cow Dung

Every morning around 6:00 am villagers bring the dung collected during the previous day to the plant. Normally, this is carried in above your head containers by men or women. An important point that should be stressed upon here is the involvement of men folk in carrying the dung to the plant site.

Usually, 25-30 kg cow dung is supplied by each family every day. The weighed cow dung is then put in a mixing tank in which equal amount of water is added. Slurry of dung and water is formed as they are mixed using pressurized air. Water for the operation of the plant is procured from a nearby tank which has a bore well connected to it. The slurry thus produced passes into the two digesters where it gets decaying anaerobically. The gas produced by this decomposition raises the floating domes. Once the dome gets fully filled, the valve connecting the dome and pressure regulation tank is opened so that gas generated is stored in the pressure regulation tank. The gas is supplied to the beneficiaries daily twice-once at 6 am and next at 6 pm. The gas generated daily is enough to give a continuous supply to all the beneficiaries for 2- 2.5 hours each in the morning and the evening. The plant supervisor and 4 workers oversee the plant operations (Prof. A. B. Rao, May 2011).

8. Human Waste for Biogas Production

Compared to animal waste, human feces and latrine waste have been used for methane generation in limited scale in most of the developing countries due to social or religious stipulation. The only exception is china where latrine waste is traditionally and socially acceptable and is used to produce biogas for cooking and lighting and bio-manure to enhance soil fertility. Human feces contain pathogens and has offensive odor. One of the best ways to dispose human waste is to treat it in the anaerobic digester and producing biogas as energy and effluent as fertilizer (Amrit B. Karki).

9. References

1. Ahring B K., 1994. Status on science and application of thermophilic anaerobic digestion [J]. Water Science & Technology, 30, 241-299.
2. Amrit B Karki, CBIOGAS AS RENEWABLE ENERGY FROM ORGANIC WASTE, Nepal.
3. Bouallagui H, Touhami Y, Ben Cheikh R and Hamdi M, 2004. "Bioreactor performance in anaerobic digestion of fruit and vegetable wastes", Process Biochemistry.
4. Brian Herringshaw, Ohio State Univercity, M. Tech. Thesis On "a study of Biogas Utilization Efficiency Highlighting Internal Combustion Electrical Generator Units".
5. Bull, M.A., R.M. Steritt and J.N. Lester: 1984 Developments in anaerobic treatment of high strength industrial wastewater. Chem. Eng. Res. Des., 62,203.
6. Chandra Kumar Sharma, Biogas – A Boon for India.
7. Chandra. R., V.K. Vijay, P.M.V. Subbarao and T.K. Khur, 2011. Production of methane from anaerobic digestion of jatropha and pongamia oil cakes, Applied Energy, Corrected Proof in Press.
8. Chandra. R., V. K. Vijay and P.M.V. , Akshay Urja, 2009. Subbarao. Biogas production from de-oiled seed cakes of jatropha and pongamia, Vol. 3(2), pp: 17-22.
9. Christian Muller, Dubendorf; May 2007. Anaerobic digestion of biodegradable solid waste in low- and middle-income countries, overview over existing technologies and relevant case studies, Eawag Aquatic Research, Water and Sanitation in Developing Countries (Sandec).
10. Department of Alternative Energy Devlopment and Efficiency,ministry of energy, devlopment strategy and planning of alternative energy for 15years in thiland2009.
11. Department of Alternative Energy Devlopment and Efficiency, Ministry of Energy, Development strategy and planning of alternative energy for 15 years(2008-2022) in Thialand (2009).
12. Griffin M.E., McMahon K.D., Mackie R.I., 1998. Methanogenic population dynamics during start-up of anaerobic digesters treating municipal solid waste and biosolids[J]. Biotechnology and Bioengineering 57, 342-355.
13. Harender Raj Gautam and Guleria SPS , Jan. 2007. "Science Tech Enterpreneur".
14. Jiang C, Liu T, Zhong J. Biomass 1989 "A study on compressed biogas and its application to the compression ignition dual-fuel engine"., pp 53–59.
15. Kanwardeep Singh, M.E. Thesis, July 2010. "Study of Solar/Biogas Hybrid Power Generation" Thapar Univercity, Patiala.
16. Karthik Rajendran,Solmaz Aslanzadeh and Mohammad J.Taherzadeh, July 2012,Household Biogas Digsters.
17. K.J. Chae, S.K. Yim, K.H. Choi, W.K. Park, and D.K. Lim "Anaerobic digestion of swine manure: Sung Hwan farm scale biogas plant in Korea".
18. Landine R C, Brown G J, Cocci A A and Virara H, 1983. "Anaerobic treatment of high strength, high solid potato waste", Agri. Wastes, 17: 111 – 123.
19. Lettinga, G. and L. Hulshoff Pol 1986: advanced reactor design, operation and economy. In: Post conference international seminar on anaerobictreatment in tropical countries. Sao Paulo, Brazil. Proceedings. pp. 25-29 .
20. Lusk, P. 1997. "Anaerobic Digestion and Opportunities for International Technology Transfer." The Third Biomass Conference of the Americas; August 24-29, 1997, Montréal, Québec. UK: Pergamon Press; pp. 1211-1220.
21. Lusk, P., Moser, M. 1996. "Anaerobic Digestion - Yesterday, Today and Tomorrow."Ninth European Bioenergy Conference; June 24-27, 1996, Copenhagen, Denmark. UK: Pergamon Press; pp. 284-289.
22. Mata A.J., Mace S., Llabres P., 2000. Anaerobic digestion of organic solid wastes. An overview of research achievements and perspectives. Bioresource Technology 74(1).
23. Nuttall, W. J. & Manz, D. L. 2008. "A new energy security paradigm for the twenty-first century Technological Forecasting and Social Change", Vol. 75, 2002, pp. 1247-59.
24. Pavan P., Battistoni P., Mata A.J., 2000. Performance of thermophilic semi-dry anaerobic digestion process changing the feed biodegradability [J]. Water Science & Technology, 41, 75-81.
25. Prof. A. B. Rao, May 2011. Center for Technology Alternatives for Rural Areas Indian Institute of Technology Bombay
26. Radhakrishna. P., 2003. Tree borne oil seeds as a source of energy for decentralized planning, Government of India, Ministry of Non-Conventional Energy Sources, New Delhi, India.
27. Srilatha H R, Krishna N, Sudhakar Bada K and Madhukara K, 1995; "Fungal pretreatment of orange processimg waste by solid-state fermentation for improved production of methane", Process Biochemistry, 30: 327-331.
28. Tchobanoglous, G., Theisen, H., and Vigil, S., 1993. Intergrated Solid Waste Management, chapter 9, McGraw-Hill, New York.
29. Veeken AHM, Hamminga P, Mingshu Z 2005. Improving sustainability of municipal solid waste management in China by source separated collection and biological treatment of the organic fraction . In: Innovative environmental management & sustainable development – [China]: - ISBN 7802092337, Wageningien UR publications.
30. Viturtia A, Mata-Alvarez J and Fazzini G, 1989 "Two phase anaerobic digestion of a mixture of fruit and vegetable wastes", Biological wastes, 29: 189-199