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Production of biogas from different waste materials: A review

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Abstract
This article is based on production of biogas from various feed stock and different waste**.** Anaerobic digestion process produces a gaseous product, called 'biogas' and it is a renewable form of energy, which is composed mostly of methane, carbon dioxide and other gases. Fixed dome, floating drum and plug flow digester are different types of digester. Biogas does not have any geographical limitations nor require advanced technology for the production of energy. Anaerobic digestion is suitable for India's climate. Municipal and kitchen waste from Houses, hostels, canteens, etc., livestock waste material like dung, bedding material, leftover feed, palm oil mill waste product, crop and agriculture residue are used for biogas production. Biogas is convenient and valuable energy source which has high calorific value and also used for various purposes like fuel, manure. Biogas production is a microbial process in which organic waste is decomposes into valuable product like Gas and Slurry. In this way it is the most eco-friendly replacement for energy. This biogas production also performs the function of waste disposal system and it also prevents the potential source of environment and spreading pathogens and disease-causing bacteria.

Keywords: Anaerobic digestion, livestock, municipal waste, agriculture residue

Introduction

Biogas is the mixture of Methane (50-70%), carbon dioxide (30-40%), 1-3 % nitrogen and traces of hydrogen sulphide, ammonia and hydrogen (Hashimoto and Varriel 1978) [7]. Biogas typically refers to a gas produced by the biological breakdown of organic matter in the absence of oxygen and also a waste management technique because it eliminates the harmful micro-organisms (Akpabio et. al. 1992) [1]. At temperature (37°C) and (55 °C) respectively for anaerobic digestion (for food waste-only) and a co-digestion process (for mixture of cow manure, agriculture by product, palm oil mill waste, food waste) has been reported for biogases production by utilization of mesophilic and thermophilic bacteria. Biogas systems provides a residue organic waste, having superior nutrient qualities against the usual organic fertilizer, also function as a waste disposal system, prevents environmental contamination and the spread of pathogens. With raised biogas production, the supplemental biogas will be beneficially used for power generation, vehicle fuel, in gas network, and in industries like sugar refineries, dairies and paper mills. The energy content of 1.0 m^3 of purified biogas is equal to 1.7 L of bioethanol, or 0.97 m^3 of natural gas and 1.1 L of gasoline (Martins et. al. 2009) [16]. Biological wastes are found as municipal wastes, kitchen wastes, agricultural wastes and animal wastes and these can utilize with the help of various technologies adaptation for leading to the use of renewable energy systems effectively and efficiently. In this article, author can discuss regarding the biogas synthesis from utilization of various kinds of biological /organic waste by application of anaerobic fermentation.

Biogas Production from livestock waste (cattle, buffalo dung, poultry)

India's livestock sector is one of the largest in the world (Livestock census, 2019) [14]. The total Livestock and poultry population is 535.78 million and 835 million in the country. Population comprises cattle, buffalo, sheep, goat, pigs and equines. Waste material i.e., dung produced by these domestic animals is a best raw material for biogas production. Due to easily and abundantly availability of cattle and buffalo dung in all over country bovine dung is mostly used for biogas production. It was observed that biogas production from cow dung is 0.034 m^3/kg (Md. Forhad *et al*., 2013) [17]. The average annual dung yield from cattle and buffalo is estimated to be approx. 870.57 MT and 1120.47 by buffalo results total 1991.04 MT of total dung production which can generate biogas approximate 39083 Mm^3 annually.

Study conducted for comparison of viability of biogas from poultry waste and the mixture of poultry and fish waste. Fish wastes are good source of high valued organic carbon for methane production and have high content of ammonia nitrogen. Poultry wastes produced more biogas than poultry droppings (Sangeetha *et al*., 2014) [22].

Biogas production from municipal solid waste

Municipal solid waste (MSW) generation has become an increasing environmental and public health problem everywhere in the world, particularly in developing countries because of rapid urbanization and population growth (Tadesse et. al. 2014) [24]. Municipal waste i.e., food waste, vegetable waste, animal material, kitchen waste etc. can be converted into biogas by the anaerobic digestion in presence of microbes. A sustainable waste management system has become an integral part of resources management. Biogas production from the municipal solid waste one of the best method of waste disposal. It has reduced environmental impact, especially greenhouse effect and global warming (Ashik Ali et. al., 2016) [2]. In India about 1,27,486 tons per day of MSW is being generated because of various household, industrial and commercial activities (CPCB India, 2012) [5]. The organic waste in MSW is raw material for anaerobic digestion in biogas production process (Igoni et. al., 2008) [10]. On an average the organic matter content of MSW in India is about 42.19% which shows a very good amount for anaerobic digestion. Also, the carbon to nitrogen ratio (C: N) is varies from 21:30 which a most suitable for bio methanation (Rao et. al., 2010) [20]. The biogas production potential from MSW has been estimated about 9.29 Mm^3/day at the rate of 95 m^3/t (Sharholy et. al., 2008) [23].

In Agartala City, physical composition of MSW is food waste, combustible matters, plastics, inert materials etc. and predicted volume of methane generation potential of MSW in 2011 was 42966.40 m^3 and it will be 52376.10 m^3, 66943.80 m^3, 85671.60 m^3 and 108559.5 m^3 in the year 2021, 2031, 2041 and 2051 respectively (Chakraborty et. al., 2019) [4].

Biogas production from palm oil mill waste

Palm Oil mill plant generates large number of solid wastes such as empty fruit bunch (23%), meso carp fiber (12%) and shell (5%) for every ton of fresh fruit bunches processed in the mills (Rupani P. 2010) [21]. During CPO processing, one ton of fresh fruit bunches could approximately generate residue/waste of palm oil mill effluent 585 L, fiber 140 kg, palm oil decanter cake 42 kg, palm shell 60 kg and oil palm empty fruit bunches 240 kg (Arif et. al., 2001) [18]. Fresh fruit bunches are used as raw material in oil mill. The oil extraction rate from palm oil biomass is about 10 - 12% with the majority 90% left as residues biomass. Around 60% of solid oil palm biomass residues i.e., are empty fruit bunches, palm kernel cake, decanter cake, palm press fibre in palm oil mills and 40% liquid waste as palm oil mill effluent generated all around the year. Palm oil biomass residues composed of hemicellulose, celluloses that could be used as substrate for methane production through anaerobic digestion. Biogas generation from decanter cake of palm oil mill ranged between 0.095 – 0.120M^3, per kg of decanter muck/cake (J Malik 2020) [15]. Similar Mono-digestion of empty fruit bunches and decanter results production of methane yields of 414.40 mL-CH_4/g-VS and 399.3 mL-CH_4/g-VS, respectively (Tepsour et. Al. 2019) [26]. Methane production of 55 m^3 CH_4/ton, 47 m^3 CH4/ton and 41 m^3 CH_4/ton was obtained from empty fruit bunches followed by palm press fiber and decanter cake (Chaikitkaewa et. al.,2015) [3].

Biogas Production from Kitchen waste

Vegetable refuse, cooked and uncooked food, extracted tea powder, waste milk and milk products are waste generated from the kitchen which can all be processed in biogas digester. Kitchen waste is a most suitable substrate for anaerobic fermentation than the other waste. It is also a very energy rich material which should be investigated as the main constituent raw material for the biogas plant. An experimental study conducted in a pilot plant which is made up of synthetic tarpaulin material and having a dimension of 2'3'' x 2'3'' x 4'5''. Room temperature ranges should be 28 ^{0}C to 32 ^{0}C (Venugopalan et.al. 2017) [28]. 12 liters of well crushed food waste slurry is added into the plant for trail and gas production rate is observed along with cooked rice waste and results 0.32 m^3 of biogas production. Worldwide researchers at the United Nations reported that 50% of the food produced is wasted (Taglia et. al. 2010) [25]. Kitchen waste fulfills this condition and boosts biogas production and also reduces size of reactor and cost of biogas production (Kale et. al. 2010). Biogas systems that take kitchen wastes are 800 times efficient than conventional biogas systems. Much of biodegradable wastes such as kitchen wastes and animal wastes are used to produce biogas, a powerful greenhouse gas. Producing renewable energy from our biodegradable wastes helps to tackle the energy crisis. Anaerobic digestion produces a solid and liquid residue called digestate which can be used as a soil conditioner to fertilise land (Dhanariya *et al*., (2014) [6].

Kitchen waste has high caloric and nutritive value to microbes and kitchen waste biogas system are 800 times efficient than conventional system. Delhi Technological University generated 650 litre biogas per day from 300-400 kg food waste per day generated by 5 meshes located at University campus. Biogas from food waste can save at least 50% of the LPG gas consumption of the campus also provide manure for gardening purpose (Vaid V and Garg S, 2013) [27].

Biogas production from crops and agriculture residues

Agricultural residues are rich in bioactive compounds. These residues can be used as an alternate source for the production of different products like biogas, biofuel, mushroom etc as the raw material in various researches and industries. Crops and agriculture residues consist of leaves, stalks, seed pods, molasses, husks, bagasse, seeds, leaves, stem, straw, stalk, shell, pulp, stubble, peel, roots, etc. The use of agro-industrial wastes as raw materials can help to reduce the production cost and also reduce the pollution load from the environment. With help of variety of microorganism's conversion of agro-industrial wastes into valuable products viz. biogas, biofuels, enzymes, animal feed, and other chemicals.

Survey conducted to ascertain the amount of biogas that can be generated from various feed stock (Ilaboya et. al., 2010) [11]. A practical laboratory scale experimental design using agricultural waste was also done to find out the effects of Alkaline (NaoH) on the volume of biogas generated using a mixture of pineapple, plantain and cassava peelings as the feed stock. Results obtained reveals a high volume of gas generated when the operating conditions inside the digester is maintained at moderately alkaline condition. Further findings also reveal that the digester temperature remained within the range of 27 to 35.5 °C throughout the period of experimentation. Biogas generation from rice husk waste by Solid State Anaerobic Digestion (SSAD) method has been performed by several researchers in laboratory scale (Hawali and Hadiyanto 2018) [8]. An effort to increase biogas production were conducted the preliminary treatment of physics, chemistry and biology for the process of delignification. Different experiment conducted with aims to accelerate the fermentation process in the reactor by microorganisms. This method is very suitable for agricultural waste, especially rice husk because total solid content is high that's why water requirement became less. SSAD is able to produce more biogas than liquid anaerobic digestion (Khalid et. al.,2010) [13].

Biogas production in eleven rural plants in Poland has been utilized for analysing the capacities of each plant for generation of 500 kW or excess kW of electricity from supply and processing of organic, Agri food waste mixed with silage. Many barriers are no political support for biogas installations and also for investor, no permission for installation of plant due to administrative burden of mandatory procedures which are found to persist in development of biogas plants as well as every other renewable source of energy. Biogases quantity can be enhanced by more focus on management of agricultural waste (spent wash or potato pulp) as well as good research work plan in their pre-treatment and saccharification processes (Muradin, M., *et al*., 2014) [19].

Table 1: Replacement values for different fuels by 1m^3 of biogas

S. No.	Fuel	Replacement Value	Estimated Equivalent with 15083 Mm^3 of biogas/annum (in millions)
1.	LPG	0.45 Kg	6787.35 Kg
2.	Firewood	3.47 Kg	52338.01 Kg
3	Cattle dung cake	12.30 Kg	185520.9 Kg
4	Charcoal	1.4 Kg	21116.2 Kg
5	Diesel	0.52 liter	7843.16 liter
6	Electricity	6.5KWh	98039.5KWh
7	Kerosene	0.62 liter	9351.46 liter
8	Gasoline	0.8 liter	12066.4 liter

(http://vikaspedia.in/energy/energy-production/bio-energy/biogas) (10)

Conclusion

Anaerobic digestion is a feasible alternative to biogas production and use of biogas-methane- from organic waste is important for saving in economic terms, keeping the environment clean, and minimizing the effects of climate change by generating cleaner green energy that makes a pollution-free atmosphere and thereby reducing the GHG emission. Biogas technology is reviewed as a promising sustainable solution for agriculture, rural, industrial and automobile sector. The by-product of biogas production, biogas slurry is a potential substitute to the chemical fertilizers. It has been found that temperature variation, pH and concentration of total solid etc., are some of the factors that affected the volume yield of biogas production. Biogas also solves major environmental problems such as CO_2 emission, soil degradation, deforestation, indoor air pollution, desertification, organic pollution and social problems such as women occupation etc. The biogas technology can be possible option to replace petroleum fuels for vehicular, industrial and domestic applications.

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