Biogas Production from Municipal Solid Waste :- A Review

Sushmita Patidar[a], Anjani Kumar Dwivedi[b]

[a]*M. Tech Research Scholar, Department of Chemical Engineering, Ujjain Engineering College Ujjain (M.P.).*
[b]*Professor, Head of the Department of Chemical Engineering, Ujjain Engineering College Ujjain (M.P.).*

ABSTRACT:- *Now a days population growth, urbanization, economic prosperity etc. result in a property increase in municipal solid waste quantities. Municipal solid waste are collected from fruit and vegetable market has high calorific and rich nutritive value to microbes due to which efficiency of methane production can be enhanced. Biogas as an energy sources is cost effective and generates a high – quantity renewable fuel. Under anaerobic digestion the organic content is reduced ,cow dung slurry along with the fruit and vegetable waste is used in the bioreactor inoculums. The digested slurry is produced at the end of this process is used as a bio fertilizer. In term of the factor affecting the biogas production , temperature, pH, moisture contents and carbon- nitrogen ratio are the main factors that contribute to the efficiency of the biogas production. In this paper anaerobic digestion , biogas production and challenges for management of fruit and vegetable waste and usage of biogas as alternative to kerosene or LPG has been discussed. In this paper reviewed previous nine years paper on biogas production from municipal solid waste.*

Keywords:- Biogas, Methane, Carbon dioxide, Municipal solid waste

INTRODUCTION

Municipal solid waste generation is significantly increasing in Indian urban areas and started creating enormous waste disposal problems in the recent past. In India, municipal solid waste management is the duty of the local municipalities. More than 90 percent of the municipal solid waste which generated in India is dumped in an unsatisfactory way, what creates environmental hazards to water, air and land, which creates the need of system for municipal solid waste management development capable to minimize the production of these and able to reduce the environmental impact and danger to the public health. Presently most of the developed countries. Waste minimization and energy generation is that the recent emerging concepts. Anaerobic digestion may be a known process to treat organic wastes [J. Mohamed et al 2016]. India produces 55 million tons of municipal solid waste generate in per annum.

Biogas is produced in anaerobic conditions through bacterial reactions through the bio – degradation of organic materials. Biogas is produced as a raw material agricultural waste , plant waste , vegetable waste , municipal solid waste , manure waste , sewage , green waste or food waste. Biogas is a renewable energy source. Biogas comprises of methane (CH_4) and carbon dioxide (CO_2) and may have small amounts of hydrogen sulphide (H_2S) and moisture. The main advantage in using anaerobic digestion is the biogas production, which can be used for cooking , heating and generation of electricity.

ANAEROBIC DIGESTION

It is also referred to as bio mechanization , is a natural process that takes place in absence of air (oxygen). This biological process generates a gas, generally known as biogas, primarily composed of methane and carbon dioxide. This gas is produced from feedstock like bio solids, livestock manure , and wet organic materials.

Anaerobic digestion consists of sludge fermentation , under strict anaerobic conditions. There are four key of anaerobic digestion: hydrolysis, acidogenesis, acetogenesis and the methanogenesis. Hydrolysis claims to conversion of non-soluble biopolymers to soluble organic compounds. The reaction is catalyzed by enzymes excreted from the hydrolytic and fermentative bacteria. End products of this reaction are soluble sugars, amino acids; glycerol and long-chain carboxylic acids. The organic waste undergoes anaerobic digestion resulting to the conversion to the conversion to simple sugars. Acidogenesis, the biological process of acidogenesis is where there is further breakdown of the remaining components by acidogenic bacteria. Here volatile fatty acids are created along with ammonia, carbon dioxide and hydrogen sulfide as well as other by-products. The process of acetogenesis is completed through carbohydrate fermentation and results in acetate, CO_2 and H_2, compounds that may be utilized by the methanogens. The presence of hydrogen is critical importance in acetogenesis of comounds such as propionic and butyric acid. Thus the presence of hydrogen scavenging bacteria is essential to make sure the thermodynamic feasibility of this reaction.

$(C_6H_{10}O_5)n + nH_2O \rightarrow n(C_6H_{12}O_6) - Hydrolysis$

$n(C_6H_{12}O_6) \rightarrow nCH_3COOH - Acetogenesis$

$3nCH_3COOH \rightarrow nCH_4 + CO_2 - Methanogenesis$

Methanogenesis constitutes the final stage of anaerobic digestion in which methanogens create methane from the final products of acetogenesis as well as from some of the intermediate products from hydrolysis and acidogenesis. In this stage methane and carbon dioxide are formed by various methanogens. Various microorganisms are active during this stage. Methanogens are sensitive to pH changes and presence of heavy metals and organic pollutants [Mehraj Pasha 2015]. The general diagram of anaerobic digestion figure-

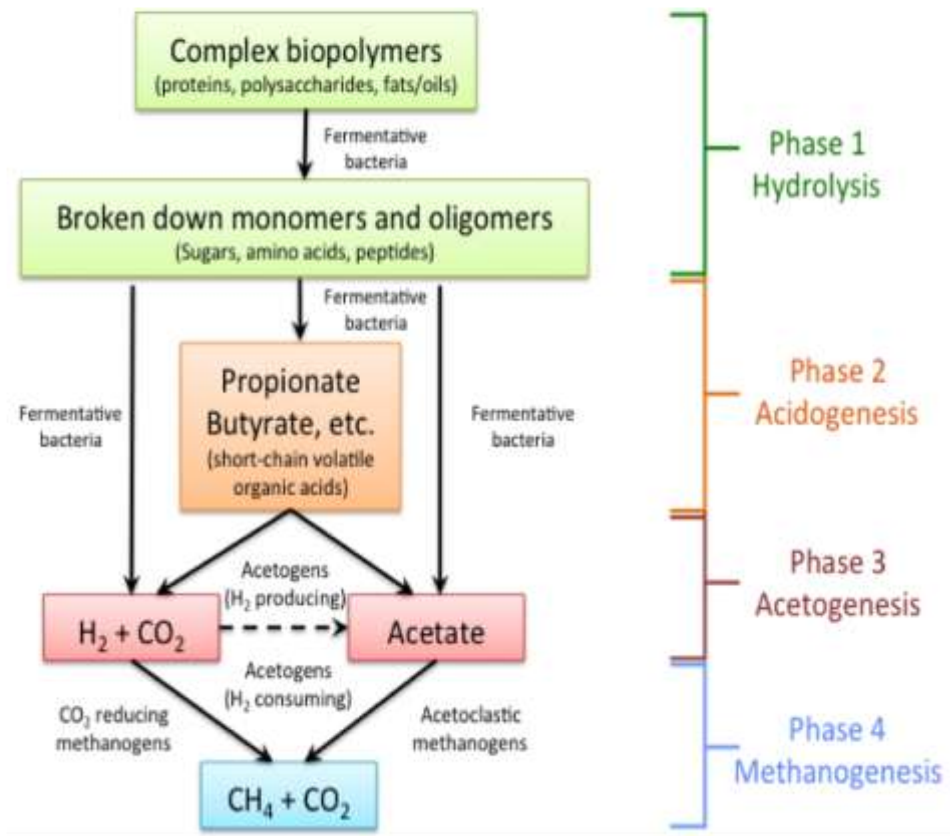

Figure -1 Diagram of trophic chain of the methanogene and its various stages(join Dutton e-Education institute)

LITRATURE REVIEW ON BIOGAS PROUDCTION

The main factor affecting on the biogas production are ph , chemical oxygen demand, volatile solid, total solid, time , temperature, hydraulic retention time. Table 1 and table 2 show literature review on biogas production from municipal solid waste from 2010 to 2018.

Table 1 and Table 2:- Literature review on biogas production from municipal solid waste

Sources	**Waste material**	**pH**	**Carbon/ Nitrogen ratio**	**Temperature**	**Total solid**	**Volatile solid**	**Volatile fatty acids**	**Retention time**	**Methane yield**
christeena (2018)	Cattle dung using with jiggery	5.7 to 7.3	46.4	12 to 24°C	12.5% to 10.7%	84.6% to 80.9%	1189 to 1110 mg/kg	Nine week	40l/kg
Zhu (2010)	Using an integrated rotary drum	7.3 to 7.8	-	55°C	38%	53%	1350mgl^{-1} and 1500mgl	100 days	0.38 and 0.19Lg^{-1}VS
Biswas (2010)	Increasing the Biogas yield of manure by WEx	-	-	180°C	20%	14.8%	-	10 min	136%
Yilmaz (2011)	Cattle manure: Effect of phase sepration	6.5 to 7.5	-	35°C	-	35%	1700 and 1300mg/l	57 days	313 and 221 ml CH_4/g.VS
Dasgupta (2012)	Bio energy conversion of varanasi`s	8.9	25-30	-	30%	80%	-	15 days	0.40 Nm^3/kgVS
Taherdanak (2013)	Wheat plant using alkaline	-	-	75°C	901.4g / kg	857g/ kg	-	30 days	404mlg^{-1}VS
Ravi shankar (2014)	Using fungi culture with methanogens	6.7	-	30-37°C	75.55%	93.36%	-	60 days	59.3%
Akpan (2015)	Biodegradable component of MSW in nsukka metropolis	6.7 to 7.1	-	28-37°C	-	-	-	28 days	84277.17m^3
Sathish (2015)	Using industrial waste (press mud)	7.1	Less than 18	30-35°C	-	-	-	45 days	0.68 m^3
Pavi (2017)	Fruit and vegetable waste	8-8.2	34.7	35°C	-	54.6%	3526.6	20 days	396.6 Nml/gVS

Name	Name of investigator	Summary
Effect of particle size on anaerobic digestion of food waste	Kouichi Izumi (2010)	For this purpose, substrate of various particle size were prepared by bead milling to support hydrolysis. The result of pretreatment showed that the mean particle size of substrate ground with a bead mill decreased from 0.843 to 0.391mm and solubilization accounted for approx. 40% of the total COD for grinding pretreatment by bead milling. Furthermore, we plan to investigate the effects of size reduction using persistent organic substrates such as seaweed and phytoplankton in a future study.
Solid state anaerobic digestion for methane production from organic waste	Yebo li (2011)	The principles and application of the SS-AD process are reviewed in this paper. The variation in biogas production yields of different feedstock is discussed as well as the need for pretreatment of lignocellulosic biomass to enhance biogas production. The effects of major operational parameters, including C/N ratio, solids content, temperature and inoculation on the performance of SS-AD are summarized. These challenges can be overcome with the improvement of process and reactor design. Continued improvement of continuous and batch SS-AD processes is necessary to treat not only MSW but lignocellulosic biomass such as crop residues and energy crops.
Biofuel production in Ireland – An approach to 2020 targets with a focus on algal biomass	Fionnuala Murphy (2013)	This paper aims to review the characteristics of algae for biofuel production based on oil yields, cultivation, harvesting, processing and finally in terms of the European Union biofuels sustainability criteria, where up to 2017, a 35% greenhouse gas emission reduction is required compared to fossil fuels. From 2017 onwards, a 50% GHG reduction is required for existing installations and from 2018, a 60% reduction for new installations is required.
Smart biogas plant	Sunil MP (2013)	The main purpose of the project is to cut down on the landfill wastes and generate a reliable source of renewable, decentralized source of energy for the future. Kitchen waste discarded causes public health hazards, the project also looks into prevention of various diseases including malaria, typhoid and also meets the social concerns in the society. These digester help in two ways: one is to reduce waste and the other is to provide valuable energy. The future work to proposed system, in the present energy crisis, after biogas utilization it can be upgrade to power generation applications such as lightening and electricity.
Biogas production using the OFMSW as feedstocks	R. Kigozi (2014)	The idea of using the OFMSW or simply municipal biowaste as feedstock for biogas production represents an environmentally sustainable energy source since it improves solid waste management while simultaneously providing an alternative clean energy sources. Therefore more research is recommended on techno-economic pretreatment innovations that cam improve the properties of organic fraction of municipal solid waste for anaerobic digestion such as low cost systematic sorting at source

		to ensure good quality feedstock, treatments that can improve pH and reduce particle sizes simultaneously.
Generation of biogas from food waste using an anaerobic reactor under laboratory conditions	Geo joy (2014)	This work was carried out to create an organic processing facility for biogas production in an anaerobic condition which will be cost effective, eco-friendly and eliminate landfill waste problem. From the result it is seen that the generation of biogas is time dependent and takes a few days for its incubation. This is evident because of the fact that the generation of methanogenesis bacteria is progressively retarded with the prevalence of acidgenesis is bacteria because of absence of fresh feed from outside. Therefore to make the process continuous feed supply should be continuous.
Performance analysis of anaerobic digestion to extract biogas from kitchen waste	Abishek joel J (2015)	In this project food waste was collected from different places as feedstock for the reactor. The main objective of this work is to utilize food wastage for generation of biogas. This work was carried out in a reactor comprising of a plastic water tank with a crusher, gas purifier and gas collector using different source of food waste available in SNS college of engineering hostel mess and canteen. The same composition is implemented in the 120 liter digester and the gas produced in measured. The gas produced in this plant can be measured, analyzed and utilized for diesel engine in upcoming days.
Biogas production from soild state anaerobic digestion for municipal solid waste	Firas Al-Zuahiri (2015)	Experiments were carried out in batch stirred reactors using different amounts of inoculum under mesophilic conditions. The maximum specific biogas production was obtained using the minimum amount of inoculums. The experimental results gave indication about the measures to be adopted to optimize the anaerobic digestion of the MSW. The experimental results showed that, in some instances, a minimum inoculums volume is to be preferred. In order to obtain a further optimization of the process, a selective pressure against methanogens is to be provided.

CONCLUSION

The paper reviewed a various parameter involved in anaerobic digesters for the production of biogas from municipal solid waste. The important parameters of the digestion process such as temperature, carbon – nitrogen ratio, pH value, total solid, volatile solid, volatile fatty acids and chemical oxygen demand. The municipal solid waste also has high nutritive and calorific value suitable for the production of biogas. In this paper reviewed that the maximum methane yield is $404mlg^{-1}VS$ [Taherdanak et al 2013] and the minimum methane yield is 0.40 N m^3/Kg [Dasgupta et al 2012]. The future work will be devoted to achieve a complete optimization of the system, with reference to different possible applications of the anaerobic digestion.

REFERENCES

1. Abishek Joel J , Murali G , Ravishankar M , Sibichakravarthy M , Sundhirasekar A , 'Performance analysis of anaerobic digestion to extract biogas from kitchen waste' International journal of scientific and engineering research ,(2015) Volume 6.
2. Akpan, P. U., Omeife, M. A. , Onyishi H. O. and Okoye , O. C. " Biogas production from biodegradable component of municipal solid waste in nsukka metropolis." International Conference on Electric Power Engineering (ICEPE 2015) October 14-16.
3. Al-Zuahiri, Firas, Domenico Pirozzi, Angelo Ausiello, Ciro Florio, Maria Turco, Luca Micoli, Gaetano Zuccaro, and Giuseppe Toscano. "Biogas production from solid state anaerobic digestion for municipal solid waste." CHEMICAL ENGINEERING 43 (2015).
4. Biswas, Rajib, Hinrich Uellendahl, and Birgitte Ki?Ahring. "Increasing the biogas yield of manure by wet explosio n of the digested fiber fraction." In 12th World Congress on Anaerobic Digestion. 2010.
5. Campuzano, Rosalinda, and Sim? Gonz?z -Mart?ez. "Characteristics of the organic fraction of municipal solid waste and methane production: A review." Waste Management 54 (2016): 3-12.
6. Dasgupta, B. V., and M. K. Mondal. "Bio energy conversion of organic fraction of Varanasi's municipal solid waste." Energy procedia 14 (2012): 1931-1938.
7. Getahun, Tadesse, Mulat Gebrehiwot, Argaw Ambelu, Tom Van Gerven, and Bart Van der Bruggen. "The potential of biogas production from municipal solid waste in a tropical climate." Environmental monitoring and assessment 186, no. 7 (2014): 4637-4646.
8. Izumi, Kouichi, Yu-ki Okishio, Norio Nagao, Chiaki Niwa, Shuichi Yamamoto, and Tatsuki Toda. "Effects of particle size on anaerobic digestion of food waste." International biodeterioration & biodegradation 64, no. 7 (2010): 601-608.
9. Joy, Geo, Juhina Das, and Pranab Das. "International Journal of Scientific Research And Education."
10. Kigozi, R., A. Aboyade, and Edison Muzenda. "Biogas production using the organic fraction of municipal solid waste as feedstock." (2013).
11. Kigozi, R., A. O. Aboyade, and Edison Muzenda. "Sizing of an anaerobic biodigester for the organic fraction of municipal solid waste." (2014).
12. Li, Yebo, Stephen Y. Park, and Jiying Zhu. "Solid-state anaerobic digestion for methane production from organic waste." Renewable and sustainable energy reviews 15, no. 1 (2011): 821-826.
13. Masih, Jeniffer Christeena, Shikha Mehta, Kamla Malik, Swati Sindhu, and Ramesh Chander Anand. "Enhancement of biogas production from cattle dung using additive." (2019).
14. Mohapp, Nikki. "UNIVERSITY OF WISCONSIN SYSTEM SOLID WASTE RESEARCH PROGRAM." (2011).
15. Murphy, Fionnuala, Ger Devlin, Rory Deverell, and Kevin McDonnell. "Biofuel production in Ireland—an approach to 2020 targets with a focus on algal biomass." Energies 6, no. 12 (2013): 6391-6412.
16. Pasha, K. Mehraj, A. Akram, K. Narasimhulu, and G. N. Kodandaramaiah. "Waste management by anaerobic digestion of kitchen waste-A review." International Journal of Innovative Research in Science, Engineering and Technology 4, no. 3 (2015): 987-990.
17. Patil, Jagadish H. "ANAEROBIC DIGESTION OF MUNICIPAL SOLID WASTE USING FUNGI CULTURE (ASPERGILLUS FLAVUS) WITH METHANOGENS."
18. Pavi, Suelen, Luis Eduardo Kramer, Luciana Paulo Gomes, and Luis Alcides Schiavo Miranda. "Biogas production from co-digestion of organic fraction of municipal solid waste and fruit and vegetable waste." Bioresource technology 228 (2017): 362-367.
19. Ranieri, Luigi, Giorgio Mossa, Roberta Pellegrino, and Salvatore Digiesi. "Energy recovery from the organic fraction of municipal solid waste: A real options-based facility assessment." Sustainability 10, no. 2 (2018): 368.
20. Sathish, S., and S. Vivekanandan. "Experimental investigation on biogas production using industrial waste (press mud) to generate renewable energy." Int. J. Innov. Res. Sci. Eng. Technol 4, no. 2 (2015): 388-392.

21. Sunil, M. P., Ashik Narayan, Vidyasagar Bhat, and S. Vinay. "Smart biogas plant." International Journal of Innovative Technology and Exploring Engineering (IJITEE) 3, no. 3 (2013): 62-66.
22. Taherdanak, Mohsen, and Hamid Zilouei. "Improving biogas production from wheat plant using alkaline pretreatment." Fuel 115 (2014): 714-719.
23. Yılmaz, V., and G. N. Demirer. "Anaerobic digestion of cattle manure: effect of phase-separation." WIT Transactions on State-of-the-art in Science and Engineering 83 (2014): 133-144.
24. Zhu, Baoning, Ruihong Zhang, Petros Gikas, Joshua Rapport, Bryan Jenkins, and Xiujin Li. "Biogas production from municipal solid wastes using an integrated rotary drum and anaerobic-phased solids digester system." Bioresource technology 101, no. 16 (2010): 6374-6380.
25. Ziauddin, Ziana, and P. Rajesh. "Production and analysis of biogas from kitchen waste." İnternational research journal of engineering and technology 2, no. 4 (2015): 622-632.