



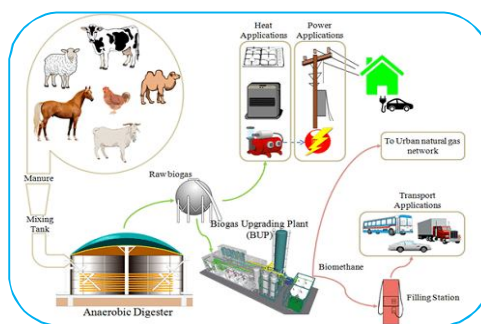
BIOGAS : ITS APPLICATION AND PRODUCTION

Dr. T. P. Sagar

**Department of Zoology, P.M. College of Excellence,
Govt. P.G. College Seoni (M.P.).**

ABSTRACT:

Biogas is obtained from the breakdown of biomass by microorganisms and bacteria in the absence of oxygen. Biogas technology is an efficient solution to address the issue of more stable and efficient renewable energy source through its potential ability to keep pollution free environment. Biogas can be produced from biomass or bio-waste; thus, it is environmentally friendly. The development and widespread adoption of biogas technologies are integral to the transition towards a low-carbon, circular economy. Environmental sustainability is a central objective in the ongoing evolution of biogas systems, ensuring that their impact on both the environment and society is positive and enduring. Continued advancements in biogas production technologies, combined with strategic investments in research and development, are essential for enhancing the efficiency and scalability of biogas systems. By addressing existing challenges and promoting innovation, biogas has the potential to become a key component of the global shift towards a more sustainable energy framework. Besides being a renewable energy source, the biogas digester systems would prevent the direct exposure of methane, carbon dioxide and other pollutant emissions into the atmosphere. More ever the combustion of biogas displace the use of fossil fuels for energy generation hence contributes to additional emission reductions of green home gases (GHS) and other air pollutants. In Indian scenario, Biogas can be a substitute for dung and firewood and it can meet the rural energy demand and also become a clean source of energy. It is a renewable energy source and can become a replacement for natural gas and Liquid petroleum gas.



KEYWORDS: Biogas, Anaerobic, Biodegradable, Methane, Fermentation, innovative technologies, and environmental benefits.

INTRODUCTION:

Biogas, generated from organic matter through anaerobic digestion (AD), is gaining prominence as a renewable energy source worldwide. The AD is a biochemical process in which microorganisms decompose organic matter in the absence of oxygen, generating energy and by-products such as biogas (primarily methane and carbon dioxide). It consists of four main stages: (i) hydrolysis – complex organic compounds are broken down into simpler molecules such as amino acids, fatty acids, and sugars, (ii) acidogenesis – fermentative bacteria convert these molecules into organic acids, alcohols, hydrogen, and carbon dioxide, (iii) acetogenesis – organic acids and alcohols are further transformed into acetic acid, hydrogen, and carbon dioxide by acetogenic bacteria and (iv) methanogenesis – methanogenic archaea convert acetic acid, hydrogen, and carbon dioxide into methane and additional carbon dioxide, completing the process.

In 1976 for the first time, an Italian physicist Volta, demonstrated methane (CH₄) in the marsh gas generated from organic matter in bottom sediments of ponds and streams. Biogas is mainly composed of 60% CH₄ and 40% CO₂. Methane is the main constituent of biogas. Bio gas can be produced by anaerobic, digestion with anaerobic organism which digest material inside a closed system or fermentation of biodegradable materials¹. Biogas is generally known as biofuel, sewerage gas, sludge gas, Gobar gas, bio energy etc. Bio gas can also be used for cooking, lighting² and running engines. It is devoid of smell and burns with a blue flame without smoke.

Biogas is a clean-burning, "green" fuel used for heating and cooking, transport and power generation. Biogas usually contains about 55-65% methane, 30-35% carbon dioxide, and traces of hydrogen, nitrogen and other impurities. Biogas typically refers to a gas produced by the biological breakdown of organic matter such as dead plant, animal material, human faeces, and kitchen waste in the absence of oxygen.

The most important issue facing humanity in the 21st century is the issue of energy and fuel. Because on the one hand, the number of energy-consuming industries is increasing, and on the other hand, fossil fuels (the most important energy consumed by these industries) are running out. Meanwhile, the pollution caused by these fuels has caused problems in the world, and international unions are passing laws to eliminate or minimize the consumption of these fuels in the coming decades.

Biogas typically refers to a gas produced by the biological breakdown of organic matter such as dead plant, animal material, human faeces, and kitchen waste in the absence of oxygen. Biogas can be used as a fuel in any country for any heating purpose, such as cooking, electricity and when compressed like natural gas can be used as vehicle fuel to power motor vehicles (Biogas & Engines, 2011). Biogas is a renewable fuel, so it qualifies for sustainable energy subsidies in some parts of the world. Biogas can also be cleaned and upgraded to natural gas standards when it becomes bio methane. According to Schnepf (2007), food waste produces two clean energy gases-hydrogen and methane (other waste materials just produces methane gas), which can be burned to produce electricity and heat, or to propel vehicles. Even though these seem to be more productive, much work has not been done in the evaluation of biogas production from food waste.

Biogas technologies

Biogas production is an evolving field, with cutting-edge research addressing existing challenges and uncovering novel applications. Recent scientific advancements have considerably enhanced biogas production, solidifying its role as a renewable energy source. Key innovations in reactor design, feedstock pre-treatment technologies, and microbial engineering have notably improved production efficiency and yield. Emerging technologies, such as AI-driven optimization systems and Power-to-X integration, are transforming biogas plants into hubs of technological innovation.

One promising advancement is auto generative high-pressure digestion (AHPD), which utilizes naturally occurring microbial activity to generate elevated pressures within the reactor (Lindeboom et al., 2011). This process increases methane concentration in the biogas, reducing the need for extensive post-production upgrading. Pre-treatment technologies have also played a critical role in improving biogas yields. Chemical, physical, thermochemical, and oxidative pretreatments enhance the breakdown of complex organic materials, rendering them more accessible for microbial digestion and boosting bio methane production. These improvements contribute to the development of more efficient biogas systems (Witaszek et al., 2020; Sher et al., 2024).

Furthermore, the integration of deep learning and artificial intelligence (AI) has optimized biogas production processes. Mahmoodi-Eshkaftaki et al. (2022) developed a deep learning neural network model to dynamically optimize volatile fatty acids during anaerobic digestion, which resulted in improved bio hydrogen yields, highlighting the potential of AI to enhance biogas production efficiency. Real-time monitoring and optimization, powered by Internet of Things (IoT) devices and AI algorithms, are becoming standard in biogas facilities. The deployment of sensors and predictive models allows operators to maintain optimal conditions for anaerobic digestion, ensuring consistent and efficient biogas output (Chinh et al., 2021). Additionally, integrating biogas plants with Power-to-X systems for hydrogen and emethanol production is being explored. This integration could enhance

energy storage solutions, contributing to a more resilient renewable energy infrastructure (Alamia et al., 2024).

A notable development is the use of multi feed stock approaches. By combining agricultural residues, food waste, and municipal solid waste, researchers have achieved higher biogas yields. This synergy arises from the complementary properties of mixed feed stocks, providing a more balanced nutrient profile for microbial digestion (Su et al., 2022). Furthermore, advancements in microbial engineering are revolutionizing the anaerobic digestion process. Genetically modified microbes are being incorporated to enhance the breakdown of recalcitrant organic materials, thus improving biogas production efficiency (Pandya et a., 2024). The integration of biogas plants with carbon capture and storage (CCS) technology also presents an exciting opportunity to achieve carbon-negative energy solutions. Such developments position biogas as a leader in global renewable energy transitions (Selim et al., 2024). This integration aligns with international net-zero targets and positions biogas as a vital player in combating climate change.

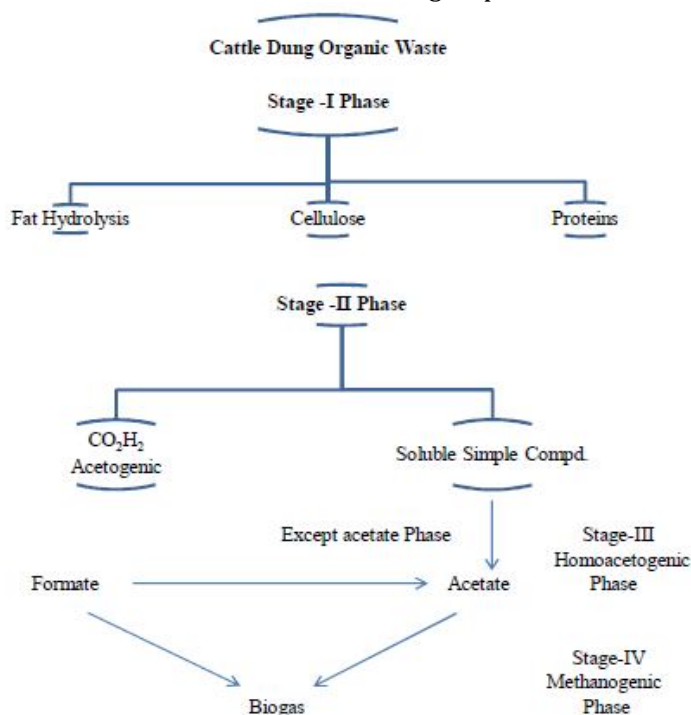
Objective of the Study

To promote sustainable bio-energy and bio-fertilizer production using local available wastes such as cow dung and food waste for environmental and economic benefit. The following main objectives of the study-

- To improve the overall sanitation and hygiene conditions and reduces energy dependence on the biomass.
- To increase the access of bio-energy and bio-fertilizers.
- To create awareness about the technology to local farmers by giving training.
- To up-scaling the technology to the poor rural households.

Production or Generation of Bio Gas

Biomass from animals are cattle dung, manure from poultry, goats, sheep and slaughter houses and fishing waste etc. Biogas production is a microbial process all microbes involved in methane production grow in the absence of oxygen. In experimental work at university of Alaska Fairbanks a 1000 litre digester using psychrophiles harvested from “Mud from a frozen lake in Alaska” has produced 200-300 litre of methane per day, about 20%-30% of the output from digesters in warmer climates. The process involves the combined action of four groups of bacteria in four stages.



Composition of Biogas

Compound	Formula	%
Methane	CH ₄	50-75
Carbon dioxide	CO ₂	25-50
Nitrogen	N ₂	0-10
Hydrogen	H ₂	0-1
H ₂ S	H ₂ S	0-3
Oxygen	O ₂	0-0.5

Source www.kolumbusfi (2007)

Biogas Utilities -:

Biogas is a cheap and clean fuel. It burns with blue flame which is root free. It acts as cheaper and better fuel for Cooking, Lighting, Running diesel and petrol engine and general electricity on sewage works in a CHP gas engine. A biogas powered train named Biogas target Amanda has been in service in Sweden since 2005. Biogas powered automobiles.

Conclusion -:

Biogas technology represents a crucial element of the transition towards sustainable energy systems. Biogas typically refers to a mixture of different gases produced by the breakdown of organic matter in absence of oxygen. It is a renewable source of energy. Biogas plants significantly lower the green house effects on the earth. Biogas production process is an established technology for energy generation. However, recent trends open new horizons for exploitation of biogas, expanding its potential applications. Since the biogas market is facing rapid development, it is envisioned that more advanced monitoring and control of the process is going to provide better utilization of the treated biomasses. A deeper understanding of microbial insights is going to play a more important role for tailoring the biogas process and for deciphering the anaerobic digestion "black box". Finally, it is foreseen that in the future the biogas plants are going to constitute advanced bioenergy factories with more secure and stable operation.

References :-

- Alamia, A., Partoon, B., Rattigan, E., & Andresen, G.B. (2024). Optimizing hydrogen and e-methanol production through Power-to-X integration in biogas plants. Energy Conversion and Management, 322, 119175. <https://doi.org/10.48550/arXiv.2406.00442>.
- "Biogas & Engines" www.clarke-energy.com-retrieved 21 November 2011.
- "Biomethane fueled vehicles the carbon neutral option" Claverton Energy conference Bath, UK. 24 Oct. 2009.
- Chinh, H.D., Anh, H., Hieu, & N.D. (2021). An IoT based Condition Monitoring System of Biogas Electrical Generator for Performance Evaluation. Proceedings of the Sixth International Conference on Research in Intelligent and Computing. Annals of Computer Science and Information Systems, 27, 7-11. <https://doi.org/10.15439/2021R24>
- Cold climates no bar to biogas production. New scientist London. Sunita Harrington. 6 November 2010. P.14 retrieved 4 February 2011.
- Lindeboom, R., Feroso, F.G., Weijma, J., Zagt, K., & van Lier, J.B. (2011). Autogenerative high pressure digestion: Anaerobic digestion and biogas upgrading in a single step reactor system. Water Science & Technology, 64(3), 647-53. <https://doi.org/10.2166/wst.2011.664>.
- Mahmoodi-Eshkaftaki, M., Mockaitis, G., & Rafiee, M.R. (2022). Dynamic optimization of volatile fatty acids to enrich biohydrogen production using a deep learning neural network. Biomass Conversion and Bio refinery, 14, 8003-8014. <https://doi.org/10.48550/arXiv.2201.09837>.
- National Non-food crops Centre. "NNFCC renewable fuels and energy fact sheet anaerobic digestion", retrieved on 2011-02-16.
- Pandya, R.S., Kaur, T., Bhattacharya, R., Bose, D., & Saraf, D. (2024). Harnessing microorganisms for bioenergy with microbial fuel cells: Powering the future. Water-Energy Nexus, 7, 1-12. <https://doi.org/10.1016/j.wen.2023.11.004>.

10. Schnepf K (2007). "Project converts biomass and food processing waste useable energy". Retrieved <http://www.plantservices.com/articles/2007/003.html>, from September 2012. waste for energy production in Dares Salaam city, Tanzania; Resources, Conservation.
11. Selim, M.M., Tounsi, A., Gomaa, H., & Shenashen, M. (2024). Enhancing carbon capture efficiency in biogas upgrading: A comprehensive review on adsorbents and adsorption isotherms. AIP Advances, 14, 040703. <https://doi.org/10.1063/5.0208686> 33.
12. Sher, F., Smjecanin, N., Hrnjić, H., Karadza, A., Omanović, R., Sehović, E., & Sulejmanović, J. (2024). Emerging technologies for biogas production: A critical review on recent progress, challenges and future perspectives. Process Safety and Environmental Protection, 188, 834–859. <https://doi.org/10.1016/j.psep.2024.05.138>.
13. Su, X., Shao, X., Geng, Y., Tian, S., & Huang, Y. (2022). Optimization of feedstock and insulating strategies to enhance biogas production of solar-assisted biodigester system. Renewable Energy, 197, 59–68. <https://doi.org/10.1016/j.renene.2022.07.090>.
14. Witaszek, K., Pilarski, K., Niedbała, G., Pilarska, A.A., & Herkowiak, M. (2020). Energy efficiency of commination and extrusion of maize substrates subjected to methane fermentation. Energies, 13(8), 1887–1905. <https://doi.org/10.3390/en13081887>



Dr. T. P. Sagar

**Department of Zoology, P.M. College of Excellence,
Govt. P.G. College Seoni (M.P.).**