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Conversion of Cow Dung, Sewage and Agricultural Waste as Source of Renewable Energy for Electricity and Heat Generation, A Review

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ABSTRACT

Biogas is a renewable, combustible fuel produced when micro-organisms breakdown organic matter such as animal manure, sewage, food-scraps or agricultural waste in an oxygen free environment or surrounding (anaerobic digestion). This renewable energy can be used as an alternative source for electricity and heat generation in our homes, office and industry. The biogas consists of four compartments processes namely; hydrolysis, fermentation, acetogenesis and methanogensis. Embrassing the biogas technology will encourage innovative breakthrough in energy generation to compliment the National Grid of electricity supply to consumers and reduce high cost of power generation at various station. The total electricity energy generated from natural gas and hydro-power in Nigeria amount to about 40,959 MWh which is not enough compared to the demand of electricity. Utilizing the waste from plant and animal that pollute and block our drainage system using the innovative anaerobic digester technology will increase the energy generation. The waste from our suck-way, cow dung and agricultural produced can be easily converted to renewable combustible fuel for lighting, cooking gas and heat for incubation centre when properly manage with anaerobic digestion technology. Also, the by-products from anaerobic digestion showed traces of emission of harmful gases such as hydrogen sulphide, carbon-monoxide. Meanwhile, the presence of carbon(iv)oxide as by-product is useful to plant during Photosynthesis. This will increase plant growth and improve agricultural waste as a component for biogas production. The biogas technology will reduce high cost of electricity and compressed natural gas consumption by citizen.

INTRODUCTION

Energy is a vital source for carry-out functional daily activities both in living and non-living things. The desire for energy is increasing every day and is the driving tool for economic development. Waste from animals and plants contain essential content of energy form. This waste form can be harnessed properly through anaerobic digester system and the by product can reduce the use of fossil fuel. The energy generated from fossil fuel is not environmental friendly and non-renewable source. The energy source from solar, wind, biomass and geothermal are renewable and can be source from any area of the nation unlike the fossil fuel which have deposit site. Agricultural, animal and food wastes are good substrates employed to produce clean and sustainable energy in a circular economy to complement energy consumption (Pradeshwaran *et al.*, 2024). Biomass energy is one of the renewable energy sources that has gained importance in recent years. This energy generation have make significant contributions to the prevention of environmental pollution and the reduction of the greenhouse effect. The conversion of biogas and bio-methane through the anaerobic digestion (AD) process is an efficient solution to the treatment of waste of different origins (Debora *et al.*, 2023). In addition, fossil fuel are not replenish and their deposit are scarce. Study have shown that oil well will run out of exploration in 50 years, natural gas in 70 years and coal in 120 years. Hence, nation and corporate bodies have intensify effort to the production of energy from renewable sources such as cow dung, sewage, and waste from agricultural material (Pradeshwaran *et al*., 2024). These sources of energy are found around in our surroundings and homes. When they are properly harness, it will serve as an alternative source of energy supply and reduce the demand for fossil fuel which is not readily available and expensive to purchase. Biogas energy plays critical role in addressing pressing global challenges such as waste management, greenhouse gas reduction and energy security. The development and widespread adoption of biogas technologies are integral to the transition towards a low-carbon circular economy (Krzysztof *et al.*, 2025). It was reported that Nigeria produces about 6.8 million m^3 of biogas every day. Even other renewable resources coming from poultry farms have been critically assessed for their possible use in biogas production. This suggests that biogas production in Nigeria may be a useful sources of reducing the urban wastes into energy (Keene *et al*., 2021).

MATERIALS AND METHODS

The main materials for this study is based on literature studies and scientific research work in animals and plants waste duly published from biomass, methane production and the infrastructural technology to obtain efficient and clean methane as source of energy for heating and lighting between 2021 to 2025. The anaerobic digestion method was considered useful and efficient in the conversion of animals and plants waste for the study of previous work. A simple schematic diagram of wastes from plant and animal using anaerobic digestion is as shown in Figure 1.

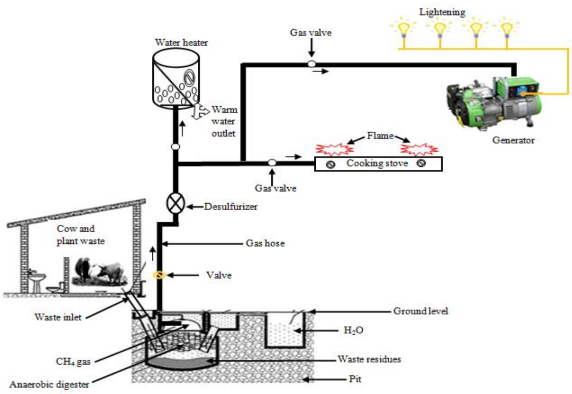

Figure 1: Schematic Diagram of Anaerobic Digestion of Animal and Plant Waste for Heating and Lighting

Animal Waste

Most roughage and feedstock consumed are passed out as waste product after digestion cycle. This waste can cause air pollution and block drainage which might cause over-flooding of the surrounding. These animal wastes in form of manure of farm animals (cattle, sheep, goat, chicken, horse) are wastes accumulated in slaughterhouses and animal product processing facilities contain hung amount of biogas and when properly harness with innovative technology can produce methane and carbon(iv)oxide, that are constituents for electricity generation and global warming (Devi *et al*., 2022). In Nigeria, the urban and the rural households still depend on biomass for their energy need. The continuous burning of fire-wood and gas flaring contribute to the degradation of the ecosystem. It has been reported that Nigeria produces about 6.8 million cubic meter of biogas every day. Even other renewable resources coming from poultry farms have been critically assessed for their possible use in biogas production. This suggests that biogas production in Nigeria may be a useful means of reducing the urban wastes into energy (Keen *et al*., 2021).

Agricultural Waste

Agricultural products grown for bio-energy, wastes from agricultural production, forest, park, and garden wastes, production wastes from agricultural product processing facilities, and vegetable biomass wastes are some examples of vegetable wastes. Also, waste from farm produce such as yam, plantain, potatoes contain huge content of biomass substrate that high energy potential for biogas production (Pradeshwaran *et al*., 2024).

Effect of Animal and Agricultural Waste

Animal and agricultural waste have adverse effect on the environment such as pollution. Most process of animal waste from livestock production facilities is often applied to land and rivers without prior treatment. This can lead to land and river pollution which can affect farming activities and cause death to aquatic animals. Bio-solids (treated municipal seawater sludge) from large wastewater facilities in urban areas are often transported and applied to land in rural areas (Chinh *et al*., 2021). This situation introduces a potential for risk of human exposure to waterborne contaminants such as human and zootoxic pathogens originating from manure, bio-solids, and leaking septic systems (Plarskiher *et al*., 2023).

Biogas

Biogas is a flammable gas that is lighter than air, colorless, odorless, and contains large amounts of methane and carbon dioxide that are produced by the decomposition of biomass resources by various bacterial groups in an airless environment. Biogas, which is close to natural gas in terms of energy value, is crucial for developing rural areas where livestock activities are carried out. Within the scope of the study, animal wastes, one of the three primary sources of biogas production, were examined (Hayyat *et al*., 2024).. The heat, electricity, gas, and liquid fuels obtained by the classical and modern processing of these resources are called as biomass energy.

Biogas Production

Biogas is a reneweable, combustible fuel produce when micro-organisms breakdown organic matter such as animal manure, sewage, food-scraps or agricultural waste in an oxygen free environment or surrounding (anaerobic digestion). This reneweable energy can be used as an alternative source for electricity generation in our homes, office and industry. The biogas consists of four compartment processes namely; hydrolysis, fermentation, acetogenesis and methaogensis (Debora *et al.*, 2023).

Hydrolysis

This is the application of water into anaerobic digestion to break down complex organic polymers (protein, fats and carbonhydrate) into simple soluble monomers (amino acid, fatty acid and sugar).

Fermentation

The decomposition of organic materials/subtrates in an air-tight or anaerobic digester to produce various by-products such as methane, carbon (iv) oxide, hydrogen gas and water Thuan *et al*., 2023).

Acetogenesis

The acetic bateria in the anaerobic digestion converts the volatile fatty acid (VFAs) and alcohol into acetate, hydrogen and carbon (iv) oxide.

Methanogenesis

This is the final stage of the anaerobic digestion where micro organism known as the methanogens convert the breakdown product into biogas (Ishak and Ahmet 2023). There are two biochemical path-ways to produce methane namely; acetotrophic and hydrogenotrophic.

Acetotrophic

This is the breakdown of acetate (acetic acid) into mathane and carbon (iv) oxide.

$$CH_3COOH \longrightarrow CH_4 + CO_2$$

Hydrogenotrophic

The recombination of hydrogen gas and carbon (iv) oxide to produced one-third of methane and water in anaerobic process.

$$CO_2 + 4H_2 \longrightarrow CH_4 + 2H_2O$$

Technology of Biogas Production

Various technology have been employed for the production of refined and efficient methane gas as a renewable alternative source of energy for domestic and industrial consumption. These technologies are used based on the source of materials available. Most of the developed have built various biogas plant to supplement electricity consumption and reduce waste and pollution of the environment (Tilki and Cicek, 2023).

N_aW_a R_o Biogas Technology

The NaWaRo technology was built and construction technology in Europe as shown in Figure 2. The biogas plants operates primarily with plant-based substrates fuelled such as silage, fruit and vegetable pomace, or distillery residues as well as liquid manure (Pilarski *et al*., 2023). However, this technology presents several technical challenges, particularly related to inefficient.

Figure 2: Biogas Plant using $N_aW_aR_o$ Technology (Source: Krzysztof *et al*., 2025)

Dynamic Biogas Technology

This biogas plant operates with phase separation facility constructed using Dynamic Biogas (Polish technology), commissioned in 2019 as shown in Figure 3. This biogas technology is characterized by the separation of fermentation phases, incorporating a hydrolyser known as a biotechnological accelerator for conducting hydrolysis and acidogenesis at a low pH (Krzysztof *et al*., 2025).. The fermentation tanks are constructed from acid-resistant steel and have a diameter smaller than the height of the fermenter. The fermenters are erected with a vertical mixing system that consists of a tubular vertical propeller with a motor and impeller inside. This design effectively eliminates the risk of surface crust formation and bottom sediment accumulation during anaerobic processes (Ibro *et al*., 2024)..

Figure 3: A Biogas Plant using Dynamic Technology (Source: Krzysztof *et al*., 2025)

ProBioGas Technology

The biogas plant using ProBioGas technology is a very specific technology in which fermentation takes place in a long reactor of about 75 m which is known as "intestinal" fermentation as shown in Figure 4. The fermenting pulp moves linearly and gradually changing its physical and chemical parameters. This technology also involves the separation of fermentation phases. A separate chamber for preliminary mixing, which initiates the hydrolysis stage is distinguished, followed by an acid-hydrogen chamber with an intensive phase of so-called acidic hydrolysis Mahmoodi *et al*., 2022).. Acetogenesis and methanogenesis in turn take place in the long chambers of the main fermentation (Sher *et al*., 2024). This solution enables the efficient change of substrates fed to the fermenter and is characterized by an exceptionally high degree of biomass fermentation (98%) (Alrowais *et al*., 2023).

Figure 4: ProBioGas Plant Located in Międzyrzecz Podlaski (Source: Mahmoodi *et al*., 2022)

RESULTS AND DISCUSSION

Result

The results obtained from the literature and research materials on the anaerobic digestion of biomass are depicted in Table 1, Table 2 and Table 3. From the findings, the production of methane using anaerobic digestion emits harmful gases, water vapour and particulate substance at various concentration.

Table 1: By-products emission level between natural and biogas

Fuel (g/Kg)	CO	H_2S	CO_2	NO_2	Particulates
Natural gas	0.40	0.60	524	1.10	0.022
Biogas	0.08	0.35	233	5.44	0.015

Table 2: Comparison of various renewable sources of fuel

S/N	Type of substrate fuel	Production (Kg)	Energy value (KCal/Kg)	Heat production (KgCal/Kg)	Thermal efficiency (%)
1	Charcoal (1Kg)	1.458	6.930	2079	28
2	Cow dung (1Kg)	12.29	2.900	209	10
3	Coal gas (1Kg)	1.177	4.004	2400	60
4	Fire wood (1Kg)	3.474	4.700	470	10
5	Kerosene (1Ltr)	0.62	9.600	4800	50

Table 3: Methane value present in various feed/substrate sources

No	Feed/substrate	Production (Kg)	Methane (%)
1	Cow dung	41.0	61
2	Crop residue	102.0	67
3	Fruit waste	91.0	50
4	Food waste	164.0	64

Discussion

The results showed that traces of hydrogen sulphide, carbon-monoxide and water vapour are constituent by-products of anaerobic digestion of biomass. These end-product have adverse effect on the atmosphere and health consequence on human. Despite the usefulness of methane as fuel and heat production, the presence of hydrogen sulphide can cause mild irritation and unconsciousness depending on the concentration and length of exposure to human. All the same, carbon(II)oxide affects breathing when inhaled. Also, the presence of water vapour during biogas production affects radio signal attenuation, propagation delay and refraction in the used of satellite communication and 5G network. Meanwhile, after refinement and compression, the enriched biogas may still contain small trace of impurities. When the biogas is used as a vehicle fuel, it can corrode the metal parts of the engine. This corrosion would lead to increased maintenance costs. However, the gaseous mixture is more suitable for kitchen stoves, water boilers and lighting. The biogas generation can be affected by the weather. The optimal temperature bacteria need to digest waste is around 37°C. In addition, during cold weather, bio-digesters require external heat energy to maintain the optimum temperature to generate biogas and for a constant supply. This will lead to additional cost during production of methane.

CONCLUSION

The conversion of animal and plant waste to biogas using anaerobic method have revealed a huge amount of methane as fuel and heat energy. But the by-products contain traces of harmful gases such as carbon (II) oxide and hydrogen sulphide (H_2S) from biomass of different feed/substrate during anaerobic digester. The presence of these harmful substances should be properly clean by employing innovative technologies and collaboration of researchers in anaerobic processes. The waste from plants and animals that litter on the surrounding can serves as potential fuel for electricity generation which is a renewable energy. The methane generated from biomass can be compressed and used as an automobile fuel for transportation and cooking gas for home in small and large scale production. This technology process can reduce global warming and environmental pollution that can cause devastating effect on living organism when properly harnessed.

REFERENCES

Alrowais, R., Said, N., Al-Otaibi, A., Hatata, A.Y., Essa, M.A. and Abdel, M. M. (2023). Comparing the effect of mesophilic and thermophilic anaerobic co-digestion for sustainable biogas production: An experimental and recurrent neural network model study. *Journal of Cleaner Production*, 392, 136248. https://doi.org/10.1016/j.jclepro.2023.136248

Chinh, H.D., Anh, H. and 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.

Debora, M., Paolo, C., Claudia, C., Giulia, C. and Pasquale, A. (2023). Production of Biogas and Biomethane as Renewable Energy Sources: A Review. *Appl. Sci.* 13, 1-27.

Devi, M.K., Manikandan, S., Oviyapriya, M., Selvaraj, M., Assiri, M.A., Subbaiya, R. Karmegam, N., Ravindran, B., S.W. Chang, S.W. and Awasth, M.K.

(2022). Recent advances in biogas production using Agro-Industrial Waste: A comprehensivereview outlook of Techno-Economic analysis. Bioresource Technology, 363, 127871. https://doi.org/10.1016/j.biortech.2022.127871

Hayyat, U., Khan, M.U., Sultan, M., Zahid, U., Bhat, S.A. and Muzamil, M. (2024). A review on dry anaerobic digestion: Existing technologies, performance factors, challenges, and recommendations. Methane, 3(1), 33–52. https://doi.org/10.3390/methane3010003

Ibro, M.K., Ancha, V.R. and Lemma, D.B. (2024). Biogas Production Optimization in the Anaerobic Co-digestion Process: A Critical Review on Process Parameters Modeling and Simulation Tools. *Journal of Chemistry*, Article ID 4599371, 1–25. https://doi.org/10.1155/2024/4599371

Ishak, C. and Ahmet, M.C. (2023). Analysis of Biogas Sources in the Context of Renewable Energy; Erzurum Province as an Example. *Pol. J. Environ. Stud.* 32(4), 3053-3062.

Keene, M., John, M., Edward, R. and Venkataraman, V. (2021). Biogas a Sustainable Source of Clean Energy in Sub Saharan Africa: Challenges and Opportunities, *Journal of Applied Material Science and Engineering Research*, 5(1),1-6.

Krzysztof, P., Agnieszka, A. P. and Jacek, D. (2025). Biogas as renewable energy source: A brief overview. *Journal of Ecological Engineering*, 26(7), 408-416.

Mahmoodi, E., M., Mockaitis, G., and Rafiee, M. R. (2022). Dynamic optimization of volatile fatty acids to enrich bio-hydrogen production using a deep learning neural network biomass conversion and bio-refinery 14, 8003-8014.

Pilarski, K., Pilarska, A.A., Kolasa-Więcek, A. and Suszanowicz, D. (2023). An agricultural biogas plant as a thermodynamic system: A study of efficiency in the transformation from primary to secondary energy. *Energies*, 16(21),7398. https://doi.org/10.3390/en16217398

Pradeshwaran, V., Sundaramoorthy, V. and Saravanakumar, A. (2024). A comprehensive review on biogas production from food waste: Exploring cutting-edge technologies and innovations. Biomass and Bioenergy, 188, 107336. https://doi.org/10.1016/j.biombioe.2024.107336

Sher, F., Smjecanin, N., Hrnjić, H., Karadza, A., Omanović, R., Sehović, E. and 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.

Tilki, F. and Cicek, E. (2003). Biomass Energy and Energy Forestry. *Journal of Kafkas University Artvin Faculty of Forestry*. 1(2), 33-38.

Thuan, N.C., Tokihiko, F. and Chau, N.N.V. (2023). Methane Production from Food Garbage Under the Batch and Semi-Continuous Anaerobic Digestion. *Journal of Ecological Engineering*, 24(4), 264–278.