VOL. 08 NO. 9,
MAY, 2025
E-ISSN 3026-958X
P-ISSN 3027-1169

African Scholar Publications & Research International
www.africanscholarpub.com

Journal of Science Innovation & Technology Research (JSITR)

Revolutionizing Waste Management in Livestock Farming: The Role of Biogas Technology in Advancing Energy Efficiency and Sustainable Practices in Ikorodu, Lagos

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DOI: https://doi.org/10.70382/ajsitr.v8i9.042

Abstract

This study investigates the role of biogas technology in revolutionizing waste management in livestock farming in Ikorodu, Lagos, a rapidly growing peri-urban region with increasing agricultural and energy demands. This study aims to examine how biogas technology can enhance energy efficiency and promote sustainable waste management practices, contributing to a circular economy and environmental conservation in Lagos. The study adopts a systematic empirical review technique, synthesizing data from peer-reviewed literature, policy papers, and recent empirical studies within the last five years to assess the relationship between biogas technology adoption, energy efficiency, and sustainable agricultural practices. The findings indicate that biogas technology significantly improves waste management in livestock farming by converting animal waste into renewable energy and organic fertilizer. This process reduces environmental pollution, lowers reliance on fossil fuels, and enhances soil fertility, fostering a more sustainable agricultural ecosystem. However, challenges such as high initial investment costs, lack of technical expertise, weak policy implementation, and limited farmer awareness hinder widespread adoption. Additionally, the study reveals that small-scale livestock farmers face greater financial and infrastructural barriers compared to commercial operators,

limiting the full-scale implementation of biogas technology. In conclusion, while biogas technology presents a viable solution for sustainable waste management and energy production in Ikorodu, its effectiveness can be maximized through improved government policies, financial incentives, capacity-building initiatives, and increased public awareness. This study recommends targeted policy interventions, research investments, and stakeholder collaboration to promote the large-scale adoption of biogas technology, ensuring a more energy-efficient and environmentally resilient livestock sector in Lagos.

Keywords: Biogas technology, Waste management, Livestock farming, Energy efficiency, Sustainable agriculture.

Introduction

One of the primary economic endeavors in both rural and urban regions of African nations is the raising of livestock and poultry. The national economy of African nations is significantly influenced by the livestock industry, particularly that of sheep, goats, and camels. The poultry industry has also grown extremely quickly in the area. However, the lack of a sustainable system for managing animal waste is causing the livestock and poultry industries to significantly contribute to Africa's waste crisis and greenhouse gas emissions. (Zafar, 2023)

According to Shakya et al. (2022), One of the main sources of odor, dangerous diseases, and toxic gasses is animal excrement. As a result, there are environmental and public health concerns. Therefore, it is important to appropriately manage livestock waste to reduce the creation of harmful pollutants and safeguard the environment. Although death, change, and waste generation are unavoidable and outside of human control, they can be prepared for and their negative effects can be lessened with good management. In many developing nations, using waste-to-energy technologies like turning animal manure into biogas has been regarded as one of the greatest ways to meet the objectives of sustainable energy development. (Khalil et al., 2019)

According to Okeke (2024) globally, fossil fuels are the primary source of energy. It's critical to look for renewable energy options as the globe moves toward creating circular economies and sustainable processes. The agricultural sector in Nigeria generates a significant amount of biodegradable waste every day, with up to 84 million tons of useable crop leftovers and 227,500 tonnes of animal manure produced annually. This presents enormous opportunities for the production of bioenergy in agricultural communities, particularly in rural areas.

Biogas is produced by microorganisms breaking down big organic molecules by anaerobic digestion, which is used in biogas plants. The development of biogas technology from animal waste as a substitute energy source can address both the issue of environmental contamination from animal waste and the issue of energy supply.

Anaerobic digestion reduces the possibility of odor, eliminates pathogens, replaces fossil fuels, and lowers methane emissions. The solid and liquid residues from the process can be used as fertilizer or compost, and their use can have positive environmental effects. Anaerobic digestion products have been applied to biomass crops and as feedstock for alternative fuels like ethanol or biodiesel. (Karki & Consolidated Management Services Nepal (P) Ltd, n.d.)

An essential source of food and renewable energy is animal excrement. However, the majority of rubbish that is dumped in lakes or allowed to decompose outdoors poses a serious threat to the ecosystem. (Saleh & Hassan, 2021). In Lagos State, including the Ikorodu region, agriculture plays a vital role in supporting rural communities and generating income. However, traditional farming practices in the region often involve inefficient waste management systems, leading to environmental pollution and loss of valuable resources. According to Asafa et al. (2023), data collected through structured questionnaires and interviews were analyzed using percentage distribution and bar charts. The study revealed that methods for managing livestock manure on farms in ikorodu included dumping, recycling, and burning. A significant portion (40%) of respondents disposed of manure by dumping it along roadways or in nearby bushes, while 10% resorted to burning dried manure. Additionally, 32.5% of farmers reported using drugs and chemicals as feed additives, and 45% adhered to feeding regulations to address challenges associated with manure management. The uncontrolled disposal of waste from animal farms is a widespread practice in southwestern Nigeria. This leads to the presence of heavy metals in the soil, posing significant environmental and health risks by contaminating the soil, groundwater, nearby streams, and rivers. (Azeez et al., 2009).

Problem Statement

Due to excessive food production and consumption, developed nations are grappling with ever-increasing waste, particularly waste from the agri-food sector. While animal production and the resulting livestock manure account for 30% of all anthropogenic methane emissions to the environment, the problem of producing biodegradable waste is frequently overlooked. Methane's global warming potential means that it will have a greater effect on climate warming with the same amount of methane in the atmosphere as CO2. Anaerobic digestion-based technologies are highly helpful in lowering the quantity of waste from the agri-food sector while also enabling controlled methane capture and energy production in cogeneration systems. (Muradin, 2021)

Livestock farming plays a crucial socio-economic role in Nigeria, providing employment, income, and a vital source of animal protein for the population. However, the expansion of livestock enterprises has led to an increase in waste production. Effective management of this waste remains a significant challenge for animal husbandry in the country, as it often contributes to environmental pollution (Obi et al., 2016). Poorly managed livestock manure can result in various environmental problems, such as nutrient runoff into water sources, unpleasant odors, and risks of disease transmission.

Livestock waste accounts for approximately 33% of the total waste produced across all sources (Wilson & Velis, 2015). Urbanization and the expansion of Lagos have encroached on previously designated agricultural areas. Despite these changes, the Ikorodu local government area continues to engage significantly in livestock production, particularly poultry, pigs, and cattle. This has led to challenges in managing livestock manure, as some farmers resort to indiscriminate waste disposal, creating potential environmental and health concerns. (Asafa et al., 2023)

Biogas technology has the potential to turn animal waste into a renewable energy source, but Ikorodu has not embraced it much because of a number of issues, including low awareness, poor infrastructure, and budgetary limitations. The majority of livestock producers still use inefficient energy sources like diesel generators and firewood, which raise operating costs, cause deforestation, and emit carbon dioxide.

This study aims to examine the role of biogas technology in revolutionizing waste management within the livestock farming sector in Ikorodu. By exploring its feasibility, economic benefits, and environmental impact, the study attempts to show biogas as a viable option for regional agricultural sustainability and energy efficiency. The findings will contribute to a deeper understanding of how local farmers can effectively manage livestock waste and reduce its negative impact on the ecosystem

Aim of the Study

The study aims to investigate the role of biogas technology in revolutionizing waste management in livestock farming in Ikorodu, Lagos, by emphasizing on its role in enhancing energy efficiency and promoting sustainable agricultural practices.

Objectives of the Study

1. To assess current waste management practices used in livestock farming in Ikorodu, Lagos Nigeria.
2. To evaluate biogas technology's viability as a sustainable waste-to-energy solution for local livestock farmers.
3. To investigate the financial feasibility of biogas systems for livestock farmers in ikorodu, Lagos.
4. To examine the environmental benefits of utilizing biogas technology.

LITERATURE REVIEW

Waste management in livestock farming

Abah et al. (2019) found that after poultry farmers clear their farms, about 40% of the farms sell their poultry waste right away, and 30% apply it straight to neighboring farmlands. Lack of dumping places (25%) and a labor scarcity (45%) were the main obstacles to getting rid of poultry manure. Sixty percent of the neighbors who live close to chicken farms complain about the farms' foul odors. 60% of respondents said they were ill with symptoms of respiratory issues, and 40% said they had digestive issues, indicating that inappropriate handling of poultry production waste from beginning to end could pose health and environmental risks. One hundred percent of farmers believed that chicken waste pollutes the air, while 85 percent of farmers said that incorrect litter disposal contaminates surface water.

In addition to producing meat, milk, and eggs, the livestock industry produces a lot of waste that, if not properly handled, could be hazardous to the environment. Rapid population increase, urbanization, shifting lifestyles, and rising per capita incomes all contribute to the demand for animal products. In the upcoming years, it is anticipated that the demand for animal products would continue to rise. In an attempt to maximize the benefits of the always rising demand for their products, livestock keepers have turned to producing and accumulating vast amounts of trash. However, from the perspectives of cost, environmental safety, and biosecurity, disposing of these wastes remains difficult. (Ogbuewu et al., 2012)

Waste from livestock is a substantial source of pollution, diseases, odor, and greenhouse gas emissions. Methane from livestock and agricultural waste accounts for 40% of global emissions, with waste disposal accounting for the remaining 18%. It is an abundant source of energy and fertilizer components that can be recovered to improve farming. (Shakya et al., 2022b)

According to the study's findings of (Olaogun, 2016) , the most popular waste disposal practices among commercial poultry and livestock keepers in Oyo State were using animal wastes as manure for farmlands or simply disposing of them in open spaces, bushes, or landfills; in total, 45% of the farms that were sampled did this. 10% of the remaining farms used sun-dried and burned animal waste, 14% flushed the waste into nearby streams or rivers as slurry, 24% combined all three methods as time or space allowed, 2% converted their waste to biogas for on-farm cooking or lighting, and 5% used some of the waste as feed for ruminants or fish. These findings indicated that a greater proportion of farms lacked an environmentally appropriate system for managing animal waste, which could lead to widespread pollution of the air, water, and land. Therefore, in order to perform environmentally responsible cattle farming, farmers must have the appropriate education. Composting is the rapid bio-oxidation of organic waste that goes through a thermophilic stage (45 to 65 degrees Celsius) when heat, carbon dioxide, and water are released by

microorganisms, primarily bacteria, fungus, and actinomycetes. Through turning or aeration, the heterogeneous organic material is converted into a homogeneous, stabilized humus-like product. The aerobic breakdown of biodegradable organic waste is known as composting. The biodegradation process is comparatively quick, usually reaching stabilized material after 4-6 weeks. The fine-textured, low-moisture, odorless composted material can be utilized as an organic fertilizer. An efficient way to preserve the nitrogen in poultry manure is to compost biological waste with it. This not only increases the fertilizer's value but also lowers the possibility that NH3 will contribute to environmental contamination. (Shakya et al., 2022)

Circular economy: waste to energy

Nigeria, the most populated country in Africa with 216 million people and a 3.2% annual population growth rate, has faced challenges in supplying its energy demands. despite having an abundance of clean energy sources like biomass, solar, wind, hydro, and tidal waves, as well as impure natural resources like fossil fuels, namely oil and natural gas. The nation's inconsistent electrical supply hinders economic development and progress. (Umar et al.2024).

The long-term availability of inexpensive, easily accessible, and ecologically acceptable energy sources is a critical component of future economic growth. Energy is directly linked to public health, climate change, and security. Energy has a significant role in every area of a nation's economy. There is a clear correlation between a nation's per capita energy usage and its standard of living. (Oyedepo, 2012). Nigeria's livestock production has skyrocketed, more than ten times higher than it was before the importation of poultry products was prohibited. There are no solid plans for disposing of the waste from these livestock operations, despite the fact that many people now view animal raising as a way to reduce poverty. (Olaogun, 2016)

In order to transform animal waste treatment systems into sustainable operations, innovative approaches that adhere to the circular economy's tenets and adopt a recycling mindset including those that permit nutrient recovery, must be developed. (Lijó et al., 2018)

The circular economy concept provides a variety of solutions for fundamental problems like waste management. One of the most widely accepted of these is the "waste-to-energy" (WtE) approach, which eliminates waste and generates energy without using fossil fuels. (Bjelić et al., 2024)

Waste-to-energy provides a comprehensive method of recovering resources from non-hazardous, non-recyclable waste; it keeps these wastes out of landfills, recovers metals and minerals, and generates renewable energy (from the biodegradable portion of waste), making it a vital component of the circular economy and adding value to society. (Paolo & Paolo, 2022)

Biogas Technology

An estimated 60% of people on the planet are thought to reside in rural parts of developing nations and depend on agriculture for a living. Approximately one billion people use residue as their main source of cooking fuel. The marketing of bio-residues is a source of small revenue in many places, especially Asia, but it also burdens the impoverished. The use of bio-residue is frequently linked to extremely low efficiency, which raises smoke emissions and has detrimental effects on health. (Karki, n.d.)

Anaerobic digestion (AD) is the procedure used to produce biogas. In a closed system, such as a bioreactor, biodigester, or anaerobic digester, AD occurs when methanogens or anaerobic bacteria break down organic materials. The AD process, which is thought to be the most ecologically friendly method of managing biowaste, involves a number of microbiological, biochemical, and physico-chemical processes. Additionally, the choice of substrate for an AD process has a big influence on the production efficiency and rate of biogas. (Godfrey, 2024)

A significant source of methane (CH4) and nitrous oxide (N2O) emissions is livestock manure, with handling and storage procedures accounting for the majority of these emissions. Methane from manure makes up around 4% of total methane emissions created by humans. Microorganisms break down manure in anaerobic digestion processes without oxygen, producing digestate and a biogas combination (mostly CH4 and CO2). Biogas is a renewable energy source that can be used to generate power or heat. By switching from emission-heavy fossil fuels to CO2 and CH4 instead of the usual combination of N2O and CH4, this process also indirectly lowers greenhouse gas (GHG) emissions. Compared to traditional methods of treating manure, anaerobic digestion might result in a reduction of over 30% in greenhouse gas emission (Godara et al., 2024)

Future energy scenarios indicate that using renewable energy sources will be crucial to reaching sustainability goals. Fossil fuels currently account for 80% of the world's energy consumption. According to earlier research, the use of fossil fuels will persist until 2035, whereas the usage of renewable energy source will increase after 2035, energy sources will grow (IEA, 2018). The policy of lowering the atmospheric concentration of carbon dioxide heavily relies on renewable energy sources. In this regard, biogas-derived energy is regarded as one of the most prevalent renewable energy sources going forward. The process of turning waste into biogas has long been recognized, and numerous studies have been done on the subject. Biogas is an infinite energy source as long as life exists. It is crucial for the ecology and the economy that this resource be used at sufficient levels. (Yapilcan & Bakirtas, 2021)

Environmental impact of livestock waste

Many gaseous pollutants from livestock operations result from the decomposition of manure, and their concentration is influenced by ventilation effectiveness, emission rates,

and stocking density. Airborne pollutants consist of organic and inorganic dust, pathogens, and other microorganisms, along with gases like ammonia, nitrous oxide, carbon dioxide, hydrogen sulfide, and methane. (Ogbuewu et al., 2012)

Nearly 64% of all ammonia emissions come from livestock, which greatly contributes to acid rain and ecosystem acidification. Another major source of methane emissions is livestock, which account for 35–40% of global methane emissions. Compared to carbon dioxide, methane has a 23-fold higher potential to cause global warming. According to data from the U.S. Environmental Protection Agency, methane emissions from cattle rose by 50% and those from pigs by 37% over the previous 15 years. (Dopelt et al., 2019)

Solid manure and liquid manure effluent can harbor pathogens that pose significant health risks to both humans and animals. The direct release of manure into water bodies and its infiltration into groundwater—often through cracks and fissures—greatly endangers human and animal health because livestock manure contains a variety of pathogens (bacteria, viruses, parasites). These pathogens, including Escherichia coli, Campylobacter, Salmonella, Leptospira, Listeria, Shigella, Cryptosporidium, Hepatitis A, Rotavirus, Nipah virus, and Avian Influenza, can be transmitted easily. (Ogbuewu et al., 2012)

METHODOLOGY

This section details the research methodology used in this study, which utilizes a systematic empirical review of existing literature to explore how biogas technology contributes to improving energy efficiency and promoting sustainable waste management in livestock farming in Ikorodu, Lagos. This method guarantees an organized and thorough synthesis of previous studies, facilitating a critical assessment of the current state of knowledge, identifying gaps, and suggesting avenues for future research.

The research utilizes a qualitative approach, employing a systematic empirical literature review to collect, analyze, and synthesize insights from pertinent academic articles, reports, and case studies. This approach is suitable for evaluating the current understanding of biogas technology, waste management, and energy sustainability in livestock farming, especially in the context of Nigeria. In order to conduct a thorough literature review, information was gathered from peer-reviewed journal articles, conference papers, industry reports, and policy documents pertaining to livestock waste management and biogas technology. The subsequent databases and search engines were utilized to find pertinent literature: Science Direct, Okford Academic, SpringerLink IEEE, Research Gate. A strategy was developed for searching that incorporated a mix of keywords and Boolean operators (AND, OR) to improve results. The primary search phrases consisted of: "Biogas technology in livestock agriculture", "Solutions for waste-to-energy in Nigeria", "Waste management of livestock ", "Energy generation from animal waste" "Barriers to biogas implementation in farming" "The circular economy and biogas".

In order to maintain the relevancy and quality of the chosen studies, the criteria for inclusion and exclusion were established as follows: Only studies released from 2012 to 2024 were considered to provide current insights. Research that examines biogas technology, the management of livestock waste, and sustainable energy methods was prioritized. Only studies containing empirical data, case studies, or policy evaluations were accepted. Research carried out in Nigeria or comparable developing nations with relevant socio-economic contexts was included.

Following the PRISMA 2020 framework for systematic reviews, this study used a Systematic Empirical Literature Review (SELR) methodology to investigate the ways in which biogas technology enhances energy efficiency and fosters sustainable waste management in cattle farming in Ikorodu, Lagos. The selection procedure is depicted in the PRISMA flow diagram (Figure 1), which includes information on study identification, screening, eligibility evaluation, and inclusion. By ensuring a systematic and transparent synthesis of previous research, this method made it possible to critically assess what is already known, identify research gaps, and make recommendations for further study.

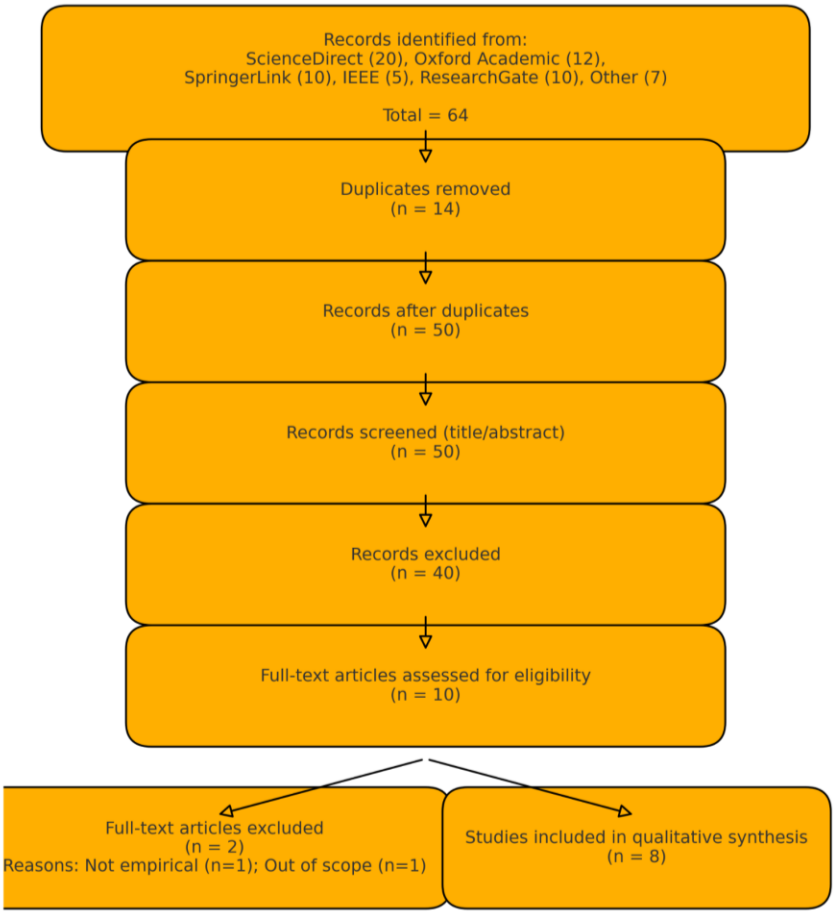


FIG 1: PRISMA flow diagram

DISCUSSION AND FINDINGS

This review highlights the main features of each research work concerning biogas, livestock agriculture, circular economy, management of animal waste, and energy efficiency. Below is a summary of 8 papers reviewed.

Table 2: Summary of the papers reviewed

TITLE OF ARTICLE	AUTHORS & YEAR	AIM & OBJECTIVE	METHODOLOGY	RESULTS
Waste Management Practices in Selected Poultry Farms and its Effect on the Environment and Human Health in Makurdi, Nigeria	Abah, H., Nwankwo, A., & Orgem, C. (2019)	To assess waste management practices in poultry farms and their impact on the environment and human health.	Survey and field study in selected poultry farms in Makurdi, Nigeria, using structured questionnaires and observations.	Findings indicated poor waste disposal practices, leading to environmental pollution and potential health risks. Recommendations for improved waste management were provided.
"Waste to Energy" as a Driver Towards a Sustainable and Circular Energy Future for the Balkan Countries	Bjelić, D., Markić, D. N., Prokić, D., Malinović, B. N., & Panić, A. A. (2024)	To explore how waste-to-energy technologies can contribute to a circular energy economy in Balkan countries.	Case studies and literature review on waste-to-energy technologies.	Waste-to-energy initiatives contribute to sustainable energy practices and help reduce environmental pollution.
Renewable Energy from Agricultural Waste: Biogas Potential for Sustainable Energy Generation in Nigeria's Rural Agricultural Communities	Godfrey, O. U. (2024)	To assess the potential of biogas production from agricultural waste for rural energy sustainability.	Experimental study and analysis of biogas generation from different agricultural waste sources.	Results showed significant potential for biogas production from organic waste, with implications for rural energy security.

Waste to Energy Technology: The Potential of Sustainable Biogas Production from Animal Waste in Indonesia	Khalil, M., Berawi, M. A., Heryanto, R., & Rizalie, A. (2019)	To evaluate the feasibility of biogas production from animal waste as a sustainable energy source.	Data analysis of biogas production processes and case studies in Indonesia.	Findings supported biogas as a viable renewable energy source, reducing environmental pollution and dependency on fossil fuels.
Environmental and Sustainability Evaluation of Livestock Waste Management Practices in Cyprus	Lijó, L., Frison, N., Fatone, F., González-García, S., Feijoo, G., & Moreira, M. T. (2018)	To analyze the sustainability of livestock waste management strategies.	Life Cycle Assessment (LCA) methodology applied to different waste management scenarios.	LCA results highlighted the need for integrated waste management solutions to reduce environmental impacts.
The Environmental Assessment of Biomass Waste Conversion to Sustainable Energy in the Agricultural Biogas Plant	Muradin, M. (2021)	To evaluate the environmental benefits of converting biomass waste into energy in agricultural biogas plants.	Case study analysis and environmental assessment models.	Results showed that biomass-to-energy conversion significantly reduces greenhouse gas emissions and enhances sustainability.
Harnessing the Power of Agricultural Waste: A Study of Sabo Market, Ikorodu, Lagos State, Nigeria	Samuel, D., Dare-Abel, A., & Asaju, A. O. (2021)	To explore the potential of agricultural waste utilization for energy production.	Field survey and waste analysis in Sabo Market, Ikorodu.	Study identified key agricultural waste streams with energy generation potential and recommended waste-to-energy adoption.

Community Participation in Utilizing Livestock Waste Biogas to Support Sustainable Energy Development	Sari, A. I., Suwarto, N., Suminah, N., & Purnomo, S. H. (2022)	To assess community engagement in livestock waste biogas production.	Survey and participatory research approach.	Findings highlighted the importance of local involvement in biogas projects for sustainability and energy security.

Source: Author

Implication of findings

The results of the systematic empirical review indicate several significant consequences for sustainable development, energy safety, environmental stewardship, and farming methods.

1. Utilizing Circular Economy Approaches for Sustainable Waste Management

Research shows that incorporating biogas technology into the management of livestock and agricultural waste can help alleviate environmental pollution, address waste disposal challenges, and foster a more sustainable and circular economy. The results reveal that strategies for waste valorization (including biogas production and the creation of organic fertilizer) can convert agricultural waste into valuable resources, thereby decreasing reliance on landfills and open waste dumping.

2. Energy Security and Rural Development

Utilizing biogas as an alternative energy source offers a noteworthy opportunity to strengthen energy security, especially in rural areas where conventional energy sources are difficult to access. Research indicates that small-scale biogas facilities can deliver clean, renewable energy for cooking, heating, and electricity needs, decreasing dependence on firewood, charcoal, and fossil fuels. This shift can enhance the living conditions of rural populations, lower deforestation rates, and reduce the health risks linked to indoor air pollution from traditional biomass fuels.

3. Economic Advantages for Small-Scale Farmers

Economic evaluations indicate that biogas technology serves as a cost-effective long-term solution for smallholder farmers, providing two main benefits: Savings on energy costs by substituting costly and non-renewable fuels. Opportunities for additional income through the sale of by-products such as organic fertilizers derived from anaerobic digestion residues. Nevertheless, the significant initial financial outlay and the lack of financing options pose substantial obstacles to extensive adoption, highlighting the necessity for government subsidies, financial incentives, and private sector investments to enhance the accessibility of biogas systems.

4. Benefits for the Environment and Public Health

The results indicate that effective management of livestock and agricultural waste using biogas technology can greatly lower greenhouse gas emissions (including methane and carbon dioxide), which are key contributors to global warming. In addition, issues related to sanitation and public health stemming from inadequate waste disposal—like waterborne illnesses and air pollution—can be addressed by implementing waste-to-energy initiatives. This underscores the necessity for enhanced waste management policies and infrastructure in developing nations to confront both environmental and health issues.

5. Supportive Policies and Institutions for Biogas Adoption

Although biogas technology has numerous advantages, its widespread implementation faces challenges due to policy deficiencies, insufficient awareness, and a lack of technical skills. The results indicate a need for more robust policy frameworks, government incentives, and capacity-building programs to foster biogas development for both households and businesses. Additionally, partnerships between the public and private sectors, along with international collaborations, could significantly contribute to advancing innovation and funding in biogas infrastructure.

CONCLUSION AND RECOMMENDATIONS

This research has delivered important insights regarding the ability of biogas technology to tackle waste management issues in livestock agriculture. The results affirm that biogas generation presents a sustainable and energy-efficient approach to handling agricultural waste, while simultaneously encouraging environmental protection, economic growth, and energy security in rural areas.

The study emphasizes the circular economy model, in which livestock waste is converted into useful resources like renewable energy (biogas) and organic fertilizers. This approach supports international sustainability objectives by lowering greenhouse gas emissions, reducing health risks tied to poor waste management, and enhancing agricultural yield. Nevertheless, the research points out significant obstacles to the broader implementation of biogas technology, such as high upfront costs, a lack of technical knowledge, inadequate policies, and insufficient public awareness. Regardless of these hurdles, the research concludes that biogas technology has significant promise for revolutionizing livestock waste management in Ikorodu, Lagos. With appropriate policies, financial support, and initiatives to build capacity, biogas technology can become a scalable solution for energy efficiency, climate change mitigation, and sustainable development in the area.

Recommendations

In light of the findings from this study, the following suggestions are put forward to improve the uptake and effectiveness of biogas technology for managing livestock waste in Ikorodu, Lagos:

1. Government Policies and Institutional Support:

The Lagos State Government, along with pertinent environmental agencies, should formulate and enforce policies that advocate for the adoption of biogas technology within livestock farming. Subsidies, tax breaks, and low-interest loans should be made available to make biogas digesters more accessible to farmers. Establishing clear regulations related to waste-to-energy will encourage investment in biogas infrastructure.

2. Financial and Technical Support for Farmers:

Both government and private financial bodies should facilitate easy access to funding for livestock farmers who wish to adopt biogas technology. Training initiatives should be developed to instruct farmers on the operation and maintenance of biogas facilities to guarantee sustainability and efficiency.

3. Public Awareness and Community Involvement:

Educational campaigns must be initiated to inform farmers and local communities about the economic, environmental, and health advantages of biogas technology. Community-driven programs should be encouraged to foster local collaboration on waste-to-energy projects.

4. Infrastructure Enhancement and Research Progress:

Investment in biogas research and development is essential to improve production efficiency and technological innovations. Additional pilot projects should be launched in Ikorodu to showcase the viability and benefits of biogas technology in managing livestock waste.

5. Integration with Circular Economy and Climate Strategies:

The incorporation of biogas adoption should be aligned with Lagos State's climate change mitigation strategies to lower greenhouse gas emissions. Encouraging the use of digestate (the residue from biogas production) as organic fertilizer can enhance soil health and decrease dependence on synthetic fertilizers.

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