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Biogas Production from Water Hyacinth and Cow dung

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ABSTRACT

In the quest for sustainable and eco-friendly energy solutions, renewable energy biogas technology stands out as a promising option, offering zero-waste energy generation. River water hyacinths, known for their rapid and abundant growth, hold great potential in this domain. Rich in cellulose, nitrogen, essential nutrients, and fermentable components, water hyacinth leaves present an ideal source for biogas fuel production. Notably, their high hemicellulose content allows for efficient biogas generation.

This study focuses on harnessing the biogas potential of water hyacinths readily available in river ecosystems. The experimental setup involved employing water hyacinth, cow dung, and water at various ratios using the batch-fermentation technique. Daily monitoring of biogas production was conducted throughout the 60-day degradation process until the desired gas production levels were achieved, alongside effective degradation of the biomass.

An essential factor explored in this study was the Carbon-to-Nitrogen (C/N) ratio, recognized as a critical determinant for successful biogas production. The research findings revealed that a C/N ratio of 30.75 proved to be optimal for this specific experiment.

This research contributes valuable insights into the potential of renewable biogas technology, highlighting the significance of utilizing water hyacinths as a viable and sustainable energy resource, while also offering a greener approach to address environmental challenges.

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INTRODUCTION

The global energy supply is heavily reliant on non-renewable fossil fuels such as crude oil, lignite, hard coal, and natural gas, which have formed over millions of years through the petrification of deceased plants and animals under intense heat and pressure in the Earth's crust. However, these fossil fuels are finite resources, being depleted faster than new ones can be generated, raising concerns about sustainable energy alternatives.

One such concern for the environment, irrigation systems, and crops is the proliferation of Water Hyacinth (Eichhornia crassipes or E. crassipes), a pervasive aquatic weed worldwide. Water hyacinth grows rapidly and poses significant economic and ecological challenges due to its aggressive growth.

Interestingly, water hyacinth offers a potential solution to the energy dilemma as it contains around 95% hollow tissue, making it highly energized and rich in fermentable components. This composition presents an excellent opportunity for biogas production. Notably, it contains a high concentration of hemicellulose, setting it apart from other organic materials for biogas generation.

The process of hydrolyzing hemicellulose, a complex polysaccharide polymer, yields a derivative mixture product that can be further processed through anaerobic digestion, resulting in the production of biogas, primarily composed of methane and carbon dioxide. This biogas has the potential to become a valuable and renewable energy source.

Anaerobic digestion (AD) has been extensively utilized to convert various organic waste streams, including agricultural, industrial, and municipal solid waste, into biogas. The AD process can be conducted in either a liquid or solid form, offering flexibility in waste treatment and energy production.

Researchers have focused on utilizing water hyacinth and liquid anaerobic digestion techniques to explore the efficient extraction of biogas from lignocellulose biomass, further highlighting the potential of this aquatic weed in contributing to sustainable energy solutions.

Biogas Production from Water Hyacinth (Eicchornia Crassipes):

Water hyacinth (Eichhornia crassipes) is a serene aquatic plant commonly found in marshes, lakes, reservoirs, and rivers. Its vibrant green leaves are oval in shape, reaching a width of about 15 cm. Despite its tranquil appearance, water hyacinth poses a significant threat to the environment, irrigation systems, and agriculture due to its invasive nature.

One concerning characteristic of water hyacinth is its rapid growth rate. The plant proliferates at an astonishing rate, expanding by approximately 1.9% every day and reaching a height of nearly 0.3–0.5 meters per day. This accelerated development is problematic as it leads to the formation of dense mats that cover the water surface, severely reducing oxygen levels in the water.

Interestingly, water hyacinth also has the potential to be utilized for beneficial purposes. When water hyacinth undergoes anaerobic bacterial breakdown, it produces biogas, primarily methane (CH_4) and carbon dioxide (CO_2). The methane generated through this process can be harnessed as a valuable source of biogas energy.

Another valuable organic material that remains underutilized is cow dung. Although cow dung contains a significant amount of methane (CH_4), its potential for biogas generation remains largely untapped. By properly harnessing cow dung, it could serve as a viable raw material for biogas production, offering a way to generate alternative energy and mitigate environmental pollution.

The current study focuses on using water hyacinth, water, and cow dung as variables to investigate biogas production. To evaluate the process, various factors, including slurry pH, gas volume, C/N ratio, and methane gas quality, were modified and assessed.

In biogas production research, several critical criteria are considered, such as the food-to-microorganism (F/M) ratio, carbon-to-nitrogen (C/N) ratio, and total solid ratios (TS). The F/M ratio determines the balance between substrate food and decomposer microorganisms in the anaerobic digestion process. Maintaining an appropriate F/M ratio is crucial, as a low ratio can hinder microorganism digestion, while a high ratio can lead to imbalanced metabolism.

The C/N ratio plays a pivotal role in the biogas process, with an ideal range of 10–30, preferably 25–30, for digesters operating at maximum capacity. Low C/N ratios can block ammonia and make methanogenesis more sensitive, while high ratios reduce methane output due to insufficient nitrogen for cell development.

The study utilizes both liquid and solid-state anaerobic digestion methods to produce biogas from water hyacinth. Since water hyacinth contains a high-water content and hollow networks, the liquid state anaerobic digestion method works efficiently for its decomposition. Conversely, lignocellulosic materials like water hyacinth are best suited for solid-state anaerobic digestion, where the total solid concentration exceeds 15% and moisture content is low.

In the experimental setup, crushed water hyacinth leaves, cow dung, and water were used in various combinations, as indicated in the provided table. The gas production and C/N ratio were monitored regularly for 60 days. Biogas measurements were taken, and methane concentrations were analyzed during this period using equipment from Arka Brenstech Private Limited, including Labio and Bio Process Control Equipment's.

The study also explored the impact of different C/N ratios on overall biogas production. Findings revealed that at a food-to-microorganisms ratio of 10 and a total solid content of 10% in the feed material, gas production reached 165.50 ml/g of total solids.

Table - 1

Sample	Water (kg)	Water Hyacinth (kg)	Cow dung (kg)	Total (kg)
A	0	1	1	2
B	1	0	1	2
C	1	1	0	2
D	0.5	1	1	2.5
E	1	0.5	1	2.5
F	1	1	0.5	2.5

C/N Ratio measurement:

The C/N ratio is a critical indicator of biogas substrate quality, particularly for anaerobic digesters, where an optimal range of 20-30 C/N ratios is desired. Table- 2 presents the C/N ratios of various raw materials. Amino acids are formed through the substrate's nitrogen content, but excessive nitrogen leads to the production of ammonia, resulting in unpleasant odours. The type of feed used also affects the C/N ratio of the manure.

Here are the specific C/N ratios of the analyzed samples:

Table - 2

Materials	Carbon (%)	Nitrogen (%)	Ratio (C:N)	Samples	C/N Ratio
Water Hyacinth	22.00	0.30	73.33	A	11.50
Cow Dung	28.00	1.10	25.45	B	15.20
Water Hyacinth	21.00	0.27	77.78	C	9.20
Cow Dung	26.50	1.05	25.24	D	25.30
Water Hyacinth	21.50	0.29	74.14	E	30.75
Cow Dung	26.00	1.01	25.75	F	20.70

Note: The analysis included multiple samples of water hyacinth and cow dung, with variations of up to 5% in their C/N ratios.

To investigate the impact of different C/N ratios, the samples were collected and tested in six reactors. Sample E, with a C/N ratio of 30.75, exhibited the highest gas production among all samples. The experiments were conducted over a 6-month period, with regular testing every 60 days to monitor gas production and degradation. Sample E, with a Water: Water Hyacinth: Cow Dung ratio of 1:0.5:1 (totalling 2.5 kg), proved to be the most efficient for anaerobic digestion, largely due to the nitrogen content present in the cow dung sample, which facilitated the formation of amino acids.

Slurry pH: (Acidity):

The production of methane is influenced by the pH level. Therefore, it is crucial to record the initial and final pH values to evaluate the adequacy of biogas fermentation. During several experiments, the pH of the feed material ranged from 7.4 to 7.7. Interestingly, in the case of sample E, the pH at the time of feeding was measured at 7.6. The outlet pH for all samples was consistently neutral, ranging between 7 and 7.1. This neutral pH is favourable for methane bacteria as they effectively break down acetic acid. As a result, methane content increases while carbon dioxide content generally decreases as the pH approaches neutral.

Sample E, with its ideal inlet pH of 7.6, demonstrated a remarkable methane content in the raw gas, ranging between 70% to 76% when the water: water hyacinth: cow dung ratio was 1:0.5:1. The higher methane content was achieved due to the increased amount of cow dung added to the substrate during co-digestion. Based on the results of these various experiments, it can be concluded that biogas derived from water hyacinth can serve as a promising renewable energy source. To further enhance overall productivity and methane content in the raw biogas, it is essential to add cow dung in the specified ratios mentioned above.

Conclusion:

Water hyacinth, a prolific waterweed, has had significant implications on the environment, irrigation, and agriculture. However, amidst its challenges, this study has shown a promising solution through biogas production. By utilizing water hyacinth leaves in combination with cow dung at a ratio of 0.5:1, with a 40-day retention time and a 10% total solid content in the feed material to the digester, substantial gas production was achieved. The biogas yield was at its peak during the first 40 days, gradually declining thereafter. The study also identified the optimal C:N ratio of 30.75 for efficient biogas generation. Notably, the highest biogas yield recorded in the various samples analyzed was an impressive 165 ml/g of TS with the water hyacinth to cow dung ratio of 0.5:1. These findings highlight the potential of harnessing water hyacinth as a valuable resource for sustainable biogas production, contributing positively to both waste management and renewable energy generation. With further research and implementation, this approach could play a crucial role in mitigating the environmental impact of water hyacinth and benefiting local communities and ecosystems alike.

References:

1) Patil JH, Antony Raj M, Shankar BB, Shetty MK, Kumar BPP. Anaerobic co-digestion of water hyacinth and sheep waste. Energy Procedia. 2014;52:572-578. DOI: 10.1016/j. egypro.2014.07.112
2) Nugraha, Winardi Dwi et al. "Biogas Production from Water Hyacinth." *Biogas - Recent Advances and Integrated Approaches* (2020): n. pag.
3) Wahyudi A. and R. Iskandar, "Effect of Water Composition in Biogas Formation from Water Hyacinth Reservoir X Padang Panjang City and Cow Stool". TeknikA, Vol 20 (1), 2013, pp. 7-11.
4) Nawir H., Djalal M. R. and Apollo 2018 Utilization of Water Hyacinth Waste as Biogas Energy Using a Digester Jurnal Ilmu-Ilmu Teknik Elektro dan Rekayasa 2 56-63
5) S J Malik, Aparna Saraf and Srinivas Kasulla "Biogas Production from Decanter Cake of Palm Oil Mill from South India" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-

6470, Volume-5, Issue-1, December 2020, pp.1144-1147

6) S J Malik and Srinivas Kasulla, "Biogas Production from Sugar Cane Press Mud and Sugar Cane Bagasse by Anaerobic Co-Digestion", Published in International Journal of Engineering Applied Sciences and Technology (ijeast), ISSN No. 2455-2143, Volume-5, Issue 7, November 2020, pp 194-197
7) Charudattan, R. Are we on top of aquatic weeds? Weed problems, control options, and challenges. In British crop protection council symposium proceedings. 2001, 77, pp 43-68.
8) Siswanto J. E. and Susanto A. 2018 Analysis of Biogas Made from Water Hyacinth and Cow Manure Chempublish Journal 3 11-20
9) Srinivas Kasulla, S J Malik, Salman Zafar, Aparna Saraf (2021) A Retrospection of Hydrogen Sulphide Removal Technologies in Biogas Purification. International Journal of Trend in Scientific Research and Development 5::857–863. https://doi.org/10.5281/zenodo.4680596
10) S. N. Sari, M. Sutisna and Y. Pratama, "Biogas Produced from the Decomposition of Water Hyacinth (Eichhornia Crassipes) with the Addition of Cow Manure as a Starter". Jurnal Institut Teknologi Nasional, Vol 1(2), 2014, pp. 1-10.
11) Srinivas Kasulla and S J Malik, "Enhancement in Biogas Production from Press Mud", Published in International Journal of Engineering Applied Sciences and technology (ijeast), ISSN No. 2455-2143, Volume-5, Issue 5, September 2020, pp 213-216
12) Anukam, A.; Mohammadi, A.; Naqvi, M.; Granström, K. A Review of the Chemistry of Anaerobic Digestion: Methods of Accelerating and Optimizing Process Efficiency. Processes 2019, 7, 504. https://doi.org/10.3390/pr7080504
13) Kasulla, Srinivas & Malik, S J & Zafar, Salman & Saraf, Aparna. (2021). A Retrospection of Hydrogen Sulphide Removal Technologies in Biogas Purification. 10.5281/zenodo.4680596
14) Srinivas Kasulla, S J Malik, Anjani Yadav, Gaurav Kathpal "Potential of Biogas Generation from Hybrid Napier Grass" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-6 | Issue-2, February 2022, pp.277-281,
15) A. Yonathan, A. R. Prasetya and B. Pramudono, "Biogas Production from Water Hyacinth (Eichhornia Crassipes): Study of Consistency and pH of the Produced Biogas". Jurnal Teknologi Kimia dan Industri, Vol 2 (2), 2013, pp. 211-215.
16) A. Ihsan, S. Bahri and Musafira. "Production Biogas Using Beef Rumen Content with Tempe Liquid waste". Journal Of Natural Science. Vol 2(2), 2013, pp. 27-35.
17) Hadiyarto A, Budiyono B, Joharri S, Hutama I, Hasyim W. The effect of F/M ratio to the anaerobic decomposition of biogas production from fish offal waste. Waste Technology. 2015;3(2):58-62. DOI: 10.12777/wastech.3.2.58-61
18) Teghammar A. Biogas production from lignocelluloses: Evaluation [thesis]. Göteborg: Chalmers University of Technology; 2013
19) M. A. Fitri and T. K. Dhaniswara, "Utilization of Cow Manure and Vegetable Waste in Biogas Production with Vegetable Waste Fermentation". Journal of Research and Technology, Vol 4 (1), 2018, pp. 47-54.
20) Huang, L., Yan, H., Liu, L., Liu, L., & Zhang, W. (2021). Biogas production from water hyacinth for rural energy supply: Techno-economic analysis and policy implications. Energy Reports, 7, 3811-3819.
21) Njoroge, B. K., Kivaisi, A. K., & Mshandete, A. M. (2018). Biogas production from water hyacinth (Eichhornia crassipes) and phragmites (Phragmites mauritianus) growing in Lake Victoria, Tanzania. African Journal of Environmental Science and Technology, 12(4), 166-172.
22) Panda, S., Singh, R. P., & Mishra, S. K. (2021). Production of biogas from water hyacinth: A promising approach to resolve environmental issues and harness energy. International Journal of Environmental Science and Technology, 18(1), 193-208.
23) Pandey, A. K., Goud, V. V., & Baredar, P. (2022). Biogas production from water hyacinth: Recent trends, challenges, and future prospects. Environmental Science and Pollution Research, 29(6), 6565-6577.
24) Sreekanth, G. B., Satyanarayana, S. V., & Venkateshwarlu, G. (2019). Biogas production from water hyacinth: A comprehensive review. Renewable and Sustainable Energy Reviews, 114, 109303.