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Research Article

Process Efficiency of Electrical Conductivity During Conversion of Cow Dung Waste Using Bacteria from Mixed Waste

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Abstract

Achieving energy-efficient and streamlined biochemical processes in waste conversion requires careful optimization of key biogeochemical parameters to overcome limitations such as process complexity, energy inefficiency, and undesirable microbial metabolic byproducts.This study investigated the effect of introducing selected microorganisms into cow dung substrate on electrical conductivity as an indicator of process efficiency during waste conversion.

Food waste and cow dung samples were collected from markets in Lugbe, Abuja. Microbial isolates were identified using molecular, biochemical, cultural, and morphological techniques, while inoculum standardization was performed using the McFarland standard. A total of twenty-four anaerobic bacteria were isolated, among which three demonstrated high biogas production potential: Candidatus Methanoperedenaceae GB37, Candidatus Methanoperedenaceae GB50, and Methanothermobacter thermautotrophicus NPK. Two experimental setups were employed: Seeded Fermented Cow Dung (SFC), inoculated with selected isolates, and Non-seeded Spontaneously Fermented Cow Dung (NSFC), which served as the control. Overall, 272 bacterial species were identified across both systems. On day 2, electrical conductivity values were 1500 for SFC and 1100 for NSFC. However, throughout most of the digestion period, NSFC exhibited higher electrical conductivity compared to SFC.

These findings suggest that the introduction of additional microorganisms may not necessarily enhance electrical conductivity or overall process efficiency during anaerobic digestion, highlighting the need for careful selection and optimization of microbial consortia in waste-to-energy systems.

1. Introduction

The principal source of energy for catabolic and anabolic process is recovered from energy synthesizing pathways during microbial metabolism. Electrical conductivity and redox reactions are closely related, particularly in the context of electrochemistry. Redox reactions

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involve the transfer of electrons, and this transfer can be harnessed to produce or utilize electrical energy. The conductivity of the medium, often an electrolyte solution, significantly influences how efficiently these electron transfers occur, affecting the rate and feasibility of redox reactions.

Redox is well correlated with microbial activity, structure, and texture. A low redox state is connected to high microbial activity, indicating bioavailable organic matter availability. Substrates with good structure had an oxidized redox status, possibly reflecting high gas-transport.

Higher conductivity in the electrolyte can lead to faster reaction rates in redox reactions because electrons can move more easily between reactants. Therefore, when microorganisms are at the peak of performance during microbial metabolism in a highly conductible substrate, more electrons are produced which in-turn limits or fasten the rates of biochemical reactions as an after effect during microbial metabolism depending on the substrate. Substrate performance is highly dependent on substrate physicochemical parameters and the inter play between microorganism. Awareness and application of the knowledge of these parameters in relation to microbial activities offer real-time monitoring and diagnostics for a target of interest, enabling precision in scientific and clinical research practices and informed decision-making for optimal resource management.

2. Materials and Methods

2.1. Description of Study Locations

23.The Federal Capital Territory is a Federal Territory in Abuja. It is within the middle belt region of the country. It has a Total area of $7,315 KM^2$ (2,824 sq. mi) and a total population of 2, 238,800 with the density of $190/KM^2$ (500/sq. mi). It has a coordinate of 9° 4'0"N 7°29'0"E. The AMAC, Lugbe Relocation Market is located along airport road in the upcoming Lugbe Area of the F.C.T. The Ultra-Modern Market boast over 900 types of shops including Warehouses, Cold Rooms, and Meat shops, Slaughter House, Wood Shade and Cattle Ranch from where the samples were collected.

Description of Sampling Point

Samples were collected at the Cattle Ranch and the AMAC Lugbe relocation Market F.C.T Abuja. Animal dung was collected from the cattle ranch (Cow droppings) in the early hours of the day from the cattle. Fruit and vegetable residue were also collected from house refuse at life camp; Abuja sampling area shown on Figure 1.

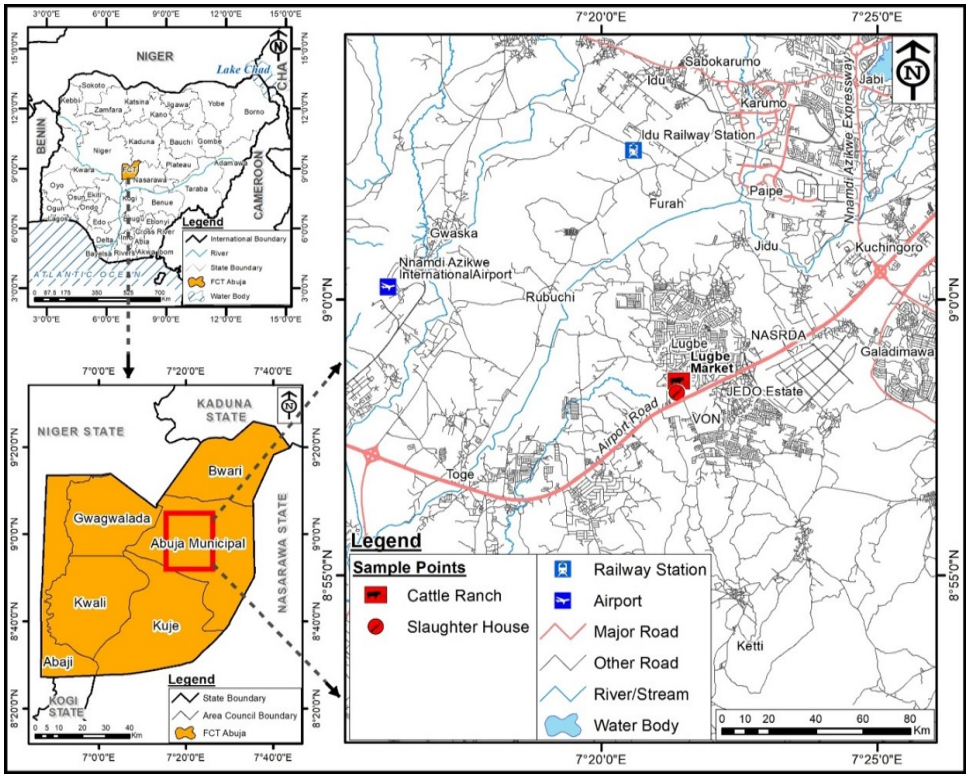

Figure 1: Map of Abuja Municipal Area Council Showing Sampling Points (Cattle Ranch and abattoir, Lugbe Market), Abuja

2.2. Determination of Electrical conductivity

Anaerobic isolates from Cow dung, mixed fruit and vegetable residue and sawdust were introduced into the substrate (Cow dung), the inoculation was done for two set-ups, seeded fermented cow dung substrate and non-seeded fermented cow dung substrate. The anaerobic isolates which showed superior ability from previous test were selected for this experiment they were multiplied using broth culture for 24 hours. Cow dung samples were collected and used to fill the bottles to $1/3^{rd}$ of the entire volume of the bottle. The bottles were then

inoculated using Mc Faland's standard. The bottles were then sealed and turned upside down to allow for escape and evacuation of gas. After the evacuation of the gas, the set up was completely sealed using para film paper and incubated at 37°C for the duration of 45 days. The set up was made in two sets so that one could be used for measuring gas (only) while the other sets was used for analysis of Electrical conductivity for each day. Figure 2 shows one of the two set ups.

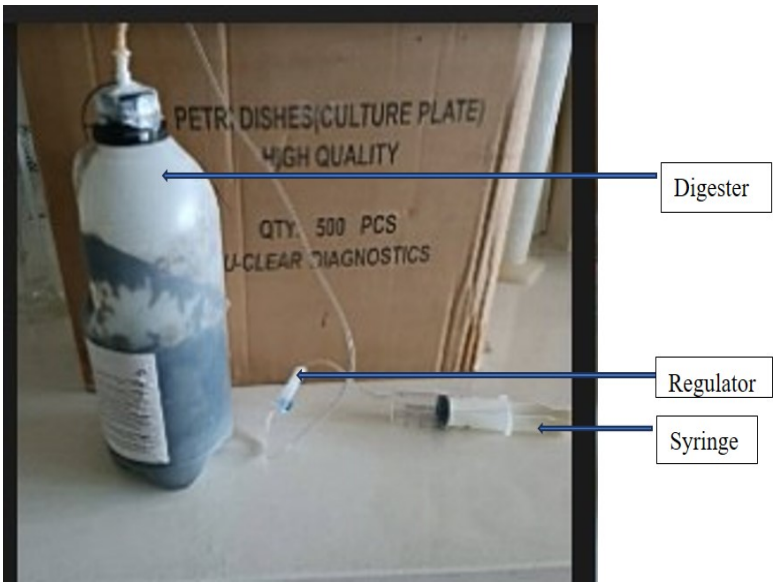

Figure 2: One of the set up for determining Electrical conductivity at IITA with the syringe, digester and regulator

3. Results and Discussion

Changes in Electrical Conductivity during Biogas production in seeded substrate

Table 1 shows the result of the effects of microbial seeding on the Electrical Conductivity of the substrate. The highest conductivity on Figure 1 (from the mean) was on day 3 (1500) with the seeded sample while the lowest was on the 30^{th} and 45^{th} day (20 unit). Day 3, 10, 15 and 5 (1150, 1150, 1000 and 1040) with the seeded had a relatively higher unit. The non-seeded was lower than all or equal to the units obtained from the seeded sample. The lowest on Table 1 was on days 30 and 45 with the non-seeded and 45 with the non-seeded (20). There was a continuous decrease in conductivity per digestion day with the seeded sample, example is the first day (from day 2-3) decrease (1500-1150) while day 3-15 (1150-1000) recorded a sharp decrease, it continued in this fashion until the last day (45) where the electrical conductivity dropped to (20). There was also a decrease in conductivity as clearly seen with the non-seeded Table 1 from days 2(1180) to (20) on day 45. There was a difference in the pattern of the conductivity recorded from the seeded sample and that of the non-seeded, the seeded had higher values compared to the non-seeded. Day 15 was also higher with the seeded sample as the conductivity of the seeded was 1000 and that of the control was 700.

Table 1: Effects of microbial seeding on Electrical conductivity (μs/cm) with seeded and non-seeded cow dung substrate

Day	Non-seeded				Seeded			
	Rep 1	Rep 2	Rep 3	$\Sigma x/y$	Rep 1	Rep 2	Rep 3	$\Sigma x/y$
2	1100	1210	1230	1180	1600	1400	1400	1500
3	1000	800	750	850	1250	1200	1000	1150
5	670	660	680	670	1300	1070	1080	1150
10	800	940	960	900	1080	1040	1000	1040
15	600	400	600	700	1400	900	700	1000
30	19	21	20	20	400	300	200	900
45	17	22	21	20	25	15	20	20

These findings have reported the positive effects of microbial seeding on biogas yield for seeded and non-seeded cow dung substrate. These findings have also reported the positive effect of microbial seeding on physicochemical parameters.

A total of one hundred and eighty anaerobic bacterial species were found in the seeded cow dung substrate while 70 species were found present in the non-seeded cow dung substrate, bacterial community identified had the ability to aid anaerobic digestion and were enhanced by microbial seeding. This work demonstrated a positive effect of microbial seeding using anaerobic species on Electrical conductivity.
Rep –Replicate

$$\sum \frac{x}{y} - \text{Mean}$$

Contribution To Knowledge

Bacteria isolated from the feedstock were molecularly identified and were used for seeding the cow dung substrate which affected the electrical conductivity of the substrate. The literature obtained from the findings in this work provides a ground for basic foundational knowledge that extends the frontiers of research in current scientific findings as it paves way and option for the choice of bio augmentation of substrates over and above the natural processes, this helps to improve and attain requisite and exclusive environmental health status. With the aforementioned findings, this work (microbial seeding) had bridged some gaps in process efficiency of electrical conductivity during waste conversion.

Recommendation

Other environmental waste should be explored in the conversion of waste to value added product as cow dung have shown positive effects in the conversion of waste to value added products as reported in this work so that the desired environmental condition can be reached.

Article Information

Disclaimer (Artificial Intelligence): The author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.), and text-to-image generators have been used during writing or editing of manuscripts.

Competing Interests: Authors have declared that no competing interests exist.

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