

PRODUCTION OF LIQUID FERTILIZER FROM MUNICIPAL WASTES

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ABSTRACT

Environmental pollution from municipal wastes generated by human, animal activities and plants has been a major challenge and problem to environmental engineers all over the world. Therefore, transforming municipal wastes into useful products of liquid fertilizers is required to decrease the amount of wastes and methane gas. This study aims to produce an efficient concept and practice, for the stabilization of Nutrient-rich fertilizer from selected municipal wastes, and to determine the efficiency with which liquid Fertilizer generates major nutrients for vegetable production and its effect on some soil physical Properties. the increasing generation of municipal waste, with over 40% being organic, necessitating effective waste management alternatives. Composting was carried out using specific municipal wastes—cow dung, sewage sludge, rice straw, food waste, and green waste—to produce liquid fertilizer in four different formulations over a three-month period. The fertilizer was analyzed for nutrients composition and fertilizer quality. The result showed 20% cow dung, 40% sewage sludge, 20% food waste, 10% green waste, and 10% rice straw combination proving most effective, with 17.04% nitrogen, 140.9 ppm phosphorus, and 652.3 ppm potassium. This result shows that municipal wastes can be converted to a valuable liquid fertilizer which enhances plant growth. The liquid fertilizer, environmentally friendly and cost-effective, contributes carbonaceous matter to the soil, improving physical, chemical, and biological properties. The study underscores the importance of comprehensive analysis for quality and recycling, highlighting the organic acids' role in dissolving soil minerals and enhancing plant uptake. Additionally, it emphasizes the crucial role of liquid fertilizer in promoting soil microbial activity and long-term soil health. the research highlights the significance of liquid fertilizer from municipal wastes in fostering sustainable agriculture, providing insights into the benefits of organic elements for microbial decomposition. It stresses the need for a balanced approach in waste materials and recommends addressing challenges, such as equipment availability for NPK analysis and water scarcity for plants, to enhance the accuracy of fertilizer analysis and ensure successful implementation.

Keywords: Municipal Waste, Organic Waste, Liquid Fertilizer, Composting, Microbial Decomposition, Sustainable Agriculture.

1 INTRODUCTION

The world generates estimated 1.7 – 1.9 billion metric tons of municipal wastes (MW) each year which can result to public health challenges if not taken care of [1,2]. In Nigeria alone, about 254 million tons of municipal wastes (MW) were generated in 2013, among which about 34 percent was recycled causing municipal wastes to be disposed in landfills and open places [2, 3]. Organic materials such as paper and paperboard, yard trimmings, food wastes, plastics, wood, rubber etc. are the largest component of MW and contain large amounts of energy that can be recovered [4]. In 2013, 134.3 million tons of MW went to landfills and 32.7 million were combusted for energy recovery [2]. Improper management of these MWs can cause large scale contamination of soil, water and air, is a significant contributor to greenhouse gas emissions and allow high potential economic values uncaptured [5]. Most of these wastes are biodegradable and can be converted into valuable resources that reduce their otherwise negative impacts to enhance the production of good crop production and plant nutrients in

intensive small-scale organic-based vegetable production and for sustaining soil health and productivity [6, 7]. Based on one of the guiding principles of farm waste management, *Waste is a Resource*, waste recycling can alleviate the problem of farm waste management [8]. Despite this level of involvement in agriculture the rapid growing population of the country, attempts to increase food production in the country have brought about the expansion of farming area, as well as an increase in the use of chemicals fertilizer, the long-term effect of which does not support sustainable agriculture, in an attempt to promote organic agriculture and ensure the production of agricultural goods at a sustainable level [9, 10] Non-renewable fossil resources are often used to manufacture inorganic fertilizer which adds to environmental pollution and ecosystem imbalance [11]. Surface and groundwater systems are contaminated by inorganic fertilizers resulting to nutrient leaching and runoff which affects human and aquatic life [12]. The National Organic Standard Board (NOSB) has defined organic agriculture as 'anecological production management system that promotes and enhances biodiversity, based on minimal use of off-farm inputs and on-farm management practices that restore, maintain and enhance ecological harmony' [8]. Organic farming avoids the use of synthetic fertilizers and pesticides and relies on developing biological diversity in the field to disrupt habitats for pest organisms and the purposeful maintenance and replenishment of soil fertility. Organic farming emphasizes the use of renewable natural resources and their recycling. It eliminates the use of synthetic pesticides, growth hormones, antibiotics and gene manipulation in the crop production system, and this poses a challenge to crop and pest management specialists to device new tactics for crop and animal protection. Attention is instead focused on disease resistance and restoring or enhancing ecological processes. Organic systems rely on crop like rice residue, yam, maize, millet, legumes, and green manures [10, 13]. The organic wastes and aspects of biological pest control to maintain soil productivity and tilt, to supply plant nutrient and to control insects, weed and other pests. Most of the synthetic fertilizers and other chemicals fertilizer that are used in non-organic farming are manufactured using resources such as fossil fuels which are not renewable. Using such resources may cause pollution and contribute to environmental degradation, thus making such agricultural practices unsustainable. Some inorganic fertilizers used to increase crop yield are leached or washed away by erosion to nearby rivers, causing water pollution, which is dangerous to aquatic life and human health. Around 1.3 billion tons of food are wasted every year in a developing country like Nigeria with old cities and communities, wastewater or sewage generated are often discharged into pit latrines in rural areas while they are discharged into septic tanks, suckaways and cesspools in towns and cities [1]. These systems are problematic as soils become saturated with pollutants and effluents with very high suspended and dissolved solids causing environmental pollution and even groundwater pollution in some cases [14]. Fruits and vegetables that include tubers and roots showed the highest amount of wastage of any food. Around 8000 tons of food and kitchen waste is generated daily in Nigeria. The wastes generated can feed on six million nations and solid waste management cost for discarded food cost into billions of ringgits [5, 15] Food wastes are normally sent to the landfill for disposal but it may break down and produce large amount of methane gas. This can become a problem because methane gas is 25 times more potent than carbon dioxide in causing greenhouse effect.

2 METHODOLOGY

2.1 Sample Collection, Feedstock Size Reduction and Slurry Preparation

The municipal wastes were collected at Girei, Adamawa State, Rice straw, food waste, sewage sludge, green waste and cow dung. In order to increase the surface area for mass transfer, the organic wastes are mechanically chopped to reduce size particle and also increase the microbial activity during decomposition [16, 17]. The materials are mixed at a ratio of 3:3:2:1:1 (3: cow dung, 3: sewage sludge, 2: food waste, 1: rice straw, 1: green waste) in a bucket, barrel or container with enough water added to it to produce a uniform slurry for biochemical reactions and adequate moisture content [18].

2.2 Controlled Biochemical Decomposition (Fermentation)

The slurry mixture was subjected to a controlled fermentation process. It was covered with plastic to increase the temperature, minimize escape of gases to the atmosphere and to let it to steep. The temperature of the pile was monitored weekly [16]. The slurry was opened and stirred after two weeks to facilitate uniform decomposition leading to the release and solubilization of nutrients species

such as ammonium (NH_4^+), phosphate (PO_4^{3-}), and potassium (K^+) [18, 19]. It was incubated for another four weeks to enhance further decomposition because the materials are not easy to decompose. Decomposition was prolonged from 30 days to 60 to 90 days for the full degradation of recalcitrant organic materials like the rice straw [20].

2.3 Solid-Liquid Separation by Filtration

The slurry was stirred for the last time, then with a filtration system, the liquid was filtered out to achieve solid-liquid separation, enriched with solubilized nutrients suitable for use as a liquid fertilizer.

2.4 Nutrient Characterization through NPK Analysis

The final liquid fertilizer was subjected to standard analytical procedures to determine its various nutrient compositions at different liquid fertilizer variations. Quantitative NPK analysis was conducted for phosphorus and potassium concentrations, using Atomic Absorption Spectroscopy (AAS) and nitrogen using the kjeldahl method [21, 22].

3 RESULTS AND DISCUSSION

3.1 Analysis of Liquid Fertilizer

Liquid fertilizer samples were taken from each treatment at 30, 60 and 90 days of the fermentation for the four different compositions and were analyzed for the changes in the physical and chemical properties throughout the fermenting process to determine the N, P, K of the fertilizers. previous studies show an enhanced nutrient mineralization during composting and anaerobic degradation of organic wastes which corresponds to the observed increase in nitrogen and potassium concentrations during fermentation [18, 19, 23]. While a decline in the phosphorus content shows the microbial immobilization or precipitation reactions also similar to other reported composting systems [24, 25] Due to the usage of sewage sludge and cow dung to serve as the major feedstocks, contributed largely to nutrient enrichment due to the high matter and nitrogen content they contain [14] It is important to carefully monitor contaminants such as heavy metals when sewage sludge is used in agricultural applications [12].

3.2 Chemical and Physical Properties of the Liquid Fertilizer

Table 1. Values of the NPK Content of the Four Variations in Compositions of the Liquid Fertilizer After 30 Days

S/N	Sample	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)
1	Cow dung 0% Sewage sludge 60%	11.7	102.5	412
2	Cow dung 20% Sewage sludge 40%	14.2	142.4	640
3	Cow dung 40% Sewage sludge 20%	0.83	83.1	160
4	Cow dung 60% Sewage sludge 0%	0.75	94.6	224

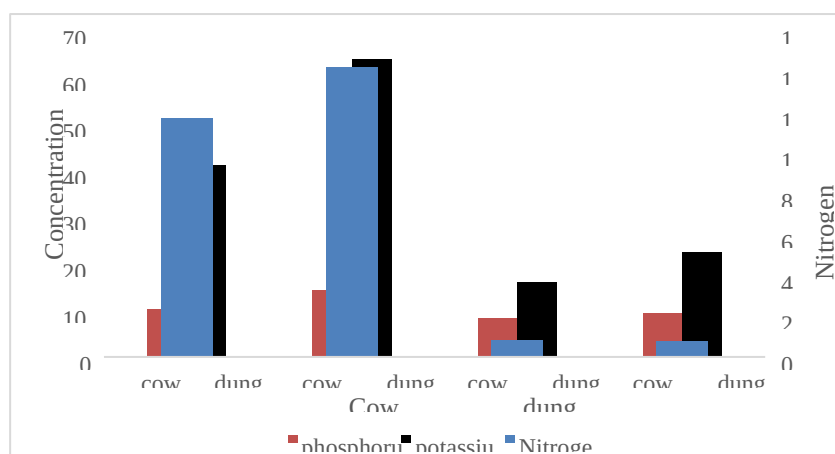


Figure 1. Variations of the Compositions in the Liquid Fertilizer after 30 Days for Cow Dung

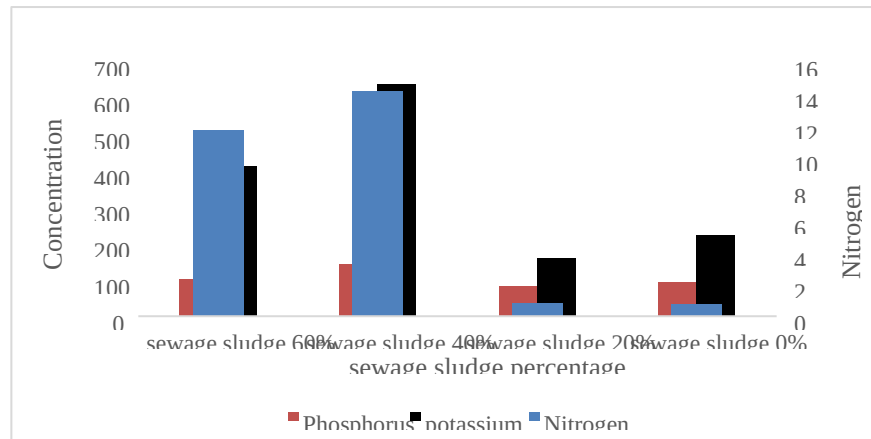


Figure 2. Variations of the Compositions in the Liquid Fertilizer after 30 Days for Sewage Sludge

Table 2. Values of the NPK Content of the Four Variation in Composition of the Liquid Fertilizer after 60 Days

S/N	Sample	Nitrogen (%)	Phosphorus P (ppm)	Potassium K (ppm)
1	Cow dung 0%	12.74	103.1	418.9
	Sewage sludge 60%			
2	Cow dung 20%	15.24	143.2	650.8
	Sewage sludge 40%			
3	Cow dung 40%	1.87	83.6	162.7
	Sewage sludge 20%			
4	Cow dung 60%	1.79	95.1	227.8
	Sewage sludge 0%			

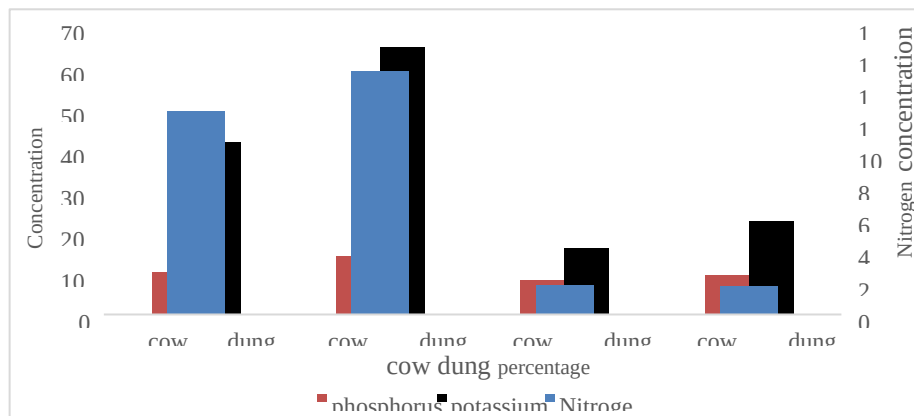


Figure 3. Variations in composition of Liquid Fertilizer after 60 Days for Cow Dung

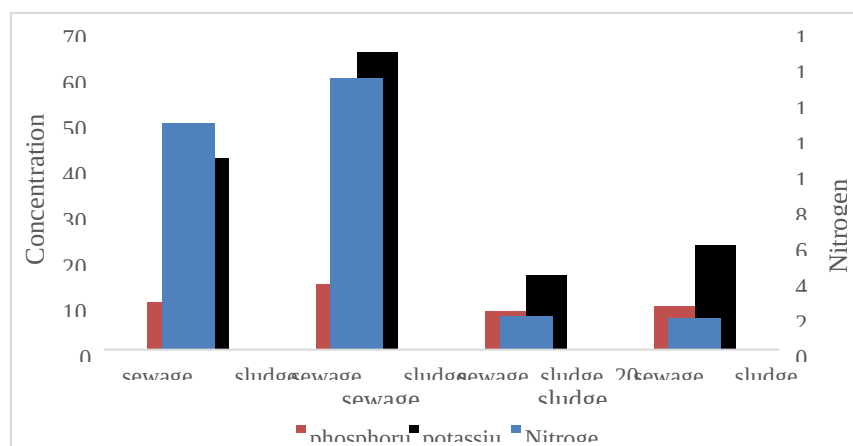


Figure 4. Variation in composition of Liquid Fertilizer after 60 Days for sewage Sludge

Table 3. Values of the NPK Content of the Four Variations in Compositions of the LiquidFertilizer after 90 Days.

S/N	Sample	Nitrogen N (%)	Phosphorus P (ppm)	Potassium K (ppm)
1	Cow dung 0% Sewage sludge 60%	14.54	101.5	419.9
2	Cow dung 20% Sewage sludge 40%	17.04	140.9	652.3
3	Cow dung 40% Sewage sludge 20%	3.67	82.3	163.1
4	Cow dung 60% Sewage sludge 0	3.59	93.6	228.3

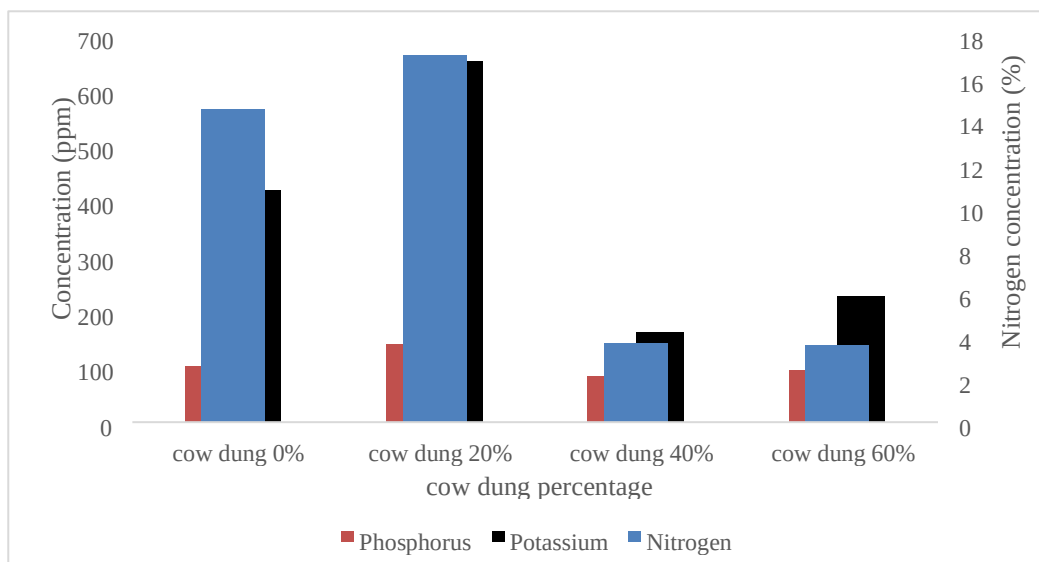


Figure 5. Variations in Composition of the Liquid Fertilizer after 90 Days for Cow Dung

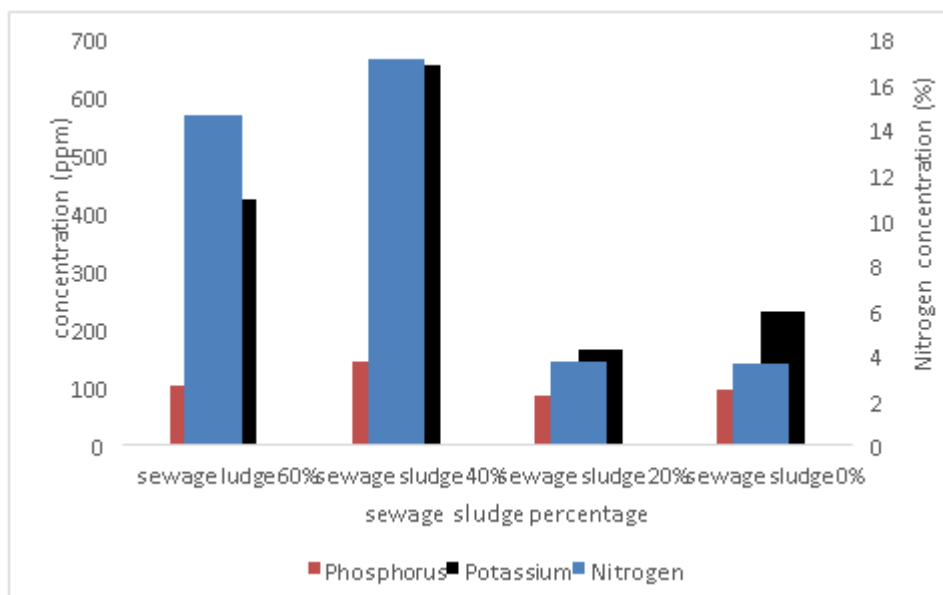


Figure 6. Variations in the Composition of the Liquid Fertilizer after 90 Days for Sewage Sludge

Table 4. Comparison of the concentrations of the best liquid fertilizer produced with Time

Time/Concentration	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)
30 Days	14.2	142.4	640
60 Days	15.24	143.2	650.8
90 Days	17.04	140.9	652.3

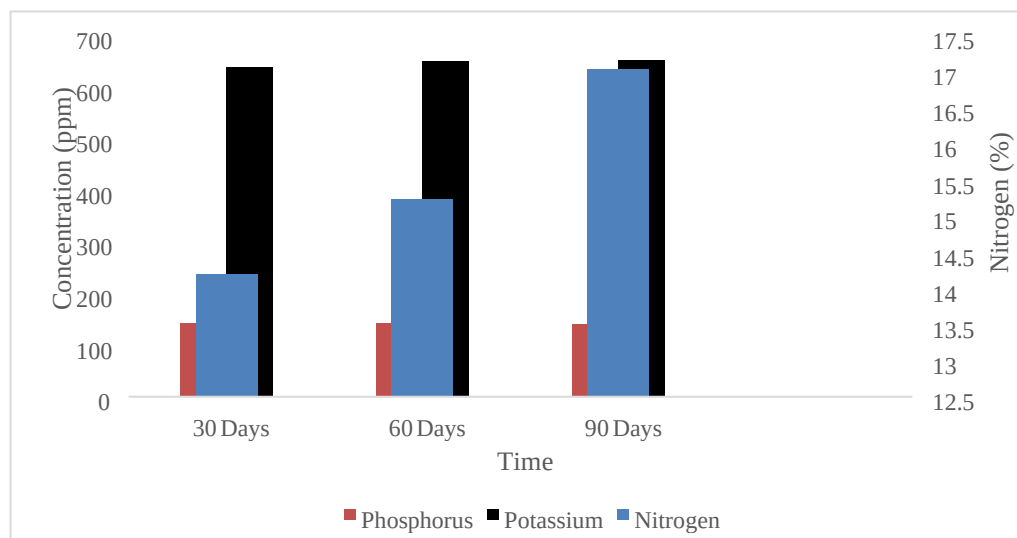


Figure 7. Comparison of the Concentration with Time

Table 5. Comparison of the 0% concentrations of Cow Dung with Time

Time/Concentration	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)
30 Days	11.7	102.5	412
60 Days	12.74	103.1	418.9
90 Days	14.54	101.5	419.9

3.2 NPK Nutrients content

The nutrient content for the treatment showed that N and K experienced an increase in the percentage at the end of composting while P showed a decreasing trend [26]. The initial value of N in early composting was 11.7, 14.2, 0.83, 0.75% [27]. At the end of composting the treatment showed an increase in total N content was 14.54, 17.04, 3.67, 3.59% [27]. The initial P value was 102.5, 142.4, 83.1, 94.6. It was observed that the P content in the compost declined at the end of the composting period in the treatments [28]. At the end of the composting the values were: 101.5, 140.9, 82.3, 93.6%. The initial value of the K percentage on the initial day was 412, 640, 160, 224 ppm, and the final value increase to 419.9, 652.3, 163.1, 228.3 ppm.

3.3 Analysis of the Fertilizer Produced

Characteristics of final product measured are nitrogen content, phosphorus content, and potassium content. The fermented product was analyzed for N.P.K. The result is shown in Table 6 for the best composition of liquid fertilizer to use with sewage sludge having the highest percentage of 40%, cow dung 20%, rice straw 10%, food waste 10% and vegetable waste 20% [29].

Table 6. Analysis of the Liquid fertilizer Produced

Chemical Properties	Reading Analysis
N (%)	17.04
P (ppm)	140.9
K (ppm)	652.3

3.4 Effect of the Liquid Fertilizer on plant

Spinaciaoleracea popularly known as spinach were planted in five different containers and the four fertilizers were applied to them with one of the containers having no fertilizer applied to it and the effects were noticed [30]. It was noticed that the four that were applied with the fertilizer grew taller and faster than the spinach in the container with no fertilizer [31]. The leaves were greener and finer than the one without fertilizer. Among the four with fertilizer, it was noticed that the container with 20% cow dung has the finest spinaches followed by the one with 0% cow dung and then 40% cow dung and the last was the 60% cow dung. able 7 shows the length of the spinaches of the five different containers after 1 month.

Table 7. Lengths of the plant after 1 Month

S/N	Compositions	Phosphorus (ppm)
Container 1	0% cow dung	17
Container 2	20% cow dung	19.4
Container 3	40 % cow dung	16
Container 4	60 % cow dung	15
Container 5	No fertilizer applied	8

4 CONCLUSIONS

The first objective of this research was to develop a nutrient-rich liquid fertilizer from municipal waste. This aim was accomplished through the production of a fertilizer derived from a mixture of 40% sewage sludge, 20% cow dung, 10% rice straw, 10% food waste, and 20% vegetable waste. These waste products underwent a 90-day anaerobic fermentation process. Samples were analyzed at 30, 60, and 90 days to track nitrogen, phosphorus, and potassium changes. The final optimized formulation after 90 days contained adequate nutrients to support plant growth, with 14.54% nitrogen, 101.5 ppm phosphorus, and 419.9 ppm potassium. The successful production and nutrient analysis of this municipal wastebased fertilizer effectively achieved the first goal of creating usable manure. The second objective outlined at the study's onset was to characterize the liquid fertilizer created fully. Once the ideal 90-day 40/20/10/10/20 waste formulation was complete, detailed lab testing was undertaken to profile its chemical properties. This found the fertilizer to contain 17.04% nitrogen, 140.9 ppm phosphorus, and 652.3 ppm potassium. Additionally, the fermentation process was monitored at fixed intervals, showing a rise in nitrogen and potassium over time alongside a decrease in phosphorus. Comparing the 0% cow dung treatment at 30, 60, and 90 days also traced increases in nitrogen from 11.7% to 14.54% with fermentation. These quantitative analyses successfully characterized key attributes of the produced fertilizer to address the second goal. Finally, the third aim of the study was to determine the impacts of the liquid fertilizer on plant growth and development. This was tested experimentally by growing spinach plants under controlled conditions while applying the different waste percentage fertilizers. After one month, the heights of plants treated with the 20% and 0% cow dung formulations showed 19.4cm and 17cm rowth respectively, compared to just 8cm for untreated plants. The fertilizers thus clearly conferred growth benefits, while higher cow dung proportions somewhat inhibited spinach height. This experimental evaluation effectively achieved the third objective of assessing how the produced municipal waste fertilizer influences vegetation.

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