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Physico-Chemical Characterization of Slaughterhouse Waste-Derived Liquid Fertilizer Using Different Processing Methods

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ABSTRACT

This study was conducted to estrablish a processing protocol for liquid fertilizer derived from slaughterhouse waste. It was conducted on March 1 to April 20, 2026 at the Municipal Slaughterhouse, Imelda, Pudtol, Apayao. The study was laid at an elevated wooden platform using plastic six drums as a processing media for T1. Raw T2. Fermented (Anaerobic), T2. Effective Microorganism assisted fermentation and Two drums of 50L slaughterhouse waste – were subjected to three (3) treatments unprocessed (T1), fermented (anaerobic fermentation) (T2), and Effective Microorganism assisted fermentation (T3). A a 15-day fermentation period followed by a secondary refinement stage using a specialized five layer gravity filtration system composed of gravel, sand, and activated charcoal. All samples from every stage of processing were collected and brought to authorized laboratories for macro-nutrient and bacterial content analysis. The study concludes that slaughterhouse waste is a highly viable and effective substrate for the production of liquid fertilizer. Through the establishment of a rigorous four-stage processing, the resarch demonstrated that EM-Assisted Fermentation (P3) the most effective technology for nutrient recovery, achieving a peak Nitrogen concentration of 10.81%. This has a significant enhanchment over raw waste and standard anaerobic processing, proving that the inoculation of Effective Microorganisms accelerates the mineralization of animal proteins into a concentrated liquid nitrogen source. Furthermore the 15-day fermentation period, combined with a five layered gravity filtration system can reduce the initially hazardous pathogen load (toal coliform >8.0MPN/100ml) to a stabilized and safe level (1.1 MPN/100ml) while completely eliminating fecal coliform.

Key words: Anaerobic fermentation, Growth, Gut Microflora, Ducks

INTRODUCTION

Background of the Study

Slaughterhouse operations produce large volumes of wastewater, bones, fats, manure, rumen contents and blood that contain high concentrations of biodegradable organic matter, nutrients, pathogens and suspended solids [1,2]. These are agrevated by rapid expansion of the livestock and meat processing industry worldwide which resulted in the increasing generation of slaughterhouse waste, posing serious environmental and public health concerns. Globally, the meat industry generated approximately 103 million tonnes of slaughterhouse waste and around 2,699 million tonnes of wastewater in 2022 alone [3]. Improper handling and disposal of these wastes contribute to water pollution, foul odoremission, greenhouse gas production, euthrophication and the spread of desease-causing microorganisms [1,4]. According to the Food

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and Agriculture Organization of the United Nations, slaughterhouse wastewater high biological oxygen demand and organic pollutants that rapidly deplete dissolved oxygen in water bodies when disharged untreated [1]. In many developing countries countries, slaughterhouse facilities lack efficient waste treatment systems, resulting in direct disposal of untreated effluents into rivers and drainage canals [2]. These practices negatively affect aquatic ecosystems, soil quality, and communities.. Moreover increasing livestock production has intensified concerns regarding sustainable waste management and environmental protection worldwide [5]. Despite these environmental risks, slaughterhouse waste contains valuable nutrients such as nitrogen, phosphorus, potassium, protenis and organic matter that can be converted into useful agricultural inputs [6]. Recent studies have emphasized the potential of recycling slaughterhouse waste into organic fertilizers through biological treatment technologies such as composting and anaerobic fermentation [4,6]. Organic fertilizers derived from animal watse improved soil fertility, enhanced microbial activity, increased water-holding capacity and reduced dependence on synthetic fertilizers [7]. The utilization of slaughterhouse waste as fertilizer also supports the principles of circular economy and sustainable agriculture by transforming waste material into value-added products [6]. Among the available biological treatments method, anaerobic fermentation has emerged as an effective and economical approach for converting slaughterhouse waste into liquid organic fertilizer [4]. The fermentation process stabilizes organic matter, minimizes odor and reduces pathogenic microorganisms while preserving essential plant nutrients [8]. The addition of molasses and effective microorganisms (EM) enhances microbial activity during fermentation, accelerating decomposition and improving fertilizer quality [9]. Beneficial microorganisms such as lactic acid bacteria and photosynthetic bacteria contribute to nutrient mineralization, pathogen suppression and improved fertilizer stability [9]. The global slaughterhouse industry is currently navigating a pivotal shift from a traditional “disposal-based” model to a “circular economy” framework. As of 2026, the management of slaughterhouse waste- which includes blood, bones, feathers and rumen content – has transitioned from being viewed as a costly liability to a high-value resource for agriculture and bioenergy [12]. The increasing demand for sustainable and environmentally friendly agricultural inputs has also hightened interest in organic fertilizer production worldwide. Organic fertilizer are recognized for their role in improving soil health, reducing chemical residues and promoting long-term agricultural productivity [7]. Several counties have adopted waste recycling technologies to convert agricultural and livestock wastes into biofertilizers as part of integrated waste management systems [6]. Furthermore, studies have shown that properly fermented animal waste fertilizers can enhanced crop growth and reduced environmental pollution compared to untreated waste disposal practices [8]. In the Philippines, slaughterhouse waste management remains a significant environmental issue, particularly in urban and rapidly developing municipaliteis where slaughterhouses operate near residential and agricultural areas. Many local slaughterhouses still practice inadequate waste disposal methods due to limited waste treatment facilities and poor environment management systems [1,10]. Untreated slaughterhouse effluents are commontly discharged into waterways, causing water contamination, unpleasant odor and sanitation problems [2]. The increasing volume of slaughterhouse waste generated by the livestock industry has therefore become a growing concern among environmental agencies and local government units.

The Philippine government has continously promoted organic agriculture and sustainable farming practices through Republic Act no. 10068 known as the Organic Agriculture Act of 2010. The law encourages the development and utilization of organic fertilizers derived from locally available resources as alternatives to synthetic agricultural inputs. Likewise, the Department of

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Agriculture through the Philippine National Standards for Organic Agriculture supports the production and use of organic soil amenements and fertilizers to improve agricultural sustainability [11]. Circular economy is touched in SDG 12 which emphasizes responsible consumption and production. To achieve this, there must be an environmentally sound management of chemicals and all wastes throughout their life cycle, in the case of slaughterhouses, that is transforming blood and bone into fertilizer directly fulfills the manadate to minimize "lost" resources [13] In many agricultural communities in the Philippines, farmers continue to face increasing production costs due to the rising prices of commercial fertilizers. This situation has encouraged interest in low-cost and locally available organic fertilizer alternatives. The convertion of slaughterhouse waste into liquid fertilizer may provide an economical nutrient source while simultaneously addressing waste disposal problems. However, the absence of standardized processing procedures affects the quality, safety and efficiency of fertilizer production. Establishing a scientifically based processing protocol is therefore necessary to ensure proper fermentation, nutrient stabilization, odor reduction and pathogen control. Hence this study.

Objective of the Study

Generally, this study aims to establish a processing protocol for liquid fertilizer derived from slaughterhouse waste. Specifically, it aims to process slaughterhouse waste into liquid fertilizer using anaerobic fermentation technology, to determine the effect of effective microorganisms on the fermentation process, compare the nutrient profiles of the treatments, evaluate the bacterial contents of the treatments, and to develop a standardized protocol for liquid fertilizer production from slaughterhouse waste.

Scope and Delimitation

The study if focused only on the preparation, fermentation, and nutrient characterization of effective microorganism-treated, anaerobic processed and naturally decomposed slaughterhouse slurry, including the analysis of macro-nutrients, and bacterial contents.

The study is delimited to the use of slaughterhouse waste as the organic fertilizer source, with the use of Effective Microorganism, anaerobic treatment compared to naturally decomposed slaughterhouse waste. Processed slaughterhouse waste was analyzed for macro-nutrient and bacterial content by authorized laboratory. The study did not assess long-term soil fertility, residual nutrient effects, pathogen load, heavy metal content, pest and disease incidence, or economic profitability.

Time and Place of the Study

This study was conducted from March to April 2026. The experiment was carried out under controlled drum conditions at the Pudtol Municipal Slaughterhouse, Imelda, Pudtol, Apayao, Philippines.

METHODOLOGY

Materials

The experimental area was located near the municipal slaughterhouse of Pudtol, Apayao. A liter of effective microorganism, six drums with covers, and lumber were purchased for the study.

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The waste from the slaughterhouse came from the septic tanks. Sand, gravel, and charcoal were collected and used as filtration materials; tools like rake, bucket, screens, clothes, funnel, containers for sample collection, faucet, string, nails, hammer, crosscut saw, permanent pens, record book, ruler, and labelling materials are required to ensure that data is accurate.

Construction of Elevated Platform

Lumbers were cut into desired sizes, set-up at 2m high, 10ft wide. 1.5ft elevation for 900L capacity plastic drums from the floor and while the 60L capacity smaller drums were elevated with 2m from the floor.

Installation of Faucets and Drum Setting

Faucets were installed at the bottom side of every drum. Bigger drums are placed at lower elevation of the platform. The smaller drums were set-up at the higher elevation of platform.

Filter Preparation and Setting on Drums

Collected gravels and sands were washed thoroughly. Five levels of filter at 5in each were set-up for three bigger drums, from bottom to top were gravel, sand, charcoal, gravel and sand. A cloth was used as separation of gravel and sand at the bottom part, a screen separation for the sand and charcoal likewise with the sand and gravel at the upper part of the filter set-up.

Collection of Slaughterhouse Waste

Slaughterhouse waste was collected from the septic tank of the municipal slaughterhouse located in Imelda, Pudtol, Apayao. The collected materials, including blood, rumen contents, and wastewater, were placed in clean, screen and rubber sealed containers to prevent contamination.

Preparation of Slurry

Naturally Decomposed Slaughterhouse Slurry (NDSS)

The collected slaughterhouse waste was placed in a drum (50 liters each) and allowed to decompose naturally for 15 days. The drum was filled with slaughterhouse slurry and left covered but unsealed to allow the release of gases and odor during decomposition. After the 15-day decomposition period, the slurry was collected and prepared for use in nutrient analysis.

Effective Microorganism - Treated Slaughterhouse Slurry (EMTSS)

Effective Microorganisms (EM) was added to the slaughterhouse waste at a rate of 200ml per 50L of slaughterhouse slurry to enhance fermentation through the activation and proliferation of beneficial microorganisms. The mixture was thoroughly stirred to ensure uniform distribution of the EM solution and then stored in unsealed drum for a 15-day fermentation period. After fermentation the slurry is prepared for laboratory nutrient analysis.

Anaerobic Processed Slaughterhouse Slurry

A 50L slaughterhouse slurry was placed in a drum and left sealed for 15 days then a sample collected slurry was delivered to a laboratory and analyzed.

Filtering of processed slurry

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For every treatment there is a corresponding fitration set-up. And after filtration the slurry collected were subjected to a analysis for nutrient and bacterial content compared to a processed and unprocessed slurry.

Nutrient Analysis

Representative samples from each slurry treatment were submitted to a soil and plant analysis laboratory for the determination of macro-element and bacterial content. Standard laboratory procedures were employed for nutrient analysis. The results obtained served as the basis for determining appropriate fertilizer application rates for the slurry treatments.

RESULTS AND DISCUSSION

Macro Nutrient Analysis of Slaughterhouse Slurry Before and After Proceeing

Macro-nutrient analysis of the slaughterhouse waste before undergoing fertilizer processing shows that phosphorus has the highest concentration, followed by potassium, and nitrogen, respectively. This shows that slaughterhouse waste possesses valuable macro-nutrients that could be utilized for the formulation of organic liquid fertilizer. This report is supported by the study of Kundu, et. al. [14] showing that's slaughterhouse residues contain significant levels of organic and inorganic nutrients.

Table 1. Macro-Nutrients Analysis of the Slaugtherhouse Waste Before Processing.

Treatments	N	P2O5	K2O
Unprocessed slaughter house waste	2.46 % wt	7.92 % wt	3.41 % wt

The table shows that unprocess slaughterhouse waste is highest in phosphorus with potassium contents but slightly lower in nitrogen content.

Table 2 shows the macronutrient analysis of the slaughterhouse waste after processing. Data shows an increase nitrogen content when subjected to fermentation and when treated with effective mircroorganisms. However the phosphorus and potassium values decreased. The changes in nutrient concentrations during the fermentation of slaughterhouse slurry particularly during fermentation and use of effective microorganism (EM) is due to the breakdown of organic matter. Phosphorous (P) and potassium (K) decrease as they are consumed by the increasing microbial population **[15]**.

Table 2. Macro-Nutrients analysis of the slaugther house waste after processing.

Treatments	(N)	P	K
T1 – unprocessed	2.46	7.92	3.41
T2 – anaerobic fermentation	7.65	< 0.3	0.22
T3 – effective micro-organism fermentation	10.56	< 0.3	0.15

Table 3 table shows the relative decrease on the phosphorus (< 0.3 %) and potassium (,0.18%) but an increase in the nitrogen (6.81%) content of Treatment 1 after filtration. Unlike treatment 2 and 3 that remains the nutrient content on phosphorus and a slight decrease on potassium content. Filtering shows no response to phosphorus content and potassium shows slight changes/levels but effective microorganism shows responsive effect to nitrogen content in terms of filtration compared to a raw and anaerobically processed waste.

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Table 3. Macro-Nutrients analysis of the slaugther house waste after filtering.

Treatments	N	P	K
T1 – unprocessed	6.81	< 0.3	< 0.18
T2 – anaerobic fermentation	6.64	< 0.3	< 0.15
T3 – effective micro-organism fermentation	10.81	< 0.3	< 0.16

The table shows equal level of total coliform and fecal coliform count (mpn/100 ml). Both decreases the amount of total and fecal coliform count indicating complete elimination of fecal patogens.

Table 4. Bacterial Count After Fermentation

Treatments	**Total Coliform Count (mpn/100ml)**	**Fecal Coliform Count (mpn/100ml)**
T2- Anaerobic Fermentation	4.6	< 1.1
T3- Effective micro-organism fermentation	4.6	< 1.1

After filtration, the table shows a significant reduction of total coliform count compared to bacterial content on total coliform count of > 8.0 to 2.6 (mpn/100ml) T1 and T2 likewise with T3 of 1.1 mpn/100ml. The fecal coliform to all the treatments has reach the below the detectable limit. The reduction in bacterial count specifically coliform, a pathogenic bacteria – following fermentation due to several environmental and biological stressors created during the processing. This can be due to organic acid production and pH shift causing acidogenesis and breaking down of organic matter into volatile fatty acids by fermenting bacteria [16] It is also possible that effective microorganisms competed with pathogenic microorganisms, thus causing the decline [17]

Table 5. Bacterial Count after Filtering

Treatments	Total Coliform count (mpn/100ml)	Fecal Coliform Count (mpn/100ml) after Filtration
T1 - unprocessed	2.6	< 1.1
T2 – Anaerobic fermentation	2.6	< 1.1
T3 – Effective micro-organism fermentation	1.1	< 1.1

Table 6 shows that the initial bacterial quality of raw slaughterhouse waste before treatment shows total coliform counts exceeding 8,0 MPN/100ml, indicating heavy bacterial contamination and conforming that raw waste is microbiologically unsafe. Fecal coliform levels are low but still posses a risks for agricultural use. Processing is necessary to reduce contamination. Filtering is a physical method of separation. This process significantly reduces coliform bacteria in slaughterhouse slurry by trapping organic solids and the microbes attached to them. Because coliforms often adhere to particulate matter and organic debris. Removing these solids effectively “strips” the bacterial load from the liquid phase [18].

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Table 6. Bacterial Count before processing.

Source	Total Coliform count (mpn/100ml)	Fecal Coliform Count (mpn/100ml)
Tank 1- Unprocessed	> 8.0	1.1
Tank 2 – Unprocessed	> 8.0	< 1.1
Tank 5 - Unprocessed	> 8.0	1.1

Table 7 shows the laboratory analysis after filtration. Result showed a decrease on the phosphorus (< 0.3 %) and potassium (<0.18%) but an increase in the nitrogen (6.81%) content of P1. Unlike P2 and P3 that remains the nutrient content on phosphorus and a slight decrease on potassium content. Filtering shows no response to phosphorus content and potassium shows slight changes/levels but effective microorganism significantly boosts nitrogen content in terms of filtration compared to a raw and anaerobically processed waste.

Table 7. Macro-Nutrients analysis of the slaughter house waste after filtering.

Process	N	P	K
T1 - unprocessed	**6.81**	**< 0.3**	**< 0.18**
T2 – anaerobic fermentation	**6.64**	**< 0.3**	**< 0.15**
T3 – effective micro-organism fermentation	**10.81**	**< 0.3**	**< 0.16**

The results suggest that both anaerobic and EM-assisted fermentation are equally effective in controlling these specific bacterial markers. While some total coliforms remain (4.6mpn/100ml), the fecal coliform level is below the detectable limit of (<1.1 mpn/100ml), which is generally a positive indicator for the safety or success of the fermentation process. A hierarchy of nutrient behavior during the filtration and fermentation may occur. While physical filtration is excellent for hygiene, it is chemically bling to phosphorus whereas biological action of effective microorganism (EM) actively transforms the nitrogen profile [19]. Filtering shows no response to Phosphorus because some may not be in solid but rather dissolved in the liquid slurry. Thus they can still pass through the filtering material [16] But there is a claim that potassium may be affected because it does not readily bind to organic particles as nitrogen does, it remains in the watery fraction of the slurry. [20]

Effective microorganism can increase amount of nitrogen via filtration because Ems allow the nitrogen to be dissolved or "digested' in the liquid slurry. [21]

CONCLUSION AND RECOMMENDATION

Conclusion

The study concludes that slaughterhouse waste is a highly viable and possible source of substrate for the production of organic liquid fertilizer.

The four-stage processing showed that the EM-assisted Fermentation (T3) is the most effective technology for nutrient recovery, to achieve the optimum nitrogen concentration of 10.81mpn/100ml.

Moreover, enhancement can further be done through the inoculation of Effective Microorganisms (EM) accelerating the mineralization of animal proteins into a concentrated liquid nitrogen source.

Furthermore, the 15-day fermentation period, combined with a five-layer gravity filtration system can reduced the initially hazardous pathogen load (total coliform >8.0mpn/ml) to a stabilized and safe level (1.1MPN/100ml) while completely eliminating fecal coliform.

CONCLUSION

Based on the results of this study, slaughter house waste is recommended as liquid fertilizer source but the adoption, safety, and future development of liquid fertilizer production from slaughterhouse waste can adopt the following:

1. The municipal slaughterhouses and Local Government units can adopt the T3 (EM-Assisted Fermentation) as a standard waste management practice to slaughterhouse slurry.
2. Further research is encouraged to bridge the gap between laboratory results and field application frequencies for specific high-value crops.
3. Future studies should investigate the long-term nutrient stability and microbial shelf-life of the filtered liquid fertilizer.

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