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SUSTAINABLE POULTRY WASTE MANAGEMENT SYSTEM TO ORGANIC COMPOST

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ABSTRACT

Composting is currently the best strategy to dispose wastes and turn them into something more stable as well as richer with nutrients. It can be combined with food waste, green waste, and animal waste, where composting process will start the biological decomposition of the substances under aerobic or anaerobic conditions. High demand and interest in the poultry sector have increased the poultry waste and sludge. Those nutrient-rich wastes have a high potential to be innovated into something useful. Four completely randomized design treatments which are T1 (20% Chicken Dung + 60% Banana Trunk + 20% Egg shell), T2 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Bone), T3 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Feather) and T4 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Blood) were laid in an experiment where the parameters including nutrient analysis which were P, K, Ca, and Mg. Other parameters are temperature, pH value, electrical conductivity, and organic matter content. The result exhibited that combining the chicken dung, banana trunk and chicken feathers can have the most significant ($p<0.05$) effects towards the most important nutrients compared to other combination of materials treatments. (196 words)

Keywords: *Compost, Chicken wastes, Chicken feathers, Waste management, Organic matter*

INTRODUCTION

A large amount of nutrient-rich and energy-rich abattoir sludge dumping has been a problem in the poultry industry, including slaughterhouses and factories. This issue requires proper waste management (Abdeshahian et al., 2016). This is because the waste may have bad implications towards the environment. It is agreeable that going green which is taking care of our environment can improve human health as both are closely linked (Bashirun, 2016). Hussain et al. (2020) found that the population of microorganisms in soil and the enzyme activity in the soil can enhance when added to organic materials. Therefore, all the manure, bone, blood, and feather wastes can be composted and used as soil supplements. This will finally prevent any environmental issues and return nutrients to the ecosystem.

Nitrogen (N), phosphorus (P) and potassium (K) are part of the basic elements necessary for the growth and development of plants and their crops. Nitrogen is an important component of protein and chlorophyll and can be found in large parts of the plant structure (Leghari et al., 2016), where it helps plants to produce better quality crops. Phosphorus, on the other hand, plays a vital role as micronutrients required by the plants for superior harvests. It regulates the production of and generative development of the crops. Potassium is known as the "quality" nutrient since it improves the overall health of growing plants and helps them defend against disease. Chicken manure can provide plant nutrients and act as an outstanding fertilizer. Soil alteration will be done to deliver the nutrients for the plants. Chicken blood also can be a bio-activator in the making of compost due to its high N content. According to Xiao Yang et al., (2019), aerobic composting method can retain the most N content between other composting method. The nutrients in composted manure also provide more stable soil amendment than fresh manure.

A study by Joardar & Rahman(2018) also revealed that chicken feathers can increase the green colour of the crops. Also produce adequate tryptophan than can serve as main source of IAA synthesis which is a significant regulator of plant production (Nagarajan et al., 2018). Keratin and amino acids in poultry feathers can be transformed into delicate nitrogen-rich organic fertilizer. Chicken bones, however have a high collagen content (Plazzotta & Manzoco, 2019). Bone residues contain large amounts of nitrogen and organic matter, also can help in lessen the soil toxicity by reduce the release of heavy metal and increase the pH of soil and leachates (Garbowski et al., 2022).

Research by Saldanha et al. (2021) shows that eggshell area is suitable for soil stabilization as it has better morphological and mineralogical characteristics than traditional lime. Soares et al., (2015) shows that composted eggshell has efficient properties of soil acid improvement and immobilization of metals as it is a source of nitrogen and supplements for crops. Lastly, banana is a type of plant that only has a a single cycle of fruiting. The banana farm had faced an incredible banana trunk waste amount which is million tons per year. Without proper waste management, those bananas can also contribute to an environmental and economic problems (Elnour & Abdelgadir, 2015). Those rich in protein and mineral source waste can improve soil formation, air circulation, water retention, permeability, enhance pressure tolerance and diminish the use of inorganic fertilizers thus suitable for composting materials (Elnour & Abdelgadir, 2015).

METHODS

Composting Procedure

Banana trunk, eggshell, and chicken sludges are used as the composting raw materials. The chicken manures were collected from the animal farm in Plantation Unit in UiTM Arau Perlis. Other chicken sludges, which are the blood and feathers, were collected from Advance Chicken Processing, poultry slaughterhouse in Jejawi, Perlis. Meanwhile, chicken bones and eggshells were collected from five different stalls. Finally, banana trunks were collected from a banana planting area in Perlis. The entire composting process was carried out at Vermicompost House, Plantation Unit in Universiti Teknologi MARA, Perlis with coordinate 6°26'54.5"N 100°16'49.0"E.

Chicken blood and banana trunks have been prepared before the experiments start. Using a machete, banana trunks were sliced into tiny pieces with particle sizes ranging from 1-2 cm to fasten the decomposition process. While chicken blood was initially measured into several 700ml container to make the process easier. Chicken dung was sieved for debris like small stones and plastics, and then the chicken dung was crushed into smaller pieces. Chicken bone and chicken feather next were cleaned using tap water and sun dried for about 2 days.

The materials were mixed into four ratios according to Charity Pisa & Wuta's (2013) composting methods. All of the items were placed in a few 7L composting containers, which had holes put in them. This is to ensure that the aerobic process results in successful breakdown. 1 litre of water was added to each composting bin during the preparation procedure to assist soften the mixes and produce a healthy dwelling habitat for the bacteria. Few alternate layers of compost piles were done to allow air access to the bottom of the pile where banana trunk was placed at the bottom to allow aeration to the bottom of the pile. The second layer laid the chicken dung. Other poultry wastes, such as chicken bone, chicken feathers and chicken blood were on the third layer.

T1 (60% banana trunk, 20% chicken dung and 20% eggshell), T2 (60% banana trunk, 20% chicken dung and 20% chicken bone), T3 (60% banana trunk, 20% chicken dung and 20% chicken feathers) and T4(60% banana trunk, 20% chicken dung and 20% chicken blood). Excessive evaporation of the compost avoided by covering the bins with sacks and black netting with 50% shading right after all the materials have been filled. After a week, first turning over been made and continued turning every twice a week with 200ml of water were added to moisten the pile. The composting process took 84 days to complete.

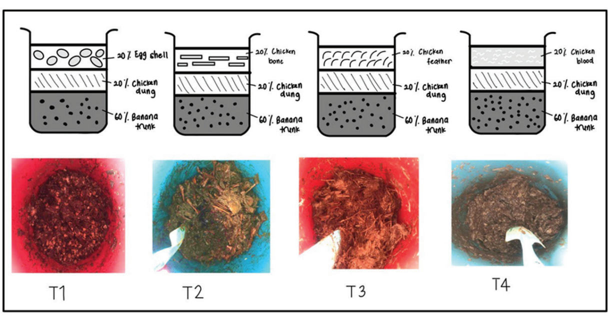


Figure 1. Initial Layer of Different Poultry Wastes Mixtures

(Source: Author)

Determination of Compost Physico-chemical Properties

The period of the composting process had been recorded for a period of eighty-four days. All the physico-chemical properties data has been measured a week after the preparation process immediately. During the observation, temperature of the composts was measured every three times a week as the temperature of the compost is very well correlated with the growth and decline of microbial growth (Tiqui & Tam, 2002).

Determination of Nutrient Content

After composting process has completed, the nutrient content of the compost was measured. Phosphorus presence was determined by using the phosphomolybdate blue method. Then, Perkin Elmer Optima 8000 ICP OES is used to analyse K, Ca and Mg which are the exchangeable bases (Singh et al., 2018). Organic matter content also was determined by observing the loss on ignition method (Matthiessen et al., 2005). The percent Organic Matter in compost was calculated as:

Exchangeable Bases (K., Mg, & Ca)

Firstly, the sample of compost pile had been sun-dried for two days (Singh et al., 2018). After the compost dried, 5g of the sample was weighed in 50ml falcon tube and added 30ml of 1 M NH4OAc. The mixture was shaken using orbital shaker for 30 minutes at 180rpm. Then, the solution was centrifuged for 3 minutes at 1000rpm to separate various elements of a liquid. Leachate of the sample was collected by using Whatman no 2 to filter them and used plastic vials to store the leachate. Lasty, the leachate had been diluted with double dilution method using deionized water before running in the Perkin Elmer Optima 8000 ICP OES in order to get the reading of K, Mg, and Ca.

Organic Matter Content by Loss on Ignition Method

Samples that had been extracted from the compost pile were sun-dried before ashing (Matthiessen et al., 2005). Each crucible was weighed first before placed compost samples in it. The reading was recorded; however, the crucibles must be cleaned before use. Five grams of sieved compost pile was added in each crucible and weighed again. Then, the crucibles were dried in the oven at 60oC for 24 hours with closing lid. The crucibles and samples had been weighed again after being dried overnight. After record the samples, the crucibles were placed in a muffle furnace for 8hours with ash at 550oC. Each of the crucibles was closed with the lid to avoid the sample disposed directly to the high temperature. Moreover, the samples were then cooled in a desiccator after removal from muffle furnace, then the samples were weighed, and readings were recorded.

Available Phosphorus

Firstly, an extractant was produced by the addition of 15 ml of 1 M NH4F solution and 4.3 ml of 0.5 M HCl solution into the measuring cylinder. The solution has been homogenized. Then, 1g of H3BO3 was diluted in 100 ml of distilled water to make 1% of boric acid solution. Then, 250 ml of mixed reagent was prepared with the combination of 50 ml of 2.5 MH2SO4, 15 ml of 4% (NH4)6Mo7O24.4H2O,30 ml of 1.75% ascorbic acid, 5 ml of 0.2755 potassium antimony-(lll) oxide tartrate and 200 ml of distilled water. After the solution was mixed well, 500 ml bottle was used to keep the mixed reagent, and it was freshly prepared before running in the spectrophotometer. Furthermore, standard series of P was prepared by the dilution of 4g of potassium dihydrogen phosphate as the base, and it was made up to 1 L in the volumetric flask. After finished diluting the stock solution, 10 ml of the stock was pipette into 100 ml of volumetric flask, thus 100 mg L-1 of new solution was formed. Next, took 30 ml from the 100 mg L-1 solution into 250 ml volumetric flask and volume with distilled water to form 12 mg L-1 of solution. The standard series were prepared according to 0, 1.2, 2.4, 3.6, 4.8 and 6.0 mg L-1.

Next, 2 g of sample was weighed into the 50 ml centrifuge tube and 14 ml of the extractant was added. The combination of sample and extractant was shake well for 60 second and Whatman 42 filter papers were used to filter the solution. However, if the filtrate solution was cloudy and thick, it must be filtered once again, and the process of filtration generally not go over 10 minutes. Then, 1 ml of each of the standard series, 2 ml of boric acid, and 3 ml of mixed reagent were mixed into test tube and leave for minimally 60 minutes to achieve blue colour. Later, each standard series and the filtrate solution of the compost samples was measured using Genesys 20 spectrophotometer at 720nm. The readings were recorded.

STATISTICAL ANALYSIS

Statistical Analysis Software (SAS) was used to conduct the statistical analysis where the data were analysed as Complete Randomized Design (CRD). One-way Analysis of Variance (ANOVA) used to determine the statistically significant of each treatment and the means had been separated using Least Significant Differences (LSD) ($p \leq 0.05$).

RESULTS AND DISCUSSION

Compost Temperature

The temperature of the compost is influenced by the microbial activity inside the composting substances. Table 1 shows no significant difference in weeks 3,6, and 12 ($p > 0.05$). Whereas week 9 shows significant differences ($p \leq 0.05$). The temperature shows decreasing trend from week 3 to week 12. At week 9, the maximum reading was discovered to be significantly higher in T2 (27.4°C), T3 (27.2°C) and T4 (27.2°C) as compared to T1 (27.0°C) ($p < 0.05$).

Table 1. Compost Temperature as Affected by Different Poultry Wastes

Treatment	Temperature (°C)			
	Week 3	Week 6	Week 9	Week 12
T1 (20% Chicken Dung + 60% Banana Trunk + 20% Egg Shell)	29.5a	28.4a	27.0b	25.8a
T2 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Bone)	30.0a	28.3a	27.4a	26.0a
T3 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Feathers)	29.6a	28.4a	27.2ab	26.0a
T4 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Blood)	29.8a	28.8a	27.2ab	25.9a

ns = not significant, * = significant

*Mean value within a column followed by the same letter is not significantly different at ($p \leq 0.05$) according to LSD.

(Source: Author)

Throughout the early period of the composting, the temperature of the compost was in the mesophilic stage where it remained in 35°C and this is the stage where the bacteria were very active in degrading the compost materials (Gilbert et al., 2020). When the organic matter has been degraded, the activities of the microorganism and enzymatic will decrease too (Khalil et al., 2013), and this is what happen during week three until week 12.

Khalil and team (2013) reported that to eliminate the pathogens in the compost, the compost must be at 55°C and retained for three days, while to execute certain fungal spored 65°C is appropriate. As observed, the temperature rose gradually among the treatments from the first day until week 3, then the temperature decreases slowly to ambient temperature from week 3 to week 12. The declining temperature of the compost can be influenced by the surrounding ambient temperature. It also may be caused by the small particles of the compost pile (Khalil et al., 2013). Aeration can also be the reason of compost temperature reduction as the pile has turn down in every composting process. Qasim et al., (2018) agreed and stated that the aeration had resulted in a cooling impact that would disrupt the decomposition.

pH Value in Compost

Table 2 shows the mean values of pH in different composting materials. It was found that all week 3 until week 12 shows significant differences ($p \leq 0.05$). All treatments develop from slightly acidic to closely alkaline over time. However, T4 can be seen has been on the top precisely.

Table 2. Compost Ph Value as Affected by Different Poultry Wastes

Treatment	Week 3	Week 6	Week 9	Week 12
T1 (20% Chicken Dung + 60% Banana Trunk + 20% Egg Shell)	6.96a	7.54a	7.37b	7.54b
T2 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Bone)	6.83ab	7.25c	7.54a	7.54b
T3 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Feathers)	6.75b	7.29bc	7.46ab	7.46b
T4 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Blood)	7.00a	7.50ab	7.54a	7.71a

Note: * = significant

*Mean value within column followed by same letter are not significantly different at ($p \leq 0.05$) according to LSD.

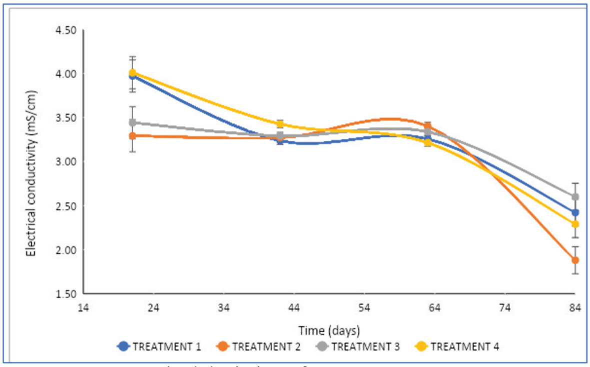
Source: Author

All the results also were the closest to C. Pisa & Wuta, (2018), where the study of composting the chicken blood and maize stover showed 6.03

to 7.74. Ameen et al., (2016) suggested pH value of 6.9 to 8.3 as suitable for crop application as the pH has been in the stage of neutral to alkaline. Low-pH composts are not fully cured and can contain high concentrations of organic acids. Organic acids are toxic to crops, therefore, lower than suggested pH composts are unacceptable (Crohn, 2016).

Electrical Conductivity (EC) in Compost

The graph shows the compost EC value as affected by different poultry wastes throughout eighty-four days of the experimental period. It shows that no significant difference ($p>0.05$) between treatments in week 6 to 9. However, there are significant different ($p\leq0.05$) on week 3 and 12. The pH and electrical conductivity (EC) were measured as indicators of soluble salt content because if the compost had been used to cultivate crops, higher salt amounts can be dangerous to germinate of seeds and plants, whereas can induce toxicity (Aslam et al., 2008; Qasim et al., 2018).



Note: Vertical bars represent ± standard deviation of mean
Legend:T1 (20% Chicken Dung + 60% Banana Trunk + 20% Egg Shell)
T2 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Bone)
T3 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Feathers)
T4 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Blood)
(Source: Author)

Figure 2. Graph of Compost EC Value as Affected by Different Poultry Wastes

Source: Author

The EC rose in the early composting stage until week three, and this is closely to previous study by Qasim et al. (2018) where the EC resulted in the range of 3.8 to 4.8 (mS/cm). The rise of EC occurs due to the phosphates and ammonium ions through the disintegrated of composting substances (Gómez-Brandón et al., 2008; Qasim et al., 2018). The EC value declines gently to week 6 but increases again during week 9, followed by a gradual reduction until the end of the composting period. This study produces a result that accordance with Yadav et al. (2012) and Gao et al., (2010), which flagged up the potential decline in EC value through the composting and vermicomposting.

It can be observed that T4 was in the top of week three and week six compared to other mixtures of compost. Thus, this outcome is comparable with Pisa & Wuta (2013). The treatments with more chicken blood has greater intensities of total basic cations. Some studies also highlighted that EC value which less than 4 dS/m would not induce any phototoxicity and safe to be applied to plants (Hwang et a., 2020)

Organic Matter Content in Compost

Based on the Table 3 shows the result of organic matter observed for eighty-four days. T3 and T4 (81.48 and 80.58) shows the maximum reading and followed by T2 (65.75) and T1(20.73).

Table 3. Compost Organic Matter Content as Affected by Different Poultry Wastes

Treatment	Organic matter content in compost (%)
T1 (20% Chicken Dung + 60% Banana Trunk + 20% Egg Shell)	20.73c
T2 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Bone)	65.75b
T3 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Feathers)	81.48a
T4 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Blood)	80.58a

Note: * = significant

*Mean value within the column followed by same letter are not significantly different at ($p \leq 0.05$) according to LSD.

(Source: Author)

T3 with the combination of 20% chicken dung, 60% banana trunk and 20% chicken feathers, show the highest organic matter. This correlates with a study that poultry feather has a very high organic matter content. Thus, this can be analysed that composted poultry feathers could be one of the better solutions for reclaiming the soil organic matter (Joardar & Rahman, 2018). A finding by Joardar & Rahman (2018) found that increasing the rate of composted poultry feathers applied to Gima kalmi crops significantly enhanced the number of foliage, dry mass, and height of the crop.

With the result of this study, application of compost was not only benefiting the crop but also the soil as the quality and fertility of the soil enhanced by the organic matter from the compost (Adugna, 2018). Though, if the compost has organic matter content higher than 85%, indicate that the compost had not been adequately degraded (Sullivan et al., 2018) and cannot be applied on the ground as also stated by Sullivan et al., (2018), the compost should be easily absorbed by the field because contain a volume of unstable organic matter.

Nutrient Content in Compost

Phosphorus (P) and Potassium (K) Status in Compost

The available phosphorus and potassium content in the compost have been observed and the results recorded in Table 4. Both T3 and T4 showed the maximum reading of phosphorus which were 49.86 and 46.35 ppm. This followed by T2 (17.58 ppm) and T1 (5.57 ppm). Then, potassium status showed the significantly highest in T2 of 17.24 cmol(+)kg-1 as compared to T4, T3 and T1 (11.96, 11.80 and 7.17 cmol(+)kg-1 respectively).

Table 4. Compost Phosphorus (P) and Potassium (K) Content as Affected by Different Poultry Wastes

Treatment	Phosphorus (P) (ppm)	Potassium (K) (cmol(+) kg-1)
T1 (20% Chicken Dung + 60% Banana Trunk + 20% Egg Shell)	5.57c	7.17c
T2 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Bone)	17.58b	17.24a
T3 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Feathers)	49.86a	11.80b
T4 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Blood)	46.35a	11.96b

Note: * = significant

*Mean value within column followed by same letter is not significantly different at ($p \leq 0.05$) according to LSD.

(Source: Author)

Treatment 3 of 49.86 ppm which a combination of the banana trunk, chicken dung and chicken feathers could be supported by the earlier study where composted chicken feathers contain greater phosphorus content which was 0.63% (Vidyasagar et al., 2013). The addition of banana trunk in the compost also increases the phosphorus content as stated by Elnour & Abdelgadir, (2015) where the phosphorus content in banana compost (0.93%) which was higher than the leaves, pseudo, stem, rhizome, and peels which are 0.4%, 0.4%, 0.5% and 0.6% respectively.

T2 of 17.24cmol (+) kg-1 shows highest result since it was the treatment with a combination of banana trunk, chicken dung and chicken bone as chicken bone have comparatively high amounts of K which was 8-10% as an organic amendment (Velenzuela et al., 2000). A study by Aminuddin & Aman, (2009) revealed that composted banana trunk has naturally produced high amount of phosphorus and nitrogen content needed for crops.

Calcium (Ca) and Magnesium (Mg) Status in Compost

The calcium and magnesium availability of the compost has been noted for each treatment (Table 5). The result for calcium availability in compost was found significantly highest in T3 of 2.88 cmol(+) kg-1 as compared to T1, T4 and T2 (2.01, 1.89 and 0.32 cmol(+)kg-1 respectively). Meanwhile, the result for magnesium availability was discovered to be significantly higher in T3 (0.39) and T1 (0.28) as compared to T2 of 0.10 cmol(+) kg-1.

Table 5. Compost Calcium (Ca) And Magnesium (Mg) Content as Affected by Different Poultry Wastes

Treatment	Calcium (Ca) (cmol(+)kg-1)	Magnesium (Mg) (cmol(+)kg-1)
T1 (20% Chicken Dung + 60% Banana Trunk + 20% Egg Shell)	2.01b	0.28ab
T2 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Bone)	0.32c	0.10c
T3 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Feathers)	2.88a	0.39a
T4 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Blood)	1.89b	0.14bc

Note: * = significant

*Mean value within column followed by same letter is not significantly different at ($p \leq 0.05$) according to LSD.

(Source: Author)

The highest calcium content was the combination of chicken dung, chicken feathers and banana trunk and this supporting the finding by Joardar & Rahman, (2018), where application of composted chicken feathers to the crop has induced green colour and improved the green colour of the foliar. It also has been described that chicken manure commonly represents the largest amounts of 17-67 kg compared to other manure such as cattle, sheep and horse which was 5-18 kg, 8-19 kg, and 7-29 kg, respectively (Mahimairaja, 1993).

A study by Singh et al., (2018) exposed that magnesium content in composted chicken dung is just higher than fresh chicken dung, also stated that cations are important substances that will influence the growth of crops. Finally, the highest value of Mg was in combination of the banana trunk, chicken dung and chicken feathers, and it was parallel to the previous finding by Vidyasagar et al., (2013) as the final composted chicken feathers had shown varying proportions of macro and micronutrient for instance Ca (0.42%) and Mg (0.07%).

CONCLUSION AND RECOMMENDATION

Waste management is a serious issue confronting contemporary civilization, and composting is the most effective approach to treat agricultural and animal waste for agricultural use. Poor disposal method of waste can cause hazard to human and environment such as water pollution when the wastes are thrown in water resources. Air pollution also occur when the wastes were burnt and this expose the environment to climate change as the ozone layer is slowly replenished (Ayilara et al., 2020). Observing the temperature rise in Malaysia, the manufacturing is found to always be the one that is responsible, as stated by JS Keshminder, (2018). Therefore, composting is the best way rather than manufacturing those chemical fertilizers.

After the crops were harvested, soil nutrient amounts will reduce. Thus, applying compost can supply nutrient to the crops and soil because it can enhance the agriculture productivity and organic matter content in the soil. Using compost as fertilizer has many more benefits such as it can eradicate harmful inorganic fertilizer on human health and ecosystem, and it is way less costly to produce as the main ingredients are from wastes.

Based on this research, it can be determined that T3 (20% Chicken Dung + 60% Banana Trunk + 20% Chicken Feathers) had continuous and quick decomposition among other things. Furthermore, T3 caused a consistent rise in pH from week 3 to week 12, whereas electrical conductivity was mild when compared to other treatments. The organic matter level in T3 was then higher than in others since the inclusion of compost organic matter can improve the soil's ability to retain water and nutrients while also improving soil aeration. Finally, nutrient allocation was balanced to crop absorption, and it can be shown that T3 had a larger nutritional content of P, K, Ca, and Mg. Further research should be conducted on nitrogen analysis, other micronutrients (other than Ca and Mg), and the efficacy of compost on crops.

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AUTHOR CONTRIBUTIONS

All authors contributed to the design of the research and the write-up. All authors have read and approved the final manuscript.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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