MJSAT

Malaysian Journal of Science and Advanced Technology

journal homepage: https://mjsat.com.my/

Physicochemical and Enzymatic Activity During Vermicomposting of Chicken Feather Waste

Nur Hana Rosmin[1], Nur Faezah Omar*[1], Nazalyyussma Yusop[1], Mohd Saiful Akbar Mohd Sahal[1], Noor Zuhairah Samsuddin[1], and Najihah Farhan Sabri[1]

[1]*Faculty of Plantation and Agrotechnology, Universiti Teknologi MARA, Perlis Branch, Arau Campus, 02600 Arau, Perlis, Malaysia.*

KEYWORDS

Chicken feather waste
Vermicompost
Physico-chemical properties
Microbial enzyme activities
Sustainable agriculture

ARTICLE HISTORY

Received 22 November 2025
Available online 21 August 2026

ABSTRACT

The poultry industry produces a large quantities of chicken feather waste, which can cause serious environmental problems due to its high keratin content. If this chicken feather waste is not managed properly, it will lead to environmental pollution and excessive accumulation in landfills. This study investigated vermicomposting as a sustainable approach to convert chicken feather waste into organic compost. The study also aims to examine the changes in the physicochemical properties and microbial enzymes that change during the process. The experiment used a Completely Randomized Design (CRD) with eight treatments (T1-T8) and three replications. The treatments were as follows: T1, chicken feather vermicompost (bacteria only); T2, chicken feather vermicompost (earthworm only); T3, chicken feather vermicompost; and T4, compost. Treatments T5–T8 used the same substrates as T1–T4 but at different ratios and without chicken dung. Samples were collected on Days 15, 30, 45, and 60. In the lab, physicochemical properties such as pH, electrical conductivity (EC), nitrogen (N), phosphorus (P), potassium (K), organic matter, and compost texture were measured. Enzyme activities including dehydrogenase, urease, invertase, keratinase, and oxidase were analysed using spectrophotometric methods to evaluate microbial roles in decomposition. The findings showed that Treatment T3, which combined earthworms and chicken manure, gave the best results by Day 60, where nitrogen was 1.35%, phosphorus 0.35%, and potassium 0.79%. Enzyme activity peaked around Days 30 to 45, with keratinase and oxidase playing key roles in breaking down the tough feather material. These results highlight the contribution of microbial enzymes to accelerated waste decomposition and nutrient release, which are indicative of compost maturity and successful laboratory analysis. Overall, the study shows that vermicomposting is an effective, low-cost, and eco-friendly solution for managing chicken feather waste while producing nutrient-rich compost that supports sustainable agriculture.

1. INTRODUCTION

Chicken feathers are a major by-product of the poultry industry, with global production exceeding billions of tons annually [1]. They consist of over 90% keratin, a highly resistant protein, making natural degradation extremely slow. Improper disposal methods, such as burning or landfilling, contribute to environmental pollution, greenhouse gas emissions, and waste accumulation [2]. Vermicomposting is an effective approach where earthworms and microbes synergistically convert organic waste into nutrient-rich compost. This process enhances soil fertility, improves organic matter content, and reduces environmental impacts. Despite the potential of vermicomposting, research on its application to chicken feathers remains limited, as keratin is highly resistant to degradation and requires specialized microbial enzymes, particularly keratinase.Despite the potential of vermicomposting, research on its application to chicken feathers remains limited, as keratin is highly resistant to degradation and requires specialized microbial enzymes, particularly keratinase.

*Corresponding author:
E-mail address: Nur Faezah Omar < nurfaezah@uitm.edu.my >
https://doi.org/10.56532/mjsat.v6iS1.783
2785-8901/

The objective of this study was to examine physicochemical changes and microbial enzyme activities during chicken feather vermicomposting. By analyzing pH, EC, compost texture, nutrient levels (NPK), organic matter, C:N ratio, and enzyme activities, the research aims to determine factors that contribute to more efficient degradation of feather waste.

2. LITERATURE REVIEW

Vermicomposting was described as a bio-oxidative process similar to conventional composting that aimed to stabilize organic matter through biological degradation. However, unlike traditional composting, vermicomposting involved the synergistic interaction between earthworms and bacteria, which enhanced the efficiency of organic waste decomposition. The earthworms stimulate microbial growth by decomposing fresh organic matter while bacteria decomposed organic matter chemically and physiologically with the use of enzymes on the decaying substances [3]. Recent reviews noted that this earthworm and bacteria interaction significantly accelerated organic matter mineralization and improved compost stability and nutrient quality in organic waste management systems [4]. Among various earthworm species, *Eudrilus eugeniae,* commonly known as the African night crawler was widely used due to its high consumption rate, rapid growth, and strong adaptability to organic wastes. Compared to traditional composting, vermicomposting lacks a thermophilic stage but produced a more homogenous product with higher microbial activity and improved biological stability [5].

In the vermicomposting of chicken feather, monitoring physico-chemical parameters was essential to ensure effective decomposition and compost stabilization. The parameters included pH, electrical conductivity (EC), compost texture, organic matter, carbon-to-nitrogen (C: N) ratio, and nutrient levels such as nitrogen (N), phosphorus (P), and potassium (K) were commonly assessed, as they influenced microbial metabolism and decomposition efficiency for recalcitrant materials [2]. Monitoring these parameters was essential, as they directly influenced microbial activity, enzyme performance, and the overall decomposition rate of the chicken feathers.

Bacteria and earthworms were the major agents responsible for the decomposition process in vermicomposting. A previous study emphasized that enzyme activity in vermicomposting is influenced by environmental conditions and is crucial for waste degradation and compost stability [6]. These enzymes included dehydrogenase, urease, invertase, keratinase, and oxidase. These enzymes performed their functions by breaking covalent bonds through hydrolysis, transferring hydrogen ions, and altering the conformation of substrate molecules to construct shorter chains or convert them into inorganic forms. Additionally, enzyme activities were widely recognized as reliable indicators of vermicompost maturity and overall process efficiency, emphasizing their importance in evaluating vermicomposting performance and stability during organic waste transformation [7].

3. METHODOLOGY

Vermicompost samples were collected on Day 15, 30, 45, and 60 to examine their physicochemical properties and enzyme activity. To avoid contamination, sterilized shovels or spoons were used during the sampling process. Each sample was placed into a clean, properly labelled container. Samples were collected at a 1:10 ratio, meaning that approximately 10% of the total compost from each treatment was taken as a representative sample for both analyses. After collection, the samples were sealed in plastic bags or glass containers to prevent moisture loss and external contamination. They were then stored in a cooler at 4°C to preserve their quality and prevent any biological changes before analysis.

The experiment was conducted using a Completely Randomized Design (CRD) with eight treatments and three replications. Based on Table 1, treatments involved combinations of chicken feathers, chicken manure, mushroom residue, and banana trunks, with variations in earthworm and microbial inoculation [8].

Table 1. Treatment composition and substrate ratio

Treatment	Composition	Ratio
T1	MMR + BT + CD + CF (bacteria only)	6:1:1.5:1.5
T2	MMR + BT + CD + CF (earthworm only)	6:1:1.5:1.5
T3	MMR + BT + CD + CF	6:1:1.5:1.5
T4	Compost (MMR + BT + CD + CF)	6:1:1.5:1.5
T5	MMR + BT + CF (bacteria only)	6:1:0:3
T6	MMR + BT + CF (earthworm only)	6:1:0:3
T7	MMR + BT + CF	6:1:0:3
T8	Compost (MMR + BT + CF)	6:1:0:3

*Note: MMR = mushroom media residue, BT = banana trunk, CD = chicken dung, CF = chicken feather

Physicochemical properties of the samples were systematically evaluated, with compost pH measured using the KCl method and electrical conductivity determined by a 1:5 soil-to-water ratio. Organic matter content and the carbon-to-nitrogen C: N ratio were assessed through loss-on-ignition, while soil texture was characterized via the settling test. Nutrient concentrations, including nitrogen, phosphorus, and potassium, were quantified using a CHNS analyser and ICP-OES. Enzyme activities were examined using a spectrophotometer, encompassing dehydrogenase through TTC reduction, urease through urea hydrolysis, invertase via sucrose hydrolysis, keratinase using the keratin azure assay, and oxidase through the L-DOPA method. All data were subjected to two-way ANOVA in SPSS version 27, with significant differences among treatments determined by Tukey's HSD test at $p < 0.05$.

4. RESULT AND DISCUSSION

4.1 Organic matter

The most significant decreases occurred in treatment T2, where OM content dropped sharply from 76.01% on day 15 to 68.30% by Day 45 as shown in Figure 1. This reduction indicates rapid microbial decomposition of fresh organic material, likely due to active breakdown of simple carbon sources such as proteins and carbohydrates using the thermophilic phase. The drastic drop in organic matter content reflects high microbial and enzymatic activity, as the treatment contained easily degradable materials such as chicken manure and fresh organic residues that were rapidly decomposed during the active composting phase. In treatment T3, which initially showed a lower OM content at Day 15 compared to T1 and T2, remained relatively stable throughout the composting period, with a value of 72.39% at day 60. This indicates that OM degradation occurred at an earlier stage, followed by stabilization through enhanced microbial and earthworm activity and humification. The slight increase in OM observed at Day 60 across treatments T1–T8 was attributed to the stabilization phase of vermicomposting. The accumulation of recalcitrant and humified organic fractions led to a relative increase in measured OM content [9].

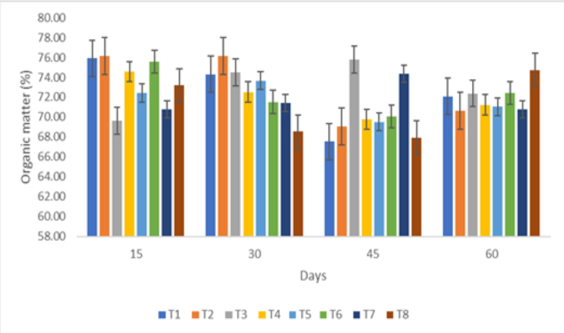

Fig. 1. Organic matter changes on days 15,30,45 and 60

4.2 *C:N ratio*

The C:N ratio declined steadily throughout the composting process in Figure 2. Among the treatments, T1, T5, and T6 showed the most notable decrease in C:N ratio, dropping steadily from the initial values on Day 15 to below 15 by Day 60, ultimately ranging between 13.3 and 14.0. This substantial reduction reflects efficient degradation of organic matter due to the presence of easily degradable substrates and high microbial and earthworm activity. The low C:N ratio at day 60 confirms that compost maturity and stability were achieved in these treatments. This outcome is consistent with [10], who reported that vermicompost accelerates the stabilization of organic matter and humus formation.

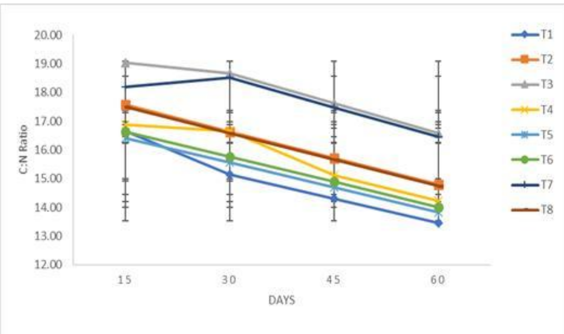

Fig. 2. C:N ratio cahnges on days 15,30,45, and 60

4.3 *Electrical conductivity (EC)*

EC values initially increased due to soluble salt release, peaking around Day 45, then declined by Day 60 as shown in Figure 3. The most significant increase occurred in treatment T6, where EC values increase to approximately 2.6 to 2.7 mS/m by day 45. This sharp increase indicates active mineralization of organic matter, resulting in the release of soluble ions such as nitrate, potassium, and calcium, which directly increased the EC. By day 60, a sharp decrease in EC was recorded in T5 and T7, where values dropped below 1 mS/m. This decline indicates a reduction in soluble salts, likely due to the completion of active decomposition and stabilization of the compost, which reduces the release of free ions. Treatments like T6 showed an early flush of nutrient availability, while T5 and T7 demonstrated faster stabilization and nutrient decline, consistent with typical vermicomposting patterns as stated by [11].

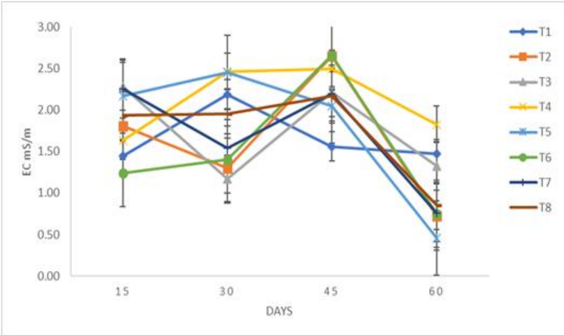

Fig. 3. Electrical conductivity changes on days 15,30,45, and 60

4.4 *Compost texture*

Texture improved gradually from coarse to finer aggregates, reflecting humification. The most drastic change in compost texture occurred in Treatment T1, which showed a distinct increasing trend throughout the 60-day composting period. From Day 15 to Day 30, the texture value increased from approximately 34% to 35.5%, reflecting active microbial decomposition of organic matter during the early composting stage. By Day 45, the texture dropped to around 33%, indicating a temporary disturbance in the composting process. From Day 45 to Day 60, the texture remained constant, indicating that microbial activity had stabilized and no further structural improvement occurred [12]. This pattern has initial enhancement, mid-phase decline, and final stabilization demonstrates that T1 experienced the most dynamic and noticeable texture changes throughout the composting period.

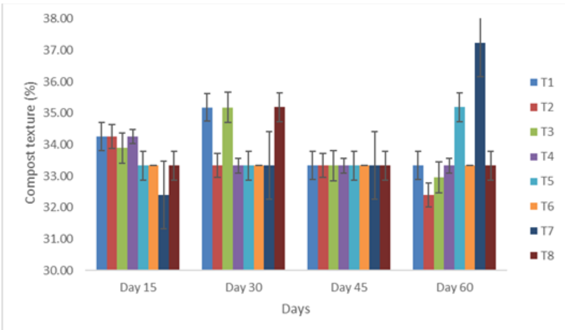

Fig. 4. Compost texture changes on days 15, 30, 45, and 60.

4.5 pH value

The most drastic change in pH was observed in treatment T4 as shown in Figure 5, which experienced a noticeable decrease in pH between day 30 and day 45, in contrast to the overall increasing or stable trends seen in other treatments. Additionally, during nitrification, hydrogen ions (H+) were released, contributing further to soil acidification [13]. These acidifying processes were active in T4 due to the high rate of organic matter breakdown and limited buffering capacity in the compost materials. As a result, T4 showed the highest variability in pH throughout the composting conditions between day 45 and day 60.

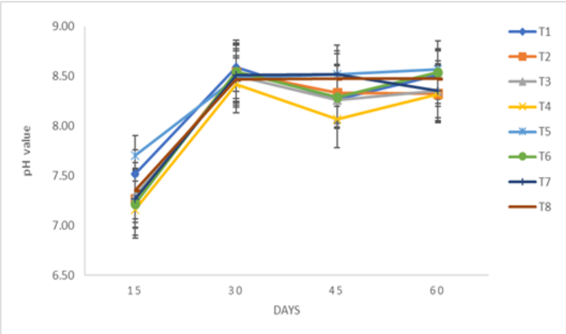

Fig. 5. pH value changes in days 15,30,45, and 60

4.6 Nutrients (NPK)

i. Nitrogen (N)

The most drastic differences were observed between treatment T3 as shown in Figure 6. T3 consistently recorded the highest nitrogen levels across all sampling days, reaching 1.20% by day 60, while T8 maintained the lowest levels, ending at 0.96%. This significant gap reflects differences in compost composition and microbial activity. T3 contained a higher proportion of vermicompost, which provided readily decomposable nitrogen sources such as amino acids and urea-derived compounds. These compounds supported high microbial activity and enzyme production, leading to efficient nitrogen mineralization [14].

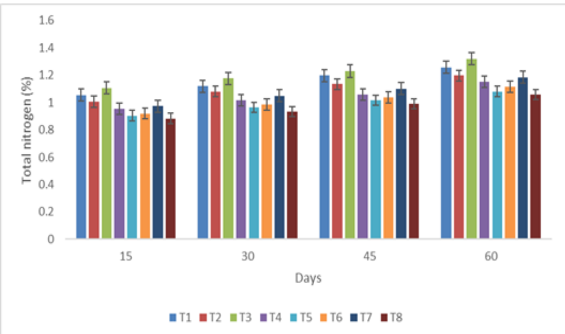

Fig. 6. Nitrogen changes in days 15, 30, 45 and 60

ii. Phosphorus (P)

The most drastic change in available phosphorus was observed in Treatment T3 as shown in Figure 7, which recorded the highest phosphorus concentration at 0.35% by day 60. This consistent and significant increase from 0.29% on Day 15 to 0.35% on day 60 indicates efficient mineralization and microbial activity throughout the composting process. In contrast, treatments like T6 and T8 showed minimal changes in phosphorus content, indicating lower microbial activity and slower decomposition. These differences highlight the effectiveness vermicompost-rich treatments like T3 in enhancing phosphorus availability through biological processes. These findings are supported by Nieto [15], found that vermicompost improved phosphorus availability and plant growth more effectively than synthetic fertilizers.

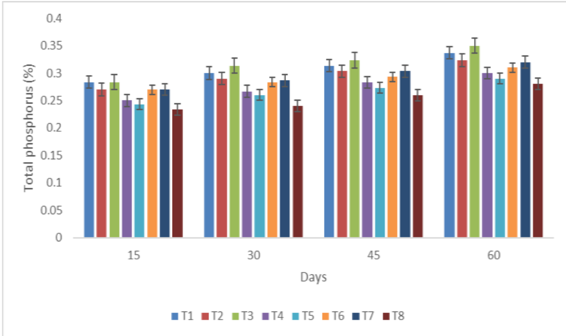

Fig. 7. Phosphorus changes in days 15, 30, 45, and 60.

iii. Potassium (K)

As shown in Figure 8, treatment T3 exhibited the most pronounced increase in potassium content. The potassium concentration increased from 0.69% on day 15 to 0.79% by day 60, which was the highest recorded among all treatments. This steady rise demonstrates effective nutrient release from organic matter, supported by microbial decomposition and the high cation exchange capacity (CEC) of the vermicompost. On day 45, T3 reached 0.78%, indicating peak microbial activity and organic matter breakdown. By day 60, potassium levels stabilized, showing that most of the potassium had been released and retained by soil particles, aided by improved soil struct... soil treate... than soil tr...

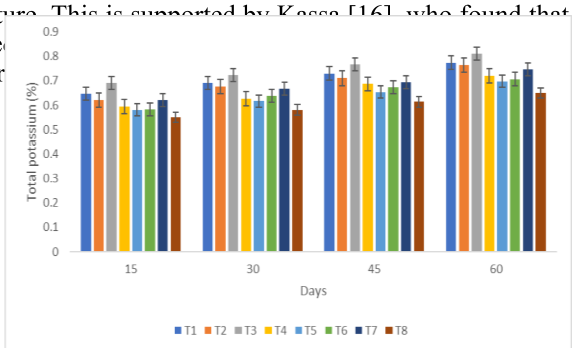

Fig. 8. Potassium changes in days 15, 30, 45, and 60.

4.7 Dehydrogenase

Dehydrogenase activity peaked between Days 30–45 in Figure 9, reflecting maximum microbial respiration and overall activity. This increase reflects the onset of decomposition of more resistant organic compounds such as cellulose and lignin. The organic inputs in T3, which included slowly degradable materials like plant residues, became more accessible as microbial communities adapted. This resulted in a second peak of enzyme activity, indicating that T3 supported renewed microbial metabolism during the mid to late stages of the composting process. The ability of T3 to maintain and increase enzyme activity after the initial decline highlights its effectiveness in sustaining microbial processes and nutrient cycling over time. This is supported by Lazcano [13], who stated that enzyme activity is influenced by the type of organic material, the availability of nutrients, and the ability of microbial communities to adapt over time.

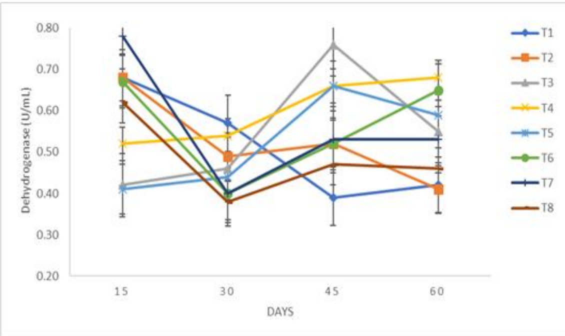

Fig. 9. Dehydrogenase changes in days 15, 30, 45, and 60.

4.8 Urease

Urease is an important enzyme that converts urea into ammonium, a form of nitrogen that plants can absorb. According to Semenov [17], urease, like other soil enzymes, responds quickly to changes in the environment or compost materials. The most significant changes in urease activity were observed between day 15, 30, and 45 in Figure 10. On day 15, urease activity peaked in treatments T1, T3, and T6, indicating strong initial microbial activity due to the presence of nitrogen-rich and easily degradable organic materials. However, by day 30, there was a drop-in urease activity likely due to the rapid depletion of available nitrogen and reduced microbial stimulation after the initial composting phase. Other changes occurred between day 30 and 45, where urease activity rebounded in treatments T3, T6, and T8. Among all treatments, T3 showed the most consistent response, with high initial activity, a clear drop, and a strong rebound, reflecting its balanced composition of fast and slow decomposing organic matter.

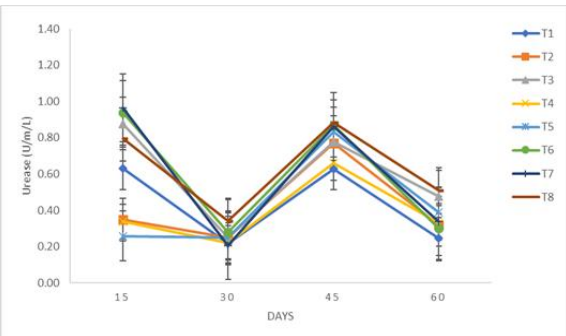

Fig. 10. Urease changes in days 15, 30, 45, and 60.

5. CONCLUSION

In conclusion, chicken feather waste was successfully converted into nutrient-enriched organic fertilizer through vermicomposting. The 60-day process showed stabilized pH, reduced EC, a lower C:N ratio, and enhanced NPK levels, indicating compost maturity. Treatments with combined substrate mixtures and microbial earthworm inoculants, which is T3 and T1, achieved the highest nutrient enrichment and enzyme activity. Overall, vermicomposting proved to be a practical and environmentally sustainable method for managing keratin-rich chicken feather waste. It produced nutrient-rich vermicompost with potential applications as an organic fertilizer or soil amendment.

REFERENCES

[1] Biswas, I., Mitra, D., Senapati, A., Mitra, D., Chattaraj, S., Ali, M., Basak, G., Panneerselvam, P., & Das Mohapatra, P. K. (2020). Valorization of Vermicompost with Bacterial Fermented Chicken Feather Hydrolysate for The Yield Improvement Of Tomato Plant: A Novel Organic Combination. International Journal of Recycling Organic Waste in Agriculture, Online First. doi: https://doi.org/10.30486/ijrowa.2020.1904599.1104

[2] Dume, B., Hanc, A., Svehla, P., Michal, P., Solcova, O., Chane, A. D., & Nigussie, A. (2022). Nutrient Recovery and Changes in Enzyme Activity During Vermicomposting of Hydrolysed Chicken Feather Residue. Environmental Technology, 1 15. doi: https://doi.org/10.1080/09593330.2022.2147451

[3] Vuković, A., Velki, M., Ečimović, S., Vuković, R., Štolfa Čamagajevac, I., & Lončarić, Z. (2021). Vermicomposting—Facts, Benefits and Knowledge Gaps. Agronomy, 11(10), 1952. doi: https://doi.org/10.3390/agronomy11101952

[4] Ratnasari, A., Syafiuddin, A., Mehmood, M. A., & Boopathy, R. (2023). A review of the vermicomposting process of organic and inorganic waste in soils: Additives effects, bioconversion process, and recommendations. Bioresource Technology Reports, 21, 101332. doi: https://doi.org/10.1016/j.biteb.2023.101332

[5] Kumar, R., Sharma, P., Gupta, R., Kumar, S., Sharma, M., Singh, S., & Pradhan, G. (2020). Earthworms for Eco-friendly Resource Efficient Agriculture. 47–84. doi: https://doi.org/10.1007/978-981-15-6953-1_2

[6] Enebe, M.C., & Erasmus, M. (2023). Mediators Of Biomass Transformation – A Focus on The Enzyme Composition of The Vermicomposting Process. Environmental Challenges, 12, 100732–100732. doi: https://doi.org/10.1016/j.envc.2023.100732

[7] Güldane Aslı Turp, Ozdemir, S., Kaan Yetilmezsoy, Oz, N., & Elkamel, A. (2023). Role of Vermicomposting Microorganisms in the Conversion of Biomass Ash to Bio-Based Fertilizers. Sustainability, 15(11), 8984–8984. doi: https://doi.org/10.3390/su15118984

[8] Sabri, N. F., Omar, N. F., Samsuddin, N. Z., & Azhar, M. A. H. (2025). Biodegradation of Chicken Feather Waste with Bacillus subtilis in Vermicomposting. Pertanika J. Trop. Agric. Sci, 48(4), 1297-1312. doi: https://doi.org/10.47836/pjtas.48.4.13

[9] Wu, Q., Zhang, J., Liu, X., Chang, T., Wang, Q., Shaghaleh, H., & Hamoud, Y. A. (2023). Effects of biochar and vermicompost on microorganisms and enzymatic activities in greenhouse soil. Frontiers in Environmental Science, 10. doi: https://doi.org/10.3389/fenvs.2022.1060277

[10] Hu, Z.-T., Huo, W., Chen, Y., Zhang, Q., Hu, M., Zheng, W., Shao, Y., Pan, Z., Li, X., & Zhao, J. (2022). Humic Substances Derived from Biomass Waste During Aerobic Composting and Hydrothermal Treatment: A Review. Frontiers in Bioengineering and Biotechnology, 10. doi: https://doi.org/10.3389/fbioe.2022.878686

[11] Sami ur Rehman, Federica De Castro, Aprile, A., Benedetti, M., & Francesco Paolo Fanizzi. (2023). Vermicompost: Enhancing Plant Growth and Combating Abiotic and Biotic Stress. Agronomy, 13(4), 1134–1134. doi: https://doi.org/10.3390/agronomy13041134

[12] Kong, Y., Zhang, J., Zhang, X., Gao, X., Yin, J., Wang, G., Li, J., Li, G., Cui, Z., & Yuan, J. (2024). Applicability and limitation of compost maturity evaluation indicators: A review. Chemical Engineering Journal, 151386–151386. doi: https://doi.org/10.1016/j.cej.2024.151386

[13] Lazcano, C., & J. Domínguez. (2011, January 1). The use of vermicompost in sustainable agriculture: Impact on plant growth and soil fertility. url: https://www.researchgate.net/publication/285899200_The_use_of_vermicompost_in_sustainable_agriculture_Impact_on_plant_growth_and_soil_fertility

[14] Lim, S. L., Wu, T. Y., Lim, P. N., & Shak, K. P. Y. (2014). The use of vermicompost in organic farming: overview, effects on soil and economics. Journal of the Science of Food and Agriculture, 95(6), 1143–1156. doi: https://doi.org/10.1002/jsfa.6849

[15] Nieto-Cantero, J., García-López, A. M., Recena, R., Quintero, J. M., & Delgado, A. (2025). Recycling Manure as Vermicompost: Assessing Phosphorus Fertilizer Efficiency and Effects on Soil Health Under Different Soil Management. Journal of Soil Science and Plant Nutrition. doi: https://doi.org/10.1007/s42729-025-02446-4

[16] Kassa Teka, Abraha, B., Mebrahtom, S., Alemtsehay Tsegay, Welday, Y., Gessesse, T. A., Ostwald, M., & Hansson, L. (2024). Effect of Vermicompost on Soil Fertility and Crop Productivity in the Drylands of Ethiopia. Compost Science & Utilization, 1–11. doi: https://doi.org/10.1080/1065657x.2024.2366784

[17] Semenov, M. V., Zhelezova, A. D., Ksenofontova, N. A., Ivanova, E. A., Nikitin, D. A., & Semenov, V. M. (2025). Microbiological Indicators for Assessing the Effects of Agricultural Practices on Soil Health: A Review. Agronomy, 15(2), 335–335. doi: https://doi.org/10.3390/agronomy15020335